How Could Things Living Today Be Connected to the Things That Lived Long Ago?

DEVELOPER: OpenSciEd

GRADE: Middle School **| DATE OF REVIEW:** February 2022

Educators Evaluating Quality Instructional Products

NextGen Science WestEd

How Could Things Living Today Be Connected to the Things That Lived Long Ago?

EQuIP RUBRIC FOR SCIENCE EVALUATION

OVERALL RATING: E
TOTAL SCORE: 9

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

Click here to see the scoring guidelines.

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

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

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Summary Comments

Thank you for your commitment to students and their science education. NextGenScience is glad to partner with you in this continuous improvement process. It is obvious that this unit was thoughtfully crafted, and it has many strengths in several areas, including clear three-dimensional learning outcomes and tasks and supporting students in developing and using the three dimensions in every lesson. In addition, the materials use authentic data sets and interactions with the scientists who discovered the giant penguin fossil, Pedro, in order for students to learn more about the phenomenon in direct and observable ways. The unit incorporates Common Core State Standards for English language arts (ELA) in authentic and meaningful ways and are connected to the unit phenomenon.

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

- **Developing specific elements of SEPs.** Currently, only some SEP elements are scaffolded for students to increasingly become independent in their use by the end of the learning sequence. Consider adding clear scaffolded opportunities for students to develop all SEP elements in the unit.
- **Incorporating Scoring Guidance.** Although scoring guidance is provided for all key assessments, specific guidance that can be used to drive future instruction is not always evident for teachers. Consider providing supports for teachers to not only use the scoring guidance to evaluate students' artifacts, but to also guide future instruction based on students' performance.

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 WAS met. The purple text is simply not part of the argument for that Extensive rating.

CATEGORY I

NGSS 3D DESIGN

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EQuIP RUBRIC FOR SCIENCE EVALUATION

I.A. EXPLAINING PHENOMENA/DESIGNING SOLUTIONS	
Making sense of phenomena and/or designing solutions to a problem drive student learning. i. Student questions and prior experiences related to the phenomenon or problem motivate sense-making and/or problem solving. ii. The focus of the lesson is to support students in making sense of phenomena and/or designing solutions to problems. iii. When engineering is a learning focus, it is integrated with developing disciplinary core ideas from physical, life, and/or earth and space sciences.	
Rating for Criterion I.A. Explaining Phenomena/Designing Solutions	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that learning is driven by students making sense of phenomena and/or designing solutions to a problem because the focus of the lesson is primarily to support students in making sense of the central phenomenon of how modern-day organisms could be connected to those from long ago as introduced through "Pedro" a giant fossil penguin. In most instances throughout the unit, opportunities for students to ask questions are related to the phenomenon and student prior experiences related to the phenomenon motivate sense-making.

Students figuring out central phenomena drive learning throughout the unit. This phenomenon is revisited consistently throughout the lesson and is used to drive learning. Related evidence includes:

- Lesson 1: Students are introduced to the phenomenon of an ancient penguin named Pedro and its connection to modern penguins.
- Lesson 2: Students discuss and predict trait variations for the shape of bones in different types of penguins and how they would compare to Pedro's.
- Lesson 3: Students are provided connections to prior lessons and reminded of the central phenomenon. Guidance is provided for the teacher: "Reorient to the unit questions. Gather students in a Scientists Circle as they enter the room. Display slide A and remind students that we started our investigation by wondering whether Pedro, the large penguin fossil found in Peru, could be connected to modern penguins. In Lesson 1, we identified two important sub-questions: (1) Where did all the different species of ancient penguins go? and (2) Where did all the different species of modern penguins come from? Say, 'We've analyzed a lot of penguin data to figure out if Pedro could be connected to modern penguins and to help us answer these two sub-questions. As we've made progress, we're beginning to think about the connections between modern and ancient organisms in new ways'" (Teacher Edition, page 105).
- Lesson 5: Students are motivated to look at other organisms. Guidance is provided for the teacher: "Summarize by saying, 'After our last lesson, we were thinking that populations of organisms could be connected by similarities in their body structures. We ended the class by reviewing our DQB and noticed that we had some questions whether the patterns we see in

penguins hold for other organisms from our list of related phenomena. Let's see if we can try to figure out if what happened with the penguins was unique or if we see similar patterns in other organisms, such as from our list of related phenomena'" (Teacher Edition, page 131). Students then are lead through a discussion about how looking at other organisms can help them see if what they saw with penguins was unique. Guidance is provided for the teacher: "Say, Let's do that by looking at some additional examples of both ancient and modern organisms just like we did with the penguins. We will not have time to look at all of the exact organisms we listed on our related phenomena, but we have substantial data sets for three organisms that might be similar to some we have on our list" (Teacher Edition, page 132). Students are then introduced to the lesson level phenomena of horseshoe crabs, horses, and whales.

- Lesson 6: Students write an argument answering the question "How are organisms today connected to organisms of long ago?" (Teacher Edition, page 150). The assessment asks the following: "Based on the model you have developed so far, make a claim about how ancient and modern penguins are connected over time. Use words and/or drawings to construct an argument in support of your claim. Support your argument with evidence that we have from the unit so far and scientific reasoning" ("How are penguins today connected to penguins from long ago" Argument and Self-Assessment, page 1).
- Lesson 8: Students connect their understandings of how ancient and modern penguins are connected over time to new organisms: horses, whales, and horseshoe crabs. Students are reminded: "That though we developed this natural selection model to account for the population changes occurring in these cases over a few generations, we originally sought out these kinds of short-term population cases because we had questions about what could be causing changes in populations of descendants from ancient to modern penguins, horses, whales, and horseshoe crabs over many generations" (Teacher Edition, page 208).
- Lesson 9: Students are offered a home learning opportunity in Part B to connect their learning back to the penguins if they are interested in doing so. While this does provide students with an opportunity to revisit the phenomenon addressed in Lesson 1, this is an optional part of the home learning for students with a high level of interest and may not be accessible to all students (Teacher Edition, page 230).
- Lesson 12: "Reorient students to the Penguin Timeline. Say, 'We know our model works in organisms we've seen adapt over shorter time periods (point to the part of the timeline that shows the last 100 years or so). How do we think that applies and what can it help us explain about longer time spans (refer to the gap of time between the ancient penguins and modern penguins)? That's what we really wanted to explain from the beginning. What does our model have to do with Pedro? Do we think natural selection can help us explain how the ancient and modern penguins are connected? Give students time to share ideas with the class'" (Teacher Edition, page 256).
- Lesson 12: Students are motivated in explaining changes in horses while providing a connection to the original penguin phenomenon: "Say, We need to start with an organism in which some interesting trait changed between ancient and modern species that is pretty easy to see. It would be cool to go back and explain penguins right now but it might be confusing to do since there are so many different species of modern penguins. Let's wait on penguins a little longer and try explaining a trait with horses first" (Teacher Edition, page 260).
- Lesson 13: "Say, We figured out that our general model for natural selection does help us explain these changes over really long periods of time, like with ancient and modern horses and ancient and modern horseshoe crabs. But we haven't yet considered how to explain something

like the penguins, where we have eighteen species of those penguins today. However, it looks like there may have been fewer species at any one time in the ancient past than we have now, based on the fossil evidence we have. Let's see if we can explain where all 18 of these modern penguins came from" (Teacher Edition, page 273).

Students are provided with opportunities to brainstorm related phenomenon and ask questions throughout the unit. These questions are often used to motivate learning from the students' perspectives. Related evidence includes:

- Lesson 1: The teacher is instructed to create a class chart of initial ideas and place an asterisk next to any connections that the class identifies as likely. After this is done the following teacher prompt is provided: "What kinds of data would you need to determine whether penguins alive today are connected to Pedro?" (Teacher Edition, page 35). Answers to this are compiled on an Evidence We Need poster. "Put up the Evidence We Need poster and keep a running list of evidence we need. As students share their ideas, pay particularly close attention to any ideas related to learning more about modern penguins. Say, It sounds like we need to find out a bit more about modern penguins. Ali and Dr. Clarke referenced the idea that Pedro is similar in some important ways to all the different species of penguins today. Maybe we can start by looking at a few of these penguins" (Teacher Edition, page 35).
- Lesson 1: Students brainstorm related phenomena. "Consider related phenomena. Project slide W and say, So far, we have been talking about penguins from long ago and penguins alive today, but we know penguins aren't the only creatures that were found both long ago and today. Ask, What other organisms do you know of that lived in the past? How are they similar or connected to an organism alive today? Make a table like the one on the slide in your science notebook. Take a couple of minutes to record your ideas in your science notebook. Be ready to share" (Teacher Edition, page 51). These related phenomena are related back to Pedro: "Summarize by saying, There are many different organisms that seem like they might be connected--just like Pedro and modern penguins. Maybe investigating Pedro and modern penguins can help us figure out how living things today could be connected to things that lived long ago" (Teacher Edition, page 53).
- Lesson 1: Students brainstorm questions which are used to create a Driving Question Board (DQB). Students are provided with question prompts they can use to revise their initially brainstormed questions.
- Lesson 2: Students brainstorm ideas for ways to investigate their questions during a Scientists Circle. "Brainstorm ideas for data and information we need. Now that the class has created a DQB, tell students that it is time to really dig into the hard work of figuring out what is going on. Stay in the Scientists Circle to brainstorm ideas for data and information we need. Post the Ideas for Data and Information We Need poster. Present slide BB and ask students, What kinds of information or data do we need to figure out the answers to our questions?" (Teacher Edition, page 55).
- Lesson 2: After sorting the initial penguin data cards based on heritable characteristics and behaviors and discussing skeletal features of penguins, students are provided with an opportunity to ask questions as an exit ticket.
- Lesson 2: At the end of the lesson students record new questions and ideas for data we need to answer the questions. These questions are revisited in lesson 3 to create a need for analyzing more data.

- Lesson 3: Students share the questions they generated at the end of the previous lesson. These questions are then used to motivate the learning in this lesson. The teacher is instructed to connect to the DQB before the students explore the fossil data card. "Connect to the Driving Question Board. Briefly point out any of the ideas students suggested on the Driving Question Board related to the ideas for investigations and data we need that these cards provide. There are likely to be many that match the data on these cards" (Teacher Edition, page 90).
- Lesson 3: Before sorting the new data cards, teacher guidance is provided for connecting this task to the DQB: "Connect to the Driving Question Board. Walk over to the DQB and Ideas for Investigation posters and ask students if they see any questions or ideas for investigations these cards could provide information about. There are likely to be many that match the data on these cards" (Teacher Edition, page 94).
- Lesson 4: "Use related phenomena to determine what we should investigate next. Say, OK, we said that we needed more data from the fossil record. Unfortunately, we know that scientists have not found very many ancient penguin fossils; we have already looked at all the penguin data we have until other scientists find more. However, we had some ideas in Lesson 1 about related phenomena to Pedro. Point students to the Related Phenomena Chart from Lesson 1. Prompt students to turn and talk with a partner about these questions: How we could use our related phenomena to see if what we have figured out can apply to more than just penguins? OR How could we get more information about what was happening to penguins by looking at some other fossil records? Ask each pair to share one idea about how related phenomena could help us with either of these goals" (Teacher Edition, page 122).
- Lesson 4: "Prompt students to visit the DQB and select one question from it that they feel they have made progress on. Students will likely select a penguin-specific question. Prompt students to develop a short answer to the question based on their work in Lessons 1-4. Remind students to write the question they chose on one sticky note and their answer on a second sticky note of a different color if possible. Then they should attach these together and stick them on the chart paper (for their class) labeled 'DQB questions we have answered'. Then ask students to evaluate the list of investigation ideas on their copy of the Ideas for Data and Information We Need poster. Ask them to add this page to their notebooks and then put a checkmark next to each idea for an investigation that we've pursued in some way or made some progress on. If time is short, all or part of this reflection task can be assigned as home learning" (Teacher Edition, pages 122–123).
- Lesson 5: "After students have added stickers to their notebook, say, Based on our work today, we have some ideas about connections between organisms based on their body structures. Think about what other information you might want to examine to help us refine our thinking and understand what the patterns we noticed might mean. Record these ideas in your notebook and be ready to share your thinking with the class in a few minutes. Invite students to share some of the ideas they recorded in their science notebooks" (Teacher Edition, page 135). Students then engage in a discussion about what other things they should look at. The following teacher prompt is provided to guide to the next activity: "It sounds like we should look for other connections in geographic location and in time" (Teacher Edition, page 135).
- Lesson 6: Students revisit the original question "How are penguins today connected to penguins of long ago?", discuss what new ideas they have figured out and return to the DQB to see how they might address some of the questions that remain. Teacher: "Based on what we learned in the last lesson I think we could now generalize this question to say, 'How are organisms today connected to organisms of long ago?', because the patterns we are seeing for penguins hold

true for the other organisms too based on what we've seen so far. Use a chart marker to add 'and other organisms' to the driving question on our DQB" (Teacher Edition, page 150).

- Lesson 6: "Connect these model ideas to our questions. Ask students to look back to the DQB to identify the big questions we asked. Say, We were wondering 'Where did modern penguins come from?' and 'Where did penguins of long ago go?' Do you think figuring out where these lines of descendants end up connecting to would help answer these questions? Why or why not?" (Teacher Edition, page 153).
- Lesson 12: "Check the DQB for questions about the origin of new variations and add any new questions students have. Go back to DQB and if there are new questions students want to add about the origin of this variation add them to the board. If there are already questions about where the variations came from, point them out" (Teacher Edition, page 256).
- Lesson 13: "Direct students to the Related Phenomena poster. Display slide N. Say, We have figured out how natural selection, mutation, and migration can explain how we currently have 18 species of penguin today that are connected through lines of descent from ancient penguins, like Pedro or the Waipara. We can trace back these penguins to their ancestors but one of the questions on the DQB was: 'Could we trace back other organisms to their ancestors? Ask students, What are other types of organisms you are wondering about that we might be able to trace back to their ancestors? What kind of evidence would you want to help you figure out how other organisms trace back to their ancestors? Listen for students to say things like insects, other birds, dinosaurs, other mammals (beyond horses and whales). Say, Wow, that sounds exciting! Let's come back next time and gather more information about these other cases of organisms we could try and trace back to their ancestors" (Teacher Edition, page 294).
- Lesson 15: "Connect to the last lessons. Say, In our last few lessons we were successful at describing the connection between ancient and modern penguins and other organisms. And in our last class, we were surprised that we ended up with even more questions about how ancient animals could be connected to animals of today after looking at the embryological sketches. Today let's return to the questions we have from earlier in our unit and see what we can now answer" (Teacher Edition, page 311).

Students' prior experiences related to the phenomena/problems in the unit are sometimes explicitly elicited. An example includes:

- Lesson 1: "Introduce the phenomenon. Show slide A. Tell students that you recently heard about a really amazing discovery made in Peru of a 36 million years [sic]old giant penguin fossil. Ask students, What experiences have you had with penguins? What do you know about penguins? Give students a few minutes to share and listen for them to tell where they have seen penguins, where they think penguins live, how penguins move and what they eat" (Teacher's Edition, page 31). However, this is the only time student prior experiences are explicitly elicited.

Suggestions for Improvement

Consider adding additional teacher prompts which specifically elicit students' prior experiences related to the phenomena.

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I.B. THREE DIMENSIONS

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

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

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

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

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

The reviewers found extensive evidence that the materials give students opportunities to build understanding of grade-appropriate elements of the three dimensions because students have numerous opportunities to use specific elements of all three dimensions to make sense of phenomena. However, students have limited opportunities to develop some of the grade-specific SEP elements.

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

The reviewers found extensive evidence that students can use or develop the SEPs in this unit because there are numerous opportunities for students to use most of the grade-appropriate SEP elements and the elements are used in service of making sense of the phenomena. However, for some claimed SEP elements, there isn't always clear evidence that students are fully developing them in the learning sequence.

Asking Questions and Defining Problems

- *Ask questions that require sufficient and appropriate empirical evidence to answer.*
  - Lesson 2: After sorting the initial penguin data cards based on heritable characteristics and behaviors and discussing skeletal features of penguins, students are provided with an opportunity to ask questions as an exit ticket. However, there are no specific guidelines for the types of questions asked to ensure they require sufficient and appropriate empirical evidence to answer.
  - Lesson 2: At the end of the lesson, students are asked to generate questions and ideas for data which could be collected to answer their questions. "Record questions to navigate to the next lesson. Present slide W. Have students record new questions and ideas for data we need to answer some of the questions on New Questions & Ideas for Data We Need" (Teacher Edition, page 79).
- *Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.*
  - Lesson 1: Students brainstorm questions based upon the resources utilized in the lessons (a list of which is provided in the materials). These questions are used to create a DQB. Students are provided with question prompts they can use to revise their initially brainstormed questions.

  - Lesson 14: Students individually complete the New Ideas and Questions Connected to Embryo Comparisons handout which contains the following questions: "A) What new ideas do you have about how to answer our Driving Question? B) What new questions did your analysis of the embryo sketches raise? C) What patterns in the data you analyzed in this lesson led you to consider these new ideas and/or questions?" (New Ideas and Questions Connected to Embryo Comparisons handout, page 1).
- *Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.*
  - Lesson 6: "Individually record new questions on sticky notes. Move to slide J and ask students to record questions that could help them understand what could cause traits in a population to change and how the traits in a population could change as well as any other new questions they may have about this phenomenon…Designate an area of the DQB for new questions that will help us figure out the cause of the traits changing. Add a heading 'How did traits in populations of organisms change?' or 'How the traits changed over time.' If there is room, move some sticky notes around to allow for a new space with the heading" (Teacher Edition, pages 155–156).
  - Lesson 15: "Pose the unit question. To close out the discussion, pose the DQB question, 'How could things living today be connected to the things that lived long ago?' Elicit students' new ideas to this question to prime students' thinking for adding a final entry to their Progress Tracker" (Teacher Edition, page 312).

Developing and Using Models

- *Use and/or develop a model of simple systems with uncertain and less predictable factors.*
  - Lesson 13: Students build a penguin common ancestry model first as a whole class and then in small groups to show how penguin species are related by comparing similarities and differences in penguin body structures. As students work with these models to add ancient penguins the following teacher guidance is provided in a callout box: Supporting Students In **Developing and Using Models**: "Sometimes models include uncertain or less predictable factors. Here, students use the penguin data strips for modern penguins and what they know about mutations and natural selection in different environments to develop their Penguin Ancestry Models to include ancient penguins - even though there are fewer body structures to compare due to the limited fossil evidence" (Teacher Edition, page 292).
- *Develop and/or use a model to predict and/or describe phenomena.*
  - Lesson 8: Students work to create a generalized model which can be used to explain why the changes which they observed in all their cases occurred. This is done both as whole class discussions with guided support as well as in partners.
  - Lesson 8: "Propose a test of the model. Remind students that a scientific model is more powerful the more types of phenomena it can explain and that, so far, our model has been developed using only 5 cases for something that we've already seen occur in the past. Propose that in order to test the generalizability of the model it should also be able to predict outcomes in new cases as well" (Teacher Edition, page 208). In addition, the following teacher guidance is provided in callout box: "Supporting Students In Engaging In Developing And Using Models: Here is an opportunity to further emphasize that one major goal of developing scientific models is to develop ones that are very generalizable and hold over long periods of time and for as large a class of phenomena as possible. You could make an explicit connection here to eventually needing to see if the model can be used to explain the changes we observed in penguin populations

happening over millions of years. Applying the model to that class of phenomena will require working with the assumption that theories and laws that describe the natural world operate today as they did in the distant past. This is an important element of the modeling practice and one that students used to explain what is happening over really long periods of time in Earth's past in their prior work in (material.pt) and [material.ss]" (Teacher Edition, page 208).
    - Lesson 8: "Complete an exit ticket to use the model of natural selection to make predictions. Show slide J. Distribute How can we use our model to make predictions? Ask students to work individually using the model of natural selection to make predictions for what the model predicts would happen in any population, in any environment, and over a different number of generations" (Teacher Edition, page 208).
- *Develop a model to describe unobservable mechanisms.*
    - Lesson 8: Students work to create a generalized model to describe the long process of natural selection which can be used to explain why the changes which they observed in all their cases occurred. This is done both as whole class discussions with guided support as well as in partners.

Planning and Carrying Out Investigations

- *Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.*
    - Lesson 10: Students investigate using a simulation of bacteria gathering food in order to determine how changes in an environment affect the distribution of traits. Students are oriented to the simulation and are provided with an opportunity to explore the simulation to determine the best way to set up the investigation.
- *Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.*
    - Lesson 9: Students collect data from a simulation of bacteria with different numbers of flagella in different environments to test their generalized model for natural selection.

Analyzing and Interpreting Data

- *Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.*
    - Lesson 14: Students look at drawings of embryos of various organisms to identify similarities and differences to begin exploring possible relationships between organisms based on the traits they have in common. However, this is not used to identify linear and nonlinear relationships.
- *Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.*
    - Lesson 1: Students watch videos and look at data cards of three modern species of penguins to determine how these penguins might be connected. Students are provided with a chart to record their observations about three modern penguin species. "Distribute a copy of Penguin Comparison to each student and have them tape it into their notebook. Tell students that the data table will help to organize our thinking about three kinds of penguins living today. Orient students to the features of the table, pointing out the row at the top for listing the penguin species and the columns of the

table for adding details about specific physical traits and behaviors noticed for each penguin species" (Teacher Edition, page 35). When looking at the penguin data cards, the following guidance is provided: "Then project slide F, which shows the emperor penguin card, and provide each pair of students with a copy of the emperor penguin card from Data Cards for Modern Penguins and Pedro. Students may wish to share their ideas with their partner prior to adding to their data tables. Give students several minutes to examine the card information for the emperor penguin and add to their data tables" (Teacher Edition, page 36).

- Lesson 1: Students look at additional penguin data cards. The following guidance is provided: "Say, First, let's explore what's on these cards a little more before we try to sort them. Instruct students to examine the cards, paying close attention to potential categories for groupings. Have students share several of their ideas for categories. List these ideas on the board. Groupings may include the following: size, number of eggs, location, diving depth. Instruct students to work in groups and come up with several different ways to sort the cards. Remind students that each group member should take a turn deciding how to sort Data Cards for Modern Penguins and Pedro. You may choose to have the groups each work together to sort all their cards in three different ways. Or, if the number of cards is overwhelming to students, instruct groups to divide the cards equally among group members. Have each group agree on one way to sort the cards (one grouping). Then have each group member sort their subset of cards according to the grouping. The group can then combine their cards to look at all 18 penguins. As a group, they can then subdivide again to try to find a different way to group the penguins" (Teacher Edition, page 40).
- Lesson 3: Students work in groups of three to organize penguin data cards by time period and look for any resulting patterns. The following teacher guidance is provided: Supporting Students in **Analyzing and Interpreting Data**: "In this process students are developing and using graphical displays of a large data set to identify temporal relationships. The size of this data set (32 data strips with 17 or 36 variables on each one) and the sub organization of groups within the data set make this a challenging data (re)organization and analysis task. It is well aligned to elements of the practice of analyzing and interpreting data in the middle school grade band. Students will need to work with these data again in Lesson Set 3 to make evidence arguments for lines of descent and common ancestors. This lesson provides an opportunity for students to develop fluency in working with these sorts of data in this way that they will need to leverage in those later lessons" (Teacher Edition, pages 90–91).
- Lesson 3: Students do a gallery walk comparing patterns on two of the timeline posters which were created by students.
- Lesson 3: Before students are asked to sort the new data cards which contain additional information, teacher guidance is provided for guiding students through how to read the data on the cards. The following additional teacher guidance is provided in a callout box: "Supporting Students in Engaging in Analyzing and Interpreting Data: These four minutes of individual exploration give students an opportunity to first orient themselves to the structure of the complex set of information on the cards before working with the larger set of data. Each of these data cards contains a lot of complex information so giving some time to individually look through a subset of the data is a helpful way to orient students to a larger data set" (Teacher Edition, page 94). Students then sort the cards individually and as a group. "Individually sort cards. Display slide L. Set the timer

for 5 minutes. Have students individually sort their subset of 4 or 5 fossil data cards based on a factor of their choice, but not by time or bone-related body structures. After they sort one way, they should find two other different ways to re-sort the cards. They can keep their previously built timeline poster on the table as a reference if they wish.∗ Sort cards in a group. Cue students to start the group work. Refer to slide L. As students are working, listen for groups to be finding patterns that link body structures with the other factors they used to organize their Ancient Penguin Data Cards, such as geographic location or climate features" (Teacher Edition, page 94).

  - Lesson 5: Students are provided with cards for either horseshoe crabs, whales, or horses and are asked to sort by similarities or differences in small groups. Before sorting the cards, students are lead through a discussion about the purpose of the sort and how they should be arranged. Some sample prompts include: "We'll have groups working with horseshoe crabs, whales, and horses today. What is the question we're trying to answer as you analyze the data we have about these modern and ancient organisms?", "Like we did with the penguins, I have data cards for various types of these ancient and modern whales, horses, and horseshoe crabs. How will you use those cards to help you answer your question about how they're connected?" (Teacher Edition, page 132).
  - Lesson 5: Students look at data cards to look for patterns based on either where or when the ancient and modern organisms lived.

- *Apply concepts of statistics and probability (including mean, median, mode, and variability) to analyze and characterize data, using digital tools when feasible.*
  - Lesson 7: Concepts of statistics are used when analyzing assigned data packets. Sometimes this is done by students (determining mean, median, and mode), and sometimes it is referenced in the data collection process. However, the type of this analysis is dependent on the data set the student is assigned; therefore, not all students are engaging with all the concepts of statistics.
- *Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).*
  - Lesson 1: Although this element is claimed in the materials (Or Lesson 1), there's no evidence of students developing or using this element.
- *Analyze and interpret data to determine similarities and differences in findings.*
  - Lesson 2: Students sort penguin data cards to identify similarities and differences in characteristics across different penguin species. The following teacher guidance is provided in the callout box: "Supporting Students in Engaging in Analyzing and Interpreting Data: Students need to find patterns in this rather large set of data. While they have been working with progressively more complex sets of data throughout middle school, the volume of information here may still intimidate some students. If students are struggling to group the strips, make sure they are laying them all out to view simultaneously. There are many structures and behaviors that are shared, so encourage them to notice the differences first, and then they can look for the shared differences, i.e., things that are similar between them but different than the rest of the penguin groups. For example, it isn't necessarily productive to focus on the external body structures and behaviors that are shared by all the penguins (like scaly feathers), so have them focus on differences and then find out who shares those same differences" (Teacher Edition, pages 70–71).

- Lesson 2: Students work in pairs to sort data to identify similarities and differences in structures of different species of penguins. Students then compare this data to look if these similarities are also true for the external and behavioral traits they sorted earlier in the lesson. The following teacher prompt is provided during the whole class discussion following this activity: "Did the penguins in these groups also tend to share external structures and behaviors in common too, like the feather and nesting you looked at earlier?" (Teacher Edition, page 77).
- Lesson 3: Working in pairs, students look at data from ancient and modern penguins which are represented on cards which contain images, maps, and other information about the penguins. Students are instructed to look for patterns in similarities and differences in penguins. The following guidance is provided to students: "Spread out the data strips for the ancient and the modern penguins. Group and sort them based on their similarities and differences using the body structure variation key as needed. Try sorting them multiple different ways. Identify any connections you notice between the ancient penguins and the modern ones" (Teacher Edition, page 89). However, at this point students are not specifically looking for similarities and differences in findings.
- Lesson 5: Students do a gallery walk to note similarities and differences in the way other groups organized their data cards.
- Lesson 9: Students construct two investigations using a simulation of bacteria with different numbers of flagella under different conditions. Students compare the results of their investigations and identify the differences in their findings.

Constructing Explanations and Designing Solutions

- *Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.*
  - Lesson 13: Students construct an explanation for the following questions "Where did the penguins of today come from? Where did the penguins of long ago go? How are the things living today connected to the things that lived long ago?" (Teacher Edition, page 292). Students use the patterns they have noticed in the similarities and differences in traits of different species of modern and ancient penguins in their explanations to the questions above.
- *Construct an explanation using models or representations.*
  - Lesson 4: As a class, students create a consensus model for grouping penguins. The following teacher guidance is provided for creating the model: "Tell students that we will use the following pattern to reach consensus: One student proposes a potential penguin grouping and justifies the grouping decision with evidence. Other students agree, disagree, or propose a modification to the grouping (based on evidence). Repeat this process until all the penguins are grouped in a way that the class can agree on (for now)" (Teacher Edition, page 106).
  - Lesson 7: Students create an initial model in their group which explains what happened in the case their groups studied and why they think it happened that way using the note cards they created. The following additional teacher guidance is provided: Supporting Students in Engaging in **Constructing Explanation and Designing Solutions** in margins: "At this point, students may perceive that they have several pieces of unconnected information and have not been shown the whole story. They are correct. In their data packets, they have in fact not been told the whole story but, rather, been provided with

all the same information that scientists had with which to put an explanation together. They will need to make reasonable connections among the pieces of evidence they have in order to develop a model that could explain all the things that happened in their case. Making inferences involves choosing the most likely explanation from the evidence that is available. Students should be familiar with making inferences of this type as they construct explanations based on their prior work in other OpenSciEd units. Encourage them to consider multiple possibilities and make some educated guesses about what makes sense for the story of how and why things are changing in the system for their case. Remind them that this is a preliminary model and they'll have opportunities to reconsider and revise their model later." (Teacher Edition, page 170).

- Lesson 7: "Revisit system models individually. Display slide Q. Distribute Develop a System Model to each student. Have them work individually to articulate their own understanding of the system model for the case they're investigating. Remind them that they are trying to tell the whole story of what's going on in their case and explain how and why the changes happened in their system model. If they finish the 'CCC: Systems and System Model' section, they should go on to the 'CCC: Scale, Proportion, and Quantity' section. Some students may not get to the second section. This is OK. For details of what students are likely to include in their answers on Develop a System Model, see the key in Key for Develop a System Model" (Teacher Edition, page 173). The key provides a sample student response.
- Lesson 7: "Have students create posters. Display slide U. The goal is to have them revise their Initial Case System Model and annotate it in a way that will be useful as they talk with classmates in the next lesson about what caused the changes in their case. Students can produce their poster in any way they would like within the time frame allowed, but they should reuse the five color index cards from their Initial Case System Model. They may choose to draw, write, use a box-and-arrows model like that depicted on the slide, present graphs, and so forth. Students should leave these posters in the classroom at the end of class. These will be referred to as their Revised Case System Models from this point forward" (Teacher Edition, page 175).
- Lesson 11: Students take the Green Anole Lizard Transfer Task as an individual assessment. "Display slide B and hand out one copy of Green Anole Lizard Transfer Task to each student. Note to students that they have a choice in modality for sharing their answers, which include oral, written or pictorial or a combination of the two∗" (Teacher Edition, page 247). The following question is found on the assessment: "2. Construct an explanation: How does natural selection explain the changes in the green lizard population over time? Take out your general model for natural selection and any completed examples of organisms changing over time in your notebook. Use words or pictures (or a combination) for your explanation. Use the key parts of the general model to explain the cause and effect of the changes in the green lizard population over time. In your explanation make sure to include: The key parts of the model Cause and effect to describe how the population changed over time The data about the green and brown lizard populations that support your explanation" (Green Anole Lizard Transfer Task, page 3).

- *Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.*

  - Lesson 10: Students use the "My Model for Changes in Bacteria Populations" handout to explain how and why different environments caused the changes they observed using both their data and the general model for natural selection.
  - Lesson 12: As a class, students construct an explanation for the variability in the change in the number of toes in ancient vs. modern horses by using the general model for natural selection and information from text.
  - Lesson 12: In small groups, students construct an explanation for the variability in the traits between ancient and modern horseshoe crabs by using the general model for natural selection and information from text.
- *Apply scientific ideas, principles, and/or evidence to construct, revise and/or use an explanation for real-world phenomena, examples, or events.*
  - Lesson 1: Students use a graphic organizer to develop initial explanations to the questions "Where did all the different types of ancient penguins go?" and "Where did all the types of modern penguins come from?" The graphic organizer uses the following headings: Claim, Possible Mechanism, Evidence we need to support our claim, Evidence we need to refute our claim.
  - Lesson 4: As a class, students create a consensus model for grouping penguins. The following teacher guidance is provided for creating the model: "Tell students that we will use the following pattern to reach consensus: One student proposes a potential penguin grouping and justifies the grouping decision with evidence. Other students agree, disagree, or propose a modification to the grouping (based on evidence). Repeat this process until all the penguins are grouped in a way that the class can agree on (for now)" (Teacher Edition, page 106).
  - Lesson 4: Students construct an explanation around the following three questions "Where did all the different species of ancient penguins go?" "Where did all the different species of modern penguins come from?" "Why are there similarities and differences in the body structures of modern and ancient penguins?" (Three Explanations Handout, page 1). The handout asks students for an explanation, evidence from the penguin groupings, and evidence we need. After completing this individually, students engage in a consensus discussion and are asked to update their ideas with new information gained from the discussion.
  - Lesson 4: Guidance is given for facilitating a discussion to analyzing the consensus conversations constructed. The following teacher guidance is provided: "Purpose: To identify the weaknesses in our current explanations in order to identify additional information or evidence that we need to strengthen our explanations." Suggested questions and sample student responses are provided to guide this discussion.

Engaging in Argument from Evidence

- *Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.*
  - Lesson 5: Lesson 5: Students engage in a gallery walk to find similarities and differences in the ways other groups organized their cards compared to their approach. "Say, You're going to take a look at how other groups that worked with the same organism decided to organize their cards. As you look at their models, record how they did their organizing and how it is similar to or different from how your group organized the organism cards.

Allow students to circulate around the room and take a quick look at the models of any other groups working with their same organism. Students should record in their science notebook the similarities and differences in other groups' organizations compared to their own. If students have a critique or question to leave for the models they visit, have them leave a sticky note citing the pertinent evidence from their own sort to support their critique/question. After 5 minutes, have students go back to their original groups and discuss what they recorded during the gallery walk and make any desired adjustments to their own model. Say, Consider the critiques others left on your model, and critique your own work now that you've seen how other groups organized the same data. As you adjust your group's model, support any changes you propose by citing relevant evidence you noticed from viewing other groups' models" (Teacher Edition, page 134). In addition, the following teacher guidance is provided in a callout box: "Supporting Students in Engaging in Argument from Evidence: As students discuss what they noticed and make adjustments to their organizational models, everyone should share ideas and ask questions of their group members to understand their thinking. Students should respectfully ask probing questions. Provide sentence starters to help students understand the thinking and ideas of their group members: Why do you think _____? Can you explain why you think these two organisms are more similar/less similar? Can you show us what evidence from the card supports your idea?" (Teacher Edition, page 134).

- Lesson 5: Students gather into jigsaw groups to share their findings and give and receive feedback. The following teacher guidance is provided: "Organize students into mixed jigsaw groups of three students: one person representing each organism. Then, get everyone's attention and remind students about norms for giving and receiving feedback. Ask students to share ideas for which classroom norms are especially important when both giving and receiving feedback. If necessary, display slide Q that lists classroom norms. Allow a few students to quickly share their thinking with the class and listen for ideas such as the following: We critique ideas, not people. We listen carefully and ask questions to help us understand. We value that people represent their ideas in different ways. We challenge ourselves to think in new ways. We are open to changing our minds. Say, 'The ideas we are talking about are very complex. These norms are all important ways to help us learn from each other. We're learning together about what is going on with many different kinds of organisms and how ancient and modern organisms may be connected to each other'" (Teacher Edition, page 141).
- Lesson 8: Students work with a partner to continue developing the generalized model. The following guidance is provided: "Remind students that when they are talking with their partners, they should be citing relevant evidence and posing and responding to questions when more detail is needed" (Teacher Edition, page 194). Specific guidance or prompts are not provided to students for engaging in this discussion.
- Lesson 11: "Students pair up and share with a partner their Green Anole Lizard Transfer Task. Show slide C. Distribute Peer Feedback Guidelines if desired. This can be taped into notebooks. Using Peer Feedback Guidelines, explain how students will give each other feedback in a conversation. Point out that students may want to take notes during this feedback partner talk. If students were already able to give feedback in Lesson 5, consider forgoing using Peer Feedback Guidelines in order to support their developing independence in giving feedback" (Teacher Edition, page 248)

- Lesson 14: Students engage in a class discussion to talk about the ideas which were generated when looking at the embryos. The following teacher guidance is provided: "Ask student volunteers to share initial ideas or questions. Emphasize the importance of restating what others have shared to check for understanding first before following-up with a related idea or question. It is suggested that at this point in the unit and year, you step more to the side and join the class as part of the circle, and encourage/support the students to discuss with and coordinate calling on each other. View this discussion similar to a forum where the space is open to hearing all ideas and working to link into each other's ideas, whether to agree, disagree or build onto the new ideas on the table. Encourage and support students in using the productive talk strategies they have been using all year as they listen to and respond to their peers' ideas (eg:[sic] I agree with _____'s idea because…; I disagree with _____'s ideas because…. , etc.)" (Teacher Edition, page 304).

- *Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.*
  - Lesson 6: Students write an argument answering the question "How are organisms today connected to organisms of long ago?" (Teacher Edition, page 150). The assessment asks the following: "Based on the model you have developed so far, make a claim about how ancient and modern penguins are connected over time. Use words and/or drawings to construct an argument in support of your claim. Support your argument with evidence that we have from the unit so far and scientific reasoning." ("How are penguins today connected to penguins from long ago" Argument and Assessment, page 1). Students then share these ideas with a partner before discussing with the whole class in a Scientists Circle. "Turn and talk to share claims with a partner. Show slide E. Say, Soon we'll be sharing these claims in a whole-class discussion. First though, turn and talk to share your ideas with a partner. Make sure you each practice backing up your ideas with evidence in addition to sharing your claims" (Teacher Edition, page 150). After these discussions, students engage in self-assessment and revise their argument. "Individually revisit our arguments. Display slide H. Give students 2 minutes to complete Part 3 of 'How are penguins today connected to penguins from long ago?' Argument and Self-Assessment using a different color to revise or add to their argument with words or pictures based on the discussion you had with the class" (Teacher Edition, page 153).
  - Lesson 8: Students present the explanation of their case study to a partner. "Orient students to the challenges in identifying similar causes, mechanisms, or relationships across case studies. Display slide B. Say, Let's get ready to share our case with someone who has a different case. Our goal is to share our case and hear another case so that we can find any causes, mechanisms, or relationships that the two different cases seem to have in common. Since many parts of the system models you put together are likely to be different and because you looked at different organisms, different places, and different times, when we hear a summary of a different case we will need to be listening for similarities in the relationships between those parts and similarities in what caused something to happen" (Teacher Edition, page 185).
  - Lesson 9: Students engage in a classroom discussion to talk about the results of their two experiments and how they support their model for natural selection. Teacher support is provided for facilitating this conversation.

Obtaining, Evaluating, and Communicating Information

- *Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).*
    - Lesson 7: Students read data packets which contain information about a species assigned to their group. The packets contain text which provides information which can be used to help find patterns to provide information to explain why the species has changed over time. "Students should work together with their group to read through and understand the Overview section of the case data packet they received, annotating in their personal copies and discussing as needed. The Overview section of each data packet also exists as a color handout that gives greater detail on the organisms and maps shown" (Teacher Edition, page 167). However, these texts are informational texts rather than scientific texts adapted for classroom use.
- *Gather, read, synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.*
    - Lesson 12: Introduce a short reading. Display slide I. Ask students to name the other main elements of the model that we need information about. They should mention that we need to know about the origin of trait variation, environment of the horses, their survival and reproduction, and offspring and inheritance. Distribute Reading v1: Horses — Ancient and Modern. Have students read and annotate the information in the reading to collect information about those four elements. However, students do not engage in multiple sources or assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.
    - Lesson 12: Students read Reading v1: Horseshoe Crabs — Ancient and Modern or Reading v2: Horseshoe Crabs — Ancient and Modern to gather information to explain the variation in horseshoe crabs. However, students do not engage in multiple sources or assess the credibility, accuracy, and possible bias of each publication and methods used, or describe how they are supported or not supported by evidence.

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

The reviewers found extensive evidence that students can use or develop the DCIs in this unit because there are numerous opportunities for students to use and develop grade-appropriate DCI elements and the elements are used in service of making sense of the phenomena. Students develop competence in DCI elements (specifically for **LS4.B**) in such a way that they can apply their understanding to several situations.

LS1.B Growth and Development of Organisms

- *Animals engage in characteristic behaviors that increase the odds of reproduction.*
    - Lesson 2: Students sort data cards which contain characteristic behaviors of penguins. However, there is no discussion of the purpose of these behaviors.

- Lesson 11: Students look at the behavior of green anole lizards as part of an assessment. However, the focus is not on the odds of these behaviors on reproduction but rather on survival.

LS2.A Interdependent Relationships in Ecosystems

- *Organisms, and populations of organisms, are dependent on their environmental interactions both with other living things and with nonliving factors.*
  - Lesson 7: Students engage in reading of case studies which highlight the ways in which an organism is dependent on its environment and/or interactions with other living things.
  - Lesson 8: While creating the consensus general model, the role of the things in the environment are considered. The following suggested prompts are provided: "OK, so in each of these cases, the environment provides living and nonliving (or biotic and abiotic) things that are needed for survival and reproduction. Is everything in the environment helpful for organisms?", "So can we say that the environment can also have living and nonliving (or biotic and abiotic) things in it that are potentially harmful to the organisms living there?" (Teacher Edition, pages 192–193).
  - Lesson 9: Students conduct investigations using a simulation of bacteria with different numbers of flagella and how the number of flagella affect their chances of survival when interacting with different types of white blood cells.
  - Lesson 11: Students complete the Green Anole Lizard task. The following is found on the assessment: "Green anole lizards are from Florida. Brown anole lizards are from Cuba. Brown lizards have recently been found on islands in Florida where only green lizards lived before. These green and brown anole lizards are different species but they have very similar behaviors - they eat similar food and live in similar habitats" (Green Anole Lizard Transfer Task, page 1). Students use this information to construct an explanation concerning how natural selection has affected green anole lizards who share the environment with brown anole lizards.
- *In any ecosystem, organisms and populations with similar requirements for food, water, oxygen, or other resources may compete with each other for limited resources, access to which consequently constrains their growth and reproduction.*
  - Lesson 7: Students engage in reading of case studies which highlight the ways in which an organism competes for various resources.
  - Lesson 8: While creating the consensus general model, the role of the things in the environment are considered. The following suggested prompts are provided: "OK, so in each of these cases, the environment provides living and nonliving (or biotic and abiotic) things that are needed for survival and reproduction. Is everything in the environment helpful for organisms?", "So can we say that the environment can also have living and nonliving (or biotic and abiotic) things in it that are potentially harmful to the organisms living there?" (Teacher Edition, pages 192–193).
  - Lesson 9: Lesson 9: Students conduct investigations using a simulation of bacteria with different numbers of flagella and how the number of flagella affect their chances of survival when interacting with different types of white blood cells.
  - Lesson 11: Students complete the Green Anole Lizard task. The following is found on the assessment: "Green anole lizards are from Florida. Brown anole lizards are from Cuba. Brown lizards have recently been found on islands in Florida where only green lizards lived before. These green and brown lizards are different species but they have very similar behaviors - they eat similar food and live in similar habitats" (Green Anole Lizard

Transfer Task, page 1). Students use this information to construct an explanation concerning how natural selection has affected green lizards who share the environment with brown lizards.

- *Growth of organisms and population increases are limited by access to resources.*
    - Lesson 7: Students engage in reading of case studies which highlight the ways in which an organism competes for various resources.
    - Lesson 8: While creating the consensus general model, the roles of the things in the environment are considered. The following suggested prompts are provided: "OK, so in each of these cases, the environment provides living and nonliving (or biotic and abiotic) things that are needed for survival and reproduction. Is everything in the environment helpful for organisms?", "So can we say that the environment can also have living and nonliving (or biotic and abiotic) things in it that are potentially harmful to the organisms living there?" (Teacher Edition, pages 192–193).
    - Lesson 9: Students conduct investigations using a simulation of bacteria with different numbers of flagella and how the number of flagella affect their chances of survival when interacting with different types of white blood cells.

LS3.B Variation of Traits

- *Genes are located in the chromosomes of cells, with each chromosome pair containing two variants of each of many distinct genes. Each distinct gene chiefly controls the production of specific proteins, which in turn affects the traits of the individual. Changes (mutations) to genes can result in changes to proteins, which can affect the structures and functions of the organism and thereby change traits.*
    - Lesson 8: Students add the role of genes and inheritance of traits to their generalized model. "With prompting, students should be able to recall a mechanism for how traits are inherited that articulates the connections among sex cells, chromosomes, genes, proteins, and traits from their prior work in (material.ge.n). These connections include these ideas: Traits themselves aren't actually passed on. Rather, each parent passes on genetic information in the form of specific alleles they contribute to their offspring via a sex cell. Genes contain the instructions that result in the formation of molecules called proteins, which are structural components that cells build. Proteins are used in the formation of physical traits" (Teacher Edition, page 198).
    - Lesson 12: "Ask students to turn and talk to discuss the role that they think mutation plays with regard to how the organisms we have been studying have changed over long periods of time, and whether mutations are common or rare" (Teacher Edition, page 257).
    - Lesson 13: Students use the idea of mutations to explain how genetic variation may have arisen in penguins when making their model of common ancestry. The following suggested prompt and sample student responses are provided: "Based on what we know about how mutations and natural selection work together over time, what is happening to each of these lines of descendant populations over time?...They randomly get mutations that could cause a change in a body structure" (Teacher Edition, page 278).
- *Variations of inherited traits between parent and offspring arise from genetic differences that result from the subset of chromosomes (and therefore genes) inherited.*

- Lesson 8: Students add the role of genes and inheritance of traits to their generalized model. "With prompting, students should be able to recall a mechanism for how traits are inherited that articulates the connections among sex cells, chromosomes, genes, proteins, and traits from their prior work in (material.ge.n). These connections include these ideas: Traits themselves aren't actually passed on. Rather, each parent passes on genetic information in the form of specific alleles they contribute to their offspring via a sex cell. Genes contain the instructions that result in the formation of molecules called proteins, which are structural components that cells build. Proteins are used in the formation of physical traits" (Teacher Edition, page 198).
- Lesson 13: Students use the idea that organisms inherit genes from their parents when constructing their common ancestry models.

LS4.A Evidence of Common Ancestor and Diversity

- *The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.*
  - Lesson 6: Students use the data collected from fossils and use the evidence gained to construct an argument around the question "Are there lines of descendants that stretch from modern penguins back to one or more of the ancient penguins?"
  - Lesson 12: Students look at representations of fossils of penguins and horseshoe crabs to use their model of natural selection to explain the differences between organisms. However, the placement of these fossils in chronological order is not addressed.
  - Lesson 13: Students use information derived from penguin fossils to determine how closely different modern and ancient species are related and construct a model timeline.
- *Anatomical similarities and differences between various organisms living today and between them and organisms in the fossil record, enable the reconstruction of evolutionary history and the inference of lines of evolutionary descent.*
  - Lesson 6: Students discuss the similarities and differences between ancient and modern penguins and use this as evidence to explain where modern penguins came from. This leads to the following conclusions: "Add the following to the New Model Ideas chart: There must have been some populations of ancient organisms that had offspring that were lines of descendants that led to modern organisms (penguins). There must also be some organisms living now or in the recent past that are descendants of the ancient organisms (penguins)" (Teacher Edition, page 153).
  - Lesson 12: Students investigate differences in the number of toes between ancient and modern horses.
  - Lesson 13: Students compare how many traits different species have in common to begin to predict which species of penguins are most closely related and have a more recent common ancestor.
- *Comparison of the embryological development of different species also reveals similarities that show relationships not evident in the fully-formed anatomy.*
  - Lesson 14: Students look at embryos of organisms to identify similarities and differences. The following teacher prompt is provided "When scientists looked at the physical structures in embryos of living things, they were surprised at some of the similarities and differences that they saw that were not as apparent in adults or new

babies" (Teacher Edition, page 299).

LS4.B Natural Selection

- *Natural selection leads to the predominance of certain traits in a population, and the suppression of others.*
    - Lesson 7: Through analyzing data from case studies, students begin seeing how the environment can influence the distribution and frequency of specific traits.
    - Lesson 8: Students create a generalized model of the natural selection process which explains that some traits become more common and others less common due to specific factors.
    - Lesson 9: Students conduct investigations using a simulation of bacteria with different numbers of flagella and how the number of flagella affect their chances of survival when interacting with different types of white blood cells. Students use the result of this experiment to revise their general model for natural selection to include the idea that "Changes in the environment can lead to different changes in the traits of the population" (Teacher Edition, page 227).
    - Lesson 10: Students add the following to the general model for natural selection: "Natural selection not only shifts the distribution of traits over many generations and changes what is typical in a population over time, it removes trait variations that are less advantageous in that environment" (Teacher Edition, page 241).
    - Lesson 11: Students complete the Green Anole Lizard task. The following is found on the assessment: "Green anole lizards are from Florida. Brown anole lizards are from Cuba. Brown lizards have recently been found on islands in Florida where only green lizards lived before. These green and brown lizards are different species but they have very similar behaviors - they eat similar food and live in similar habitats" (Green Anole Lizard Transfer Task, page 1). Students use this information to construct an explanation concerning how natural selection has affected green anole lizards who share the environment with brown anole lizards.
    - Lesson 13: Students construct an explanation for the following questions "Where did the penguins of today come from? Where did the penguins of long ago go? How are the things living today connected to the things that lived long ago?" using the patterns they have noticed in the similarities and differences in traits of different species of modern and ancient penguins (Teacher Edition, page 292).

LS4.C Adaptation

- *Adaptation by natural selection acting over generations is one important process by which species change over time in response to changes in environmental conditions. Traits that support successful survival and reproduction in the new environment become more common; those that do not become less common. Thus, the distribution of traits in a population changes.*
    - Lesson 7: Through analyzing data from case studies, students begin seeing how the environment can influence the distribution and frequency of specific traits.
    - Lesson 8: Students create a general model for natural selection which explains how the frequency of traits in a population change over time.
    - Lesson 9: Students conduct investigations using a simulation of bacteria with different numbers of flagella and how the number of flagella affect their chances of survival when interacting with different types of white blood cells. Students use the result of this experiment to revise their general model for natural selection to include the idea that

"Changes in the environment can lead to different changes in the traits of the population" (Teacher Edition, page 227).
  - Lesson 10: Natural selection not only shifts the distribution of traits over many generations and changes what is typical in a population over time, it removes trait variations that are less advantageous in that environment
  - Lesson 11: Students complete the Green Anole Lizard task. The following is found on the assessment: "Green anole lizards are from Florida. Brown anole lizards are from Cuba. Brown lizards have recently been found on islands in Florida where only green lizards lived before. These green and brown lizards are different species but they have very similar behaviors - they eat similar food and live in similar habitats" (Green Anole Lizard Transfer Task, page 1). Students use this information to construct an explanation concerning how natural selection has affected green lizards who share the environment with brown lizards.
  - Lesson 12: "Define 'adaptation by natural selection' as a scientific term. Say, We just described how mutation provides new trait variation and natural selection works with this trait variation over time to help a species survive in its environment. The scientific term for this process is 'adaptation.' You might have used the word adaptation in earlier grades to name the structures that an organism has that help it survive in its environment. You also may have heard the word used in other ways outside of science. But today we're naming the process of adaptation; mutation and natural selection are mechanisms that contribute to that process. To be really clear that we are talking about the process we will refer to this as 'adaptation by natural selection'" (Teacher Edition, page 263).
  - Lesson 13: Students use the idea that the frequency of traits changes due to environmental conditions when making their class model of common ancestry for penguins.

ESS2.B Plate Tectonics and Large-Scale System Interactions

- *Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart.*
  - Lesson 3: Students look at data cards which contain maps to show how the Earth's surface has changed over time.
  - Lesson 5: Students look at data cards which contain maps to show how the Earth's surface has changed over time.

Crosscutting Concepts (CCCs) | **Extensive**

The reviewers found extensive evidence that students have the opportunity to use or develop the CCCs in this unit because there are numerous opportunities for students to use grade-appropriate CCC elements and the elements are used in service of making sense of phenomena.

Patterns

- *Graphs, charts, and images can be used to identify patterns in data.*
  - Lesson 1: Students watch videos and look at penguin data cards to compare and contrast the types of living penguins in order to determine how they could be connected to each other as well as Pedro. The following teacher prompt is provided: "Project slide M and say, Let's take a closer look at the different types of penguins alive today and Pedro to identify patterns in the data" (Teacher Edition, page 41).

- Lesson 1: Students look at additional penguin data cards. The following guidance is provided: "Say, First, let's explore what's on these cards a little more before we try to sort them. Instruct students to examine the cards, paying close attention to potential categories for groupings. Have students share several of their ideas for categories. List these ideas on the board. Groupings may include the following: size number of eggs location diving depth Instruct students to work in groups and come up with several different ways to sort the cards. Remind students that each group member should take a turn deciding how to sort Data Cards for Modern Penguins and Pedro. You may choose to have the groups each work together to sort all their cards in three different ways. Or, if the number of cards is overwhelming to students, instruct groups to divide the cards equally among group members. Have each group agree on one way to sort the cards (one grouping). Then have each group member sort their subset of cards according to the grouping. The group can then combine their cards to look at all 18 penguins. As a group, they can then subdivide again to try to find a different way to group the penguins" (Teacher Edition, page 40).
- Lesson 1: Students use a map to discuss patterns in geographic locations of the penguins.
- Lesson 2: Students revisit the data cards they looked at in the previous lesson. The following teacher prompt is provided: "Say, Think about the ideas and patterns we uncovered when looking at the cards for different penguins and creating this timeline. What important ideas or patterns did we see in the data about how the different penguins are similar and different?" (Teacher Edition, page 65).
- Lesson 2: Students sort penguin data cards to identify similarities and differences in characteristics across different penguin species. The following teacher guidance is provided in callout box "Supporting Students in Engaging in Analyzing and Interpreting Data: Students need to find patterns in this rather large set of data. While they have been working with progressively more complex sets of data throughout middle school, the volume of information here may still intimidate some students. If students are struggling to group the strips, make sure they are laying them all out to view simultaneously. There are many structures and behaviors that are shared, so encourage them to notice the differences first, and then they can look for the shared differences, i.e., things that are similar between them but different than the rest of the penguin groups. For example, it isn't necessarily productive to focus on the external body structures and behaviors that are shared by all the penguins (like scaly feathers), so have them focus on differences and then find out who shares those same differences" (Teacher Edition, pages 70–71).
- Lesson 3: Students look at data from ancient and modern penguins which are represented on cards which contain images, maps, and other information about the penguins. Students are instructed to look for patterns in similarities and differences in penguins. The following guidance is provided to students: "Spread out the data strips for the ancient and the modern penguins. Group and sort them based on their similarities and differences using the body structure variation key as needed. Try sorting them multiple different ways. Identify any connections you notice between the ancient penguins and the modern ones" (Teacher Edition, page 89). Students share the patterns they find with a partner.
- Lesson 5: Students are provided with cards for either horseshoe crabs, whales, or horses which contain images and data about the different organisms and are asked to sort by

similarities or differences in small groups. The following teacher guidance is provided: Supporting Students in **Developing and Using Patterns** (in margins) "If students are struggling to identify body structures on which to l base their sorting, help them to think more deeply with probing questions such as these: What do you notice about your organisms overall? What parts of your organisms are you able to examine? What features do you notice about the ___ (legs, skulls, shells) of your organisms? What were the structures that all _____ have in common for your organism? If students are struggling to get started, ask them to look for one characteristic that will allow them to divide their organisms into two groups. Prompt them to continue dividing into subgroups based on differences in body structures" (Teacher Edition, page 133).
    - Lesson 9: Students look at graphs generated from during the computer simulation to identify what is happening to trait variability in the bacteria population.
    - Lesson 14: Students look for patterns in similarities and differences in picture of embryos. The following question is found on the assessment in the unit: "What patterns in the data you analyzed in this lesson led you to consider these new ideas and/or questions?" (New Ideas and Questions Connected to Embryo Comparisons handout, page 1).
- *Patterns in rates of change and other numerical relationships can provide information about natural systems.*
    - Lesson 13: Students construct an explanation for the following questions "Where did the penguins of today come from? Where did the penguins of long ago go? How are the things living today connected to the things that lived long ago?" (Teacher Edition, page 292) using the patterns they have noticed in the similarities and differences in traits of different species of modern and ancient penguins.
- *Patterns can be used to identify cause-and-effect relationships*
    - Lesson 4: Students use the patterns they have identified in data to help develop an explanation for the question "Where did all the different types of modern penguins come from?"
    - Lesson 6: Students engage in a classroom discussion where they begin to identify causes for how species have changed over time based upon the patterns in data they have identified.

Cause and Effect

- *Cause and effect relationships may be used to predict phenomena in natural or designed systems.*
    - Lesson 11: Students take the Green Anole Lizard Transfer Task as an assessment. "Administer assessment individually to students. Display slide B and hand out one copy of Green Anole Lizard Transfer Task to each student. Note to students that they have a choice in modality for sharing their answers, which include oral, written or pictorial or a combination of the two" (Teacher Edition, page 247). The following question is found on the assessment: "2. Construct an explanation: How does natural selection explain the changes in the green lizard population over time? Take out your general model for natural selection and any completed examples of organisms changing over time in your notebook. Use words or pictures (or a combination) for your explanation. Use the key parts of the general model to explain the cause and effect of the changes in the green lizard population over time. In your explanation make sure to include: The key parts of the model Cause and effect to describe how the population changed over time The data

about the green and brown lizard populations that support your explanation" (Green Anole Lizard Transfer Task, page 3).

- *Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.*
    - Lesson 7: Students complete the "Using the CCC Lens" handout for cause and effect which asks the following questions: "How does having a specific trait variation affect the individual?" "Would that specific trait variation always affect every individual the same way?", "How does having a specific trait variation affect the offspring that an individual can produce?", "Does the trait variation affect how likely the individual would be to produce offspring?", "How does having different trait variations affect the whole population?", "How does having different trait variations in the population affect the trait variations that appear in the offspring produced by that population?", "What is the probability (how likely do you think it is) that the specific trait variation would affect an individual's ability to survive?", "What is the probability (how likely do you think it is) that the specific trait variation would affect an individual's ability to produce offspring?" (Using the CCC Lens Handout, pages 1–2). While this does encourage students to use cause and effect thinking around probability, it is not clear that this addressed phenomena having more than one cause
    - Lesson 7: The following teacher prompt is provided: "Ask, Does everyone's trait variation work by making it more likely that they'll survive or reproduce? They should answer yes. Does anyone have a trait variation that always guarantees that an individual will survive or reproduce? They should answer no. Remind them to keep this in mind as they work on the next activity" (Teacher Edition, page 173).
    - Lesson 7: Students come to consensus about a chain of cause and effect. A sample chain is provided to the class prior to groups engaging in their consensus conversation. In addition, the following teacher guidance is provided: "Supporting Students In Developing and Using Cause and Effect: 'Students often struggle with what constitutes a cause-and-effect relationship. When asked to describe something that affects another part of their system, they may describe parts or relationships that do not represent a cause and its effect. For instance: The passing of clean air laws and birds eating peppered moths both happened in England. Those things are related because they're part of the same system. However, one is not the cause of the other. The population at the beginning is related to the population at the end. This is a true statement, but it is not a cause-and-effect statement. The population at the beginning does not cause the population at the end. Check these statements by asking "Does ___ cause ___ to happen?' If the answer is 'no', it is not a cause-and-effect relationship. Lesson 6 of the Genetics unit (Muscles) included a deep dive into defining cause-and-effect relationships that it may be helpful to remind students about if they are familiar with that unit. Students may also propose cause-and-effect relationships that are not supported by evidence. The color of the moths causes them to mate only with moths of the same color. This is a possible cause-and-effect relationship, but there is no evidence to support it. The plants bloomed earlier because the temperature was hotter earlier. There is no evidence that temperature affects when the mustard plants bloom. Check these statements by asking students what evidence supports their statement" (Teacher Edition, pages 174–175).
    - Lesson 8: Students use cause and effect arrows to indicate the cause and effect relationships which are part of their model. "Also, we know that useful scientific models

explain not only the model parts and components but also the relationships among those parts and components. Let's add arrows that show the cause-and-effect relationships between the other parts of the model. And then we should describe the cause-and-effect relationships between the parts we linked with an arrow similarly to what we did for our individual case models. But now we want general statements that describe what's similar in all the cases. These statements can be phrased 'Because of this . . .', like the example I'm showing you here" (Teacher Edition, page 194). The model created shows multiple causes.

- Lesson 9: When looking at the results of their computer simulation, students discuss the question "Why might you and your partner have gotten similar shifts but not exactly the same results?" (Teacher Edition, page 226). This provides students with an opportunity to consider other causes (such as random chance or hunting strategy) for the changes they see.

Stability and Change

- *Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.*
  - Lesson 4: Students develop explanations regarding why similarities and differences exist between modern and ancient penguins using the patterns they have observed.
  - Lesson 6: Students use the data they have analyzed up to this point and develop an answer to the question "How are organisms today connected to organisms of long ago?" (Teacher Edition, page 150).
  - Lesson 7: Through looking at different case studies, students can see that traits can change over different time scales. As students discuss the similarities and differences of the different cases, the following anticipated student response is provided: "They all have multiple generations or years, but sometimes it took 30 generations and sometimes it took only 2" (Teacher Edition, page 166).
  - Lesson 8: In the generalized model, students explain the idea that some traits remain stable, and others change in a population based on the environment.
- *Small changes in one part of a system might cause large changes in another part.*
  - Lesson 8: In their generalized model, students explain how one small change in the environment can lead to a change in the frequency of traits in a population.
  - Lesson 10: Students design an investigation to determine how one change in the environment of the bacteria can affect the trait distribution of a population. The following teacher guidance is provided in callout box: Supporting Students In Developing and Using **Stability and Change**: "This activity provides an opportunity for student choice in how they set up the environments, and not all students will test the same conditions. However, each student will bring their results to their explanations where they can explain how the small changes in one part of a system might cause large changes in another part for each environment" (Teacher Edition, pages 238–239).

Suggestions for Improvement

None

How Could Things Living Today Be Connected to the Things That Lived Long Ago?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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 events where students are expected to figure something out (a phenomena) or solve part of a problem in a way that requires a grade-appropriate element of each of the three dimensions working together.

Throughout the unit, there are several events where students utilize all three dimensions to figure something out related to the phenomenon. For example:

- Lesson 1: Students watch videos of penguins and look at penguin data cards to identify patterns to determine possible relationships between penguins. In this activity, students integrate the following three dimensions:
    - DCI: **LS4.A**
    - CCC: **Patterns**
    - SEP: **Analyzing and Interpreting Data**
- Lesson 2: Students sort data cards with external, internal, and behavioral characteristics of penguins to identify patterns of similarities and differences in these traits to begin determining relationships between different penguin species. In this activity, students integrate the following three dimensions:
    - DCI: **LS4.A**
    - CCC: **Patterns**
    - SEP: **Analyzing and Interpreting Data**
- Lesson 2: Students sort data cards with external, internal, and behavioral characteristics of penguins to identify patterns of similarities and differences in these traits to begin determining relationships between different penguin species. In this activity, students integrate the following three dimensions:
    - DCI: **LS4.A**
    - CCC: **Patterns**
    - SEP: **Analyzing and Interpreting Data**
- Lesson 6: Students construct an argument to explain where modern penguins came from using the patterns they have found in data. In this activity, students integrate the following three dimensions:
    - DCI: **LS4.A**
    - CCC: **Patterns**
    - SEP: **Analyzing and Interpreting Data**

- Lesson 9: Students collect data from simulations and analyze the data for patterns to test and revise their model for natural selection. In this activity, students integrate the following three dimensions:
    - DCI: **LS4.B**
    - CCC: **Patterns**
    - SEP: **Planning and Carrying Out Investigations**, **Analyzing and Interpreting Data**
- Lesson 11: Students construct an explanation for the question, "How does natural selection explain the changes in the green lizard population over time?" In their explanations they include: "The key parts of the model Cause and effect to describe how the population changed over time, the data about the green and brown anole lizard populations". (Green Anole Lizard Transfer Task, page 3). In this activity, students integrate the following three dimensions:
    - DCI: **LS4.B**
    - CCC: **Cause and Effect**
    - SEP: **Constructing Explanations and Designing Solutions**
- Lesson 14: Students use patterns in similarities and differences identified in penguin structure as well as their general model of natural selection to answer the questions "Where did the penguins of today come from? Where did the penguins of long ago go? How are the things living today connected to the things that lived long ago?" (Teacher Edition, page 292). In this activity, students integrate the following three dimensions:
    - DCI: **LS4.A**, **LS4.B**
    - CCC: **Patterns**
    - SEP: **Constructing Explanations and Designing Solutions**

Suggestions for Improvement
None

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 because the materials are organized so that lessons are sequenced

coherently from the student's perspective and build on prior lessons using a variety of strategies. Clear links between lessons are provided so that teachers know where they have been and where they are going. Students regularly return to the phenomena, have opportunities to ask new questions, and see how their questions are driving the progression of learning.

A variety of strategies are used to make the links between most lessons explicitly to students. For example:

- Lesson 1: Students generate questions about the ancient giant penguin, Pedro. Their questions include "What other penguin fossils have been found? Where have other penguin fossils been found? What were the traits or characteristics of penguins from long ago? How closely connected are penguins to other birds living today? How did Pedro end up in Peru while all the ones (penguins) now live in colder places? Why do most penguins live in Antarctica? Will the penguins' food change (in the future)? How do organisms change over time? What caused the changes in penguins? What was the environment like back then? How does the location of where Pedro was found look in the past? Do all the changes help organisms to become better? Were there other fossils like Pedro?" (Teacher Edition, page 53).
- Lesson 2: "At the end of the last lesson we had some questions about other ancient penguins like Pedro. One question we had was something like, 'Where did the penguins alive today come from?'" (Teacher Edition, page 60). Students are focused on developing initial explanations of how modern and ancient penguins are connected.
- Lesson 3: Students continue to make sense of their question from Lesson 2 about where modern penguins come from by "Looking at fossils of other ancient penguins" (Teacher Edition, page 85). While the teacher supports students in making connections to the parents of the ancient penguins or traits within families of ancient penguins, students may not readily see the need to investigate other ancient penguins or how it will help to make sense of the central phenomena.
- Lesson 4: The teacher reminds students that "we started our investigation by wondering whether Pedro, the large penguin fossil found in Peru, could be connected to modern penguins. In Lesson 1, we identified two important sub-questions: (1) Where did all the different types of ancient penguins go? and (2) Where did all the different types of modern penguins come from?" In the lesson, students attempt to answer the sub-questions by grouping and sequencing cards representing ancient penguins on a timeline to show what might have happened over time with the different types of penguins and by explaining "similarities and differences in the traits we see between modern penguins and ancient penguins" (Teacher Edition, page 99).
- Lesson 5: The teacher helps students summarize their learning so far: "What did we figure out in our last lesson?" and then proposes the focus question of the lesson: "How could looking at data from other ancient and modern organisms besides penguins help us answer our questions?" (Teacher Edition, page 115.) Students then examine photos and sketches of different modern and ancient organisms — crabs, whales, horses — to identify and share patterns they notice in each of the cases.
- Lesson 6: Students use penguin data cards to answer their questions from the past lessons of "How are penguins today connected to penguins from long ago?" and specifically "Do we think modern types of organisms, like penguins, must have descended from other organisms, like penguins, in the past?" (Teacher Edition, page 136). Students put together evidence to support their response. However, students may not readily see the need to investigate other organisms.
- Lesson 6: Students are asked to come up with new questions about "How did traits in populations of organisms change." The materials suggest students might ask: "Can a whole population change at the same time? Why do only certain traits change and others don't? Do

certain environments cause this change (and not other changes)? Do all penguins of a type live in one place? Do penguins of the same type living in different places look or act different? Does the variation or range in the population change depending on where organisms live? Can organisms learn to have different traits? Do the living organisms change individually or do only their offspring change? Can the genes of an entire population change at the same time? Is there something that causes a mutation to happen all at once, for all individuals in the population at the same time? Can we make an entire population change by changing its environment? How fast does it take for the change to take effect? Is this type of change happening in organisms alive today due to climate change? Will everything keep changing in the future? Is there any way to observe this change ourselves?" (Teacher Edition, page 141).

- Lesson 7: The lesson builds on students' questions from the previous lesson related to "How could investigating whether such changes happen over a shorter time scale (fewer generations in any population) help us make progress on parts of our expanded DQB?" However, even though the teacher prompts students to think about questions around "How did traits in populations of organisms change," students may not readily see the need to investigate changes in small timescales.
- Lesson 8: Students build a model to answer their question about "what is causing the changes in the populations" (i.e., in the different organism cases) (Teacher Edition, page 161) which relates to their question from Lesson 6 about "how traits in populations of organisms change" (Teacher Edition, page 136).
- Lesson 9: The teacher prompts students to think about whether their model is "able to predict and explain changes in other populations too (like bacteria)" and students identify ways that they can test their model in a simulation (Teacher Edition, page 193). Although the teacher proposes testing students' models on different populations, students may not readily see the need to test models on bacteria populations.
- Lesson 10: Students investigate an unanswered question from the previous lesson: "At the end of the previous lesson, we figured out that our model could explain the changes in the trait distribution in a population of simulated bacteria due to one type of environmental change (predators), and we wondered if it would predict and explain outcomes from other changes to the environment" (Teacher Edition, page 217).
- Lesson 11: Students return to the unit driving question and use their model to explain the connection between modern and ancient penguins: "Ask students whether they think the general model of natural selection could help us explain some of the differences we saw in ancient and modern organisms using the prompts below" (Teacher Edition, page 231).

The lessons work together to build proficiency in all three dimensions for a targeted set of performance expectations. For example:

- **MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past**.
  - Lesson 2: Students analyze data to look for patterns in traits in modern penguins and relate them to Pedro.
  - Lesson 3: Students analyze data to find patterns in traits for ancient penguin fossils and relate them to modern penguins. Students use the patterns to develop a timeline.
  - Lesson 4: Students utilize the patterns they have noticed in the previous lesson to develop an explanation for the relationship between the penguins and what may be causing the patterns they have recognized in the data.

  - Lesson 13: Students use patterns in similarities and differences in characteristics of penguins from fossil data as well as their generalized model of natural selection to develop a model to show how modern penguins could be connected to each other and ancient penguins.
- **MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships**.
  - Lesson 4: Students utilize the patterns they have noticed in previous lessons to develop an explanation for the relationship between the penguins and what may be causing the patterns they have recognized in the data.
  - Lesson 5: Students analyze data for other organisms to find connections between ancient and modern organisms and discuss whether the similarities and differences are related to where or when they lived.
  - Lesson 7 and 8: Students investigate case studies of different populations of organisms and use the information collected to construct a general model for natural selection.
  - Lesson 12: Students use their general model of natural selection to explain the similarities and differences in ancient and modern horses and horseshoe crabs.
  - Lesson 13: Students use patterns in similarities and differences in characteristics of penguins from fossil data sets as well as their generalized model of natural selection to develop a model to show how modern penguins could be connected to each other and ancient penguins.
- **MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment**
  - Lesson 9: Students use a computer simulation to carry out an investigation to determine how the number of flagella bacteria have influenced their chances of surviving and reproducing. Students use this information to revise the general natural selection model.
  - Lesson 10: Students design an investigation and develop an explanation for why certain traits allow organisms to survive and reproduce. Students create a model to explain why the different environments caused the changes in trait variation to occur.
- **MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.**
  - Lessons 5–10: Students work to develop a general natural selection model. However, there is no evidence of mathematical expressions being used to support explanations within the unit.
- **MS-LS1-4. Use arguments based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.**
  - Lesson 7 and 8: Students investigate case studies of various plant and animal species to develop an argument based on evidence for how animal and plant traits affect likelihood of survival and reproduction. However, the specific use of plant structures and/or animal behaviors is dependent on the case study assigned, so not all students may fully develop this performance expectation.

Suggestions for Improvement

- Consider providing opportunities for students to use mathematical expressions in constructing their explanations.

- Consider including strategies that support students in more clearly seeing the need to investigate the driving question in each lesson. Strategies can include using different prompts, highlighting an intriguing aspect of the anchoring phenomenon, or even introducing an investigative phenomenon. For example, in Lesson 7, the teacher can introduce an investigative phenomenon about a new species that was recently discovered and have students make a claim about whether the change must have occurred slowly or rapidly over time. The lesson can then focus on gathering evidence to support students' claims; later students can connect what they learn back to their explanations of the anchoring phenomenon.

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 unit establishes some connection between life and earth science domains. However, the materials do not always make clear to students how ideas from different domains work together in a critical way to explain the phenomena using CCCs.

The unit phenomena can be addressed within the claimed life science DCIs. In addition, connections to Earth and space science DCIs are made through new learning and previous learning in other OpenSciEd units. For example:

- **ESS1.C: The History of Planet Earth**: The materials state that students "draw on their understanding of ESS1.C to interpret and organize fossil data from different ages in Earth's history millions of years ago to make several passes at how the penguins (and other organisms of today) could be related to each other and connected to those from long ago" (Teacher Edition, page 14).
    - Lesson 1: "Briefly recall what we know about fossils from the Everest Unit. Ask, What do you know from the Everest Unit about how a fossil would become exposed so a scientist like Mr. Altamirano could find it? Sample student responses: When plates move and collide, land can get pushed up and expose fossils that were buried. When plates move apart, fossils that were buried could be exposed. Erosion from wind and rain can wear away the land and expose fossils. Sometimes both plates moving and erosion is what leads to fossils being exposed like the fossil at the top of Everest" (Teacher Edition, page 32).

- **ESS2.B: Plate Tectonics and Large-Scale System Interactions,** *Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart*.
    - Lesson 3: Students utilize an element of **ESS2.B**. On data cards, students are provided with maps which demonstrate how the continents and other Earth's features appeared during the time the ancient penguins lived. Students use these cards to identify patterns (similarities and differences) between the penguins. However, while this is used to help students find patterns among their penguins, the movement of plates and changing of the Earth's surface is not explicitly used in explanations of why the penguins have changed.
    - Lesson 5: Students utilize elements of **ESS2.B** when looking at penguin data cards and identifying how Earth's surface has changed. However, while this is used to help students find patterns among their penguins, they movement of plates and changing of the Earth's surface is not explicitly used in explanations of why the penguins have changed.

Students have multiple opportunities to use the CCCs to make sense of phenomena in the unit. However, the usefulness of the CCCs to make sense of phenomena across science domains is not explicitly pointed out to students.

- Lesson 5: Students are asked to "show their response with a thumb up, down, or sideways" to two questions: "Do you think that how similar organisms are (based on their body structures) will be connected to where they live? Do you think that how similar organisms are (based on their body structures) will be connected to when they live(d) in time?" (Teacher Edition, page 136). However, there may be a missed opportunity in this lesson to point out to students that the CCC **Patterns** is helpful or even necessary for bridging ideas from Earth Science and Life Science to figure out a piece of the phenomenon.
- Lesson 8: The materials suggest that the teacher can "further emphasize that one major goal of developing scientific models is to develop ones that are very generalizable and hold over long periods of time and for as large a class of phenomena as possible. [...] This is an important element of the modeling practice and one that students used to explain what is happening over really long periods of time in Earth's past in their prior work" (Teacher Guide, page 191). However, the usefulness of **Systems and System Models** to make sense of phenomena across two or more science domains is not explicit.

Suggestions for Improvement

Consider providing guidance for using grade-appropriate elements of CCCs to make connections across science domains. For example, students can be prompted to reflect on how their use of **Patterns** are a necessary lens or bridge for figuring out a piece of the phenomenon using ideas from both Earth and Life science.

I.F. MATH AND ELA

How Could Things Living Today Be Connected to the Things That Lived Long Ago?

EQuIP RUBRIC FOR SCIENCE EVALUATION

Provides grade-appropriate connection(s) to the Common Core State Standards in Mathematics and/or English Language Arts & Literacy in History/Social Studies, Science and Technical Subjects.	
Rating for Criterion I.F. Math and ELA	Extensive *(None, Inadequate, Adequate, Extensive)*

The reviewers found extensive evidence that the materials provide grade-appropriate connections to the Common Core State Standards (CCSS) in mathematics, English language arts (ELA), history, social studies, or technical standards because grade-appropriate connections to CCSS in mathematics and ELA are found throughout the unit.

Students have many opportunities to read, speak, and write throughout the materials, and the materials call out appropriate ELA connections that are made in Lessons 1–3, 5–8, 11, 12, and 14. For example:

- Lesson 5: "**CCSS.ELA-LITERACY.SL.8.1.D** *Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented*. On day 2 of this lesson, students have two opportunities to engage in respectful feedback conversations with their classmates: as groups who examined changes in body structures of the same organism (horseshoe crabs, horses, or whales) come together and share their ideas and models and when students form triads to share their thinking and models showing relationships among body structures, time in which organisms live(d), and environments in which organisms live(d) for all three organisms investigated" (Teacher Edition, page 143).
- Lesson 8: "**CCSS.ELA-LITERACY.SL.8.3** *Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidence and identifying when irrelevant evidence is introduced*. Students work in partnerships to create a general model that explains both of their cases, then share those model ideas with another partner to see if they can also explain a third case. Each time they discuss these model ideas, students make claims about cause-and-effect relationships between some parts of their system and cite broad patterns in the evidence from their cases to support those ideas. Each student provides and responds to feedback to and from their partner as to whether those mechanisms apply across both systems. A discussion self-assessment is provided in this lesson to invite students to individually reflect on how well they shared their own thinking but also how well they gave critiques to others about their arguments and evidence" (Teacher Edition, page 209).

The materials make grade-appropriate connections to mathematics standards in Lessons 4 and 7.

- Lesson 4: "This lesson will leverage student reasoning about samples and populations that rely on ideas that they will have developed in CCSS 7th grade math. In that grade they will have used random sampling to draw inferences about a population. As part of this work (CCSS.MATH.CONTENT.7.SP.A.1) they will have developed the understanding that statistics can be used to gain information about a population by examining a sample of the population and that generalizations about a population from a sample are valid only if the sample is representative of that population. Coordinate with your 7th grade math teacher to find out specific examples of simulations or data sets students worked with to generate statistics inferences based on random sampling they carried out on a larger population that you can reference in your discussions" (Teacher Edition, page 104).

- Lesson 7: "In working with all data sets, students will use the following ideas: CCSS.MATH.CONTENT.7.SP.B.3 [...], CCSS.MATH.CONTENT.6.SP.A.3 [...], CCSS.MATH.CONTENT.6.SP.B.4 [...]. Students working with Peppered Moth Data Packet or Cliff Swallow Data Packet will use the additional ideas listed below as they analyze various data subsets in their data packets. CCSS.MATH.CONTENT.8.SP.A.1 [...] CCSS.MATH.CONTENT.8.SP" (Teacher Edition, page 178).

Suggestions for Improvement

None

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

CATEGORY II

NGSS INSTRUCTIONAL SUPPORTS

How Could Things Living Today Be Connected to the Things That Lived Long Ago?

EQuIP RUBRIC FOR SCIENCE EVALUATION

II.A. RELEVANCE AND AUTHENTICITY

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

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

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

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

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

The reviewers found adequate evidence that the materials engage students in authentic and meaningful scenarios that reflect the real world. The phenomena presented are somewhat engaging to students and inspire curiosity, although the push to figure out the phenomena is often teacher directed. Students typically experience the phenomena as firsthand as possible. Additionally, students are provided with opportunities to make connections to their own experiences, however connections to their own community or culture are limited.

Students mostly experience the phenomena used as firsthand as possible. They have some opportunities to connect the phenomenon to their lives and prior experiences. Related evidence includes:

- Lesson 1: An alternate activity is provided for students who may not have familiarity with penguins. “If students’ comments during this sharing time indicate to you that they may not be familiar with what penguins of today look like or how they behave, you may want to take a few minutes here to show a live feed to a zoo of a penguin encampment. The Detroit zoo has a live camera feed for their penguins that can be accessed at https://detroitzoo.org/penguins-live-cam/” (Teacher Edition, page 31).
- Lesson 1: The following guidance is provided to increase student relevance regarding the ancient penguin fossil presented. “Consider posting a digital copy of the podcast and transcript on your classroom website or similar space for students who are interested in listening to it again outside of class and encourage them to share both the transcript and podcast with others in their family. Some students may find a variety of ways it is relevant to themselves and to others in their community, beyond the discovery of Pedro himself. Examples include the stories of what drew these people into their careers, international connections, a diverse group of scientists, and/or thinking about what the environment and things that lived in it were like in one’s own local area, many millions of years ago” (Teacher Edition, page 32). While this provides some opportunity for students to connect the phenomena to their own community or culture, it is the only significant opportunity provided in the unit.

- Lesson 1: Students listen to a podcast and look at a photo journal about the discovery of an ancient penguin. A transcript of the podcast is also provided. While listening to the podcast students record notes in their journal
- Lesson 1: Students are oriented to the height of the penguin using both a comparison to humans and a visual representation. "Share and note the height of the fossil penguin. Continue to share about the penguin fossil that was found by telling students that it was the size of a human! Using a meterstick against a wall, measure approximately 5 feet (about 1.5 meters) up from the ground. Notate this height on the wall using something like a 5-6 inch piece of painters' tape, or a sticky note, or masking tape at the 5-foot mark to show students how big the penguin was" (Teacher Edition, page 31).
- Lesson 1: Students brainstorm related phenomena. "Consider related phenomena.* Project slide W and say, So far, we have been talking about penguins from long ago and penguins alive today, but we know penguins aren't the only creatures that were found both long ago and today. Ask, What other organisms do you know of that lived in the past? How are they similar or connected to an organism alive today? Make a table like the one on the slide in your science notebook. Take a couple of minutes to record your ideas in your science notebook. Be ready to share" (Teacher Edition, page 51). These related phenomena are related back to Pedro: "Summarize by saying, There are many different organisms that seem like they might be connected--just like Pedro and modern penguins. Maybe investigating Pedro and modern penguins can help us figure out how living things today could be connected to things that lived long ago" (Teacher Edition, page 53).
- Lesson 7: Students are introduced to five different case studies. Students are introduced to the organisms in these case studies primarily through pictures and reading.
- Lesson 11: A new phenomenon is introduced for use on an assessment. "Introduce the assessment. Say, In this unit, we've developed a general model for natural selection that we have applied to several cases in different environments. Today we will explore a new phenomenon happening with a different type of organism. We can see if our general model holds up and we can still use it to explain what is happening, even though we have never investigated this ecosystem together before" (Teacher Edition, page 247). This leads to the introduction of the green lizard phenomenon. Students are provided with a description of the lizards as well as pictures of both the lizards and the plants in the area on the assessment.
- Lesson 13: "Direct students to the Related Phenomena poster. Display slide N. Say, We have figured out how natural selection, mutation, and migration can explain how we currently have 18 species of penguin today that are connected through lines of descent from ancient penguins, like Pedro or the Waipara. We can trace back these penguins to their ancestors but one of the questions on the DQB was could we trace back other organisms to their ancestors? Ask students, What other types of organisms you are wondering about that we might be able to trace back to their ancestors? What kind of evidence would you want to help you figure out how other organisms trace back to their ancestors? Listen for students to say things like insects, other birds, dinosaurs, other mammals (beyond horses and whales). Say, Wow, that sounds exciting! Let's come back next time and gather more information about these other cases of organisms we could try and trace back to their ancestors" (Teacher Edition, page 294)

The phenomena used are somewhat engaging to students, however the push to figure out the phenomena is often teacher directed. Related evidence includes:

- Lesson 1: Students engage in a discussion about how the penguins alive today might be connected to ancient penguins. The following teacher guidance is provided: "Purpose of this discussion: The purpose of this discussion is to get students' initial ideas and experiences on the table and to provide a supportive opportunity for students to make sense of what may not be fully formed ideas and to promote curiosity about possible connections living things have with one another" (Teacher Edition, page 33).
- Lesson 1: "Summarize the progress made and a plan for next steps. Conclude the lesson by working with students to decide next steps. Project slide CC and say, We figured out a lot in this lesson! We figured out that penguins living today and penguins that were alive long ago have many important similarities to one another, but also some key differences. We also figured out that we have a lot of questions about how the penguins from long ago could be connected to penguins alive today. We could really start investigations anywhere because all our questions are so connected! Let's pick back up next time with what we figured out so far, and we can decide then where to go next" (Teacher Edition, page 56).
- Lesson 4: "Use related phenomena to determine what we should investigate next. Say, OK, we said that we needed more data from the fossil record. Unfortunately, we know that scientists have not found very many ancient penguin fossils; we have already looked at all the penguin data we have until other scientists find more. However, we had some ideas in Lesson 1 about related phenomena to Pedro. Point students to the related phenomena chart from Lesson 1. Prompt students to turn and talk with a partner about these questions: How we could use our related phenomena to see if what we have figured out can apply to more than just penguins? OR How could we get more information about what was happening to penguins by looking at some other fossil records? Ask each pair to share one idea about how related phenomena could help us with either of these goals. Conclude the lesson by looking forward to the next lesson. Refer to the definition of fossil record added to the Word Wall. Say, OK, so we've explored some of the fossil record, but we've only been looking at the penguin-related part of it. It sounds like it would be really productive to check out some other species of living things found in the fossil record to see if we can find some patterns that are more complete than those we found for penguins. Let's pick up there next time" (Teacher Edition, page 122). While the related phenomena which were brainstormed in lesson 1 are used to motivate learning, the need to further investigate them is generated by the teacher.
- Lesson 11: "Consider how our General Model can be used to explain the patterns we have observed in penguins or other organisms. Present slide E and say, We have seen the power of our general model in explaining multiple phenomena that we have observed. Do you think that our general model can be equally powerful in explaining the patterns we have observed in penguins or other organisms? Tell students that in the next lesson, we are going to dive deeply into thinking about how the General Model can be used to explain these patterns in other organisms. For now, have students begin to think with a partner about how it can be applied" (Teacher Edition, page 249). While students are provided with a reason to use their general model on another organisms, the motivation is provided entirely by the teacher.

Suggestions for Improvement

- Consider providing teacher support for cultivating student questions which are explicitly connected to their experiences, community, or culture. Following home connection opportunities, consider including time for students to bring back their findings and discuss.

- Consider providing more guidance which would generate more student push to investigating the phenomenon rather than having it be teacher directed. For example, provide more opportunities, such as those provided in Lesson 1 in which student questions are directly used as motivation.

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 student ideas and reasoning are elicited throughout the unit.

Students are provided with opportunities to share ideas with each other, and some teacher support is provided for eliciting student ideas. For all discussions, the teacher is provided with suggested prompts and sample student responses. These prompts and sample responses provide guidance for teachers to draw out student ideas. For example:

- Lesson 1: The teacher leads a discussion in which students determine what kind of data they would need to determine whether the penguins of today are connected to Pedro. These ideas are recorded on an "Evidence We Need" poster.
- Lesson 2: Students brainstorm ideas for ways to investigate their questions. "Brainstorm ideas for data and information we need. Now that the class has created a DQB, tell students that it is time to really dig into the hard work of figuring out what is going on. Stay in the Scientists Circle to brainstorm ideas for data and information we need. Post the Ideas for Data and Information We Need poster. Present slide BB and ask students, What kinds of information or data do we need to figure out the answers to our questions?" (Teacher Edition, page 55).
- Lesson 4: "Use related phenomena to determine what we should investigate next. Say, OK, we said that we needed more data from the fossil record. Unfortunately, we know that scientists have not found very many ancient penguin fossils; we have already looked at all the penguin data we have until other scientists find more. However, we had some ideas in Lesson 1 about related phenomena to Pedro. Point students to the related phenomena chart from Lesson 1. Prompt students to turn and talk with a partner about these questions: How we could use our related phenomena to see if what we have figured out can apply to more than just penguins? OR How could we get more information about what was happening to penguins by looking at some other fossil records? Ask each pair to share one idea about how related phenomena could help us with either of these goals" (Teacher Edition, page 122).
- Lesson 5: "After students have added stickers to their notebook, say, Based on our work today, we have some ideas about connections between organisms based on their body structures.

Think about what other information you might want to examine to help us refine our thinking and understand what the patterns we noticed might mean. Record these ideas in your notebook and be ready to share your thinking with the class in a few minutes. Invite students to share some of the ideas they recorded in their science notebooks" (Teacher Edition, page 135). Students then engage in a discussion about what other things they should look at. The following teacher prompts are provided to guide to the next activity: "It sounds like we should look for other connections in geographic location and in time" (Teacher Edition, page 135).

- Lesson 10: Students engage in a turn and talk to explain their predictions for what will happen to the number of bacteria in each population over time. The following teacher guidance is provided: Attending to Equity in margins: "Universal Design for Learning: This is an important opportunity to emphasize that each individual has contributions to make to their community of learners. Throughout this unit, students will be asked to be open to sharing knowledge products that represent their current thinking and learning from their classmates, which can support their engagement if the classroom culture is one that values diverse thinking and ideas. It is through differences in thinking that the class will grow their knowledge together" (Teacher Edition, page 237).

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

- Lesson 1: The science notebook is introduced to students. "Remind students that the notebook is their tool for recording their observations, evidence, and ideas to share with the classroom community. They should see it as a space to brainstorm and record their thinking as well as a place to show how their thinking changes as they learn more" (Teacher Edition, page 32).
- Lesson 1: Students use a graphic organizer to develop initial explanations to the questions "Where did all the different types of ancient penguins go?" and "Where did all the types of modern penguins come from?"
- Lesson 2: The Progress Tracker is introduced as a way for students to track thinking over time. Samples of response in the Progress Tracker are provided. The following teacher guidance is provided: "The purpose of this Progress Tracker is to keep track of our ideas, data, and patterns over the course of the storyline that we can later use as evidence to support our claims. In the case of this lesson, another use for the tracker is to recall what happened in the previous lesson and navigate into the current lesson. The tracker also serves as a way to allow students to get comfortable and become confident recording the ideas they come up with as a class in their own words (rather than waiting to copy down the teacher's notes). For this reason Progress Trackers should not be 'graded' and should allow for a way for students to record their ideas. The example provided is just a sample entry of what we predict some students might say based on a class discussion."
- Lesson 4: Students construct an explanation around the following three questions using a provided handout: "Where did all the different species of ancient penguins go?", "Where did all the different species of modern penguins come from?", and "Why are there similarities and differences in the body structures of modern and ancient penguins?" (Three Explanations Handout, page 1). The handout asks students for an explanation (which can either be written or illustrated), evidence from the penguin groupings, and evidence we need. After completing this individually, students engage in a consensus discussion and are asked to update their ideas with new information gained from the discussion.

- Lesson 6: Students write an argument answering the question "How are organisms today connected to organisms of long ago?" (Teacher Edition, page 150). The assessment asks the following: "Based on the model you have developed so far, make a claim about how ancient and modern penguins are connected over time. Use words and/or drawings to construct an argument in support of your claim. Support your argument with evidence that we have from the unit so far and scientific reasoning." ("How are penguins today connected to penguins from long ago" Argument and Self-Assessment, page 1).

Students are provided with opportunities to receive feedback and adjust their thinking. Evidence includes:

- Lesson 1: Students construct an initial explanation to answer the questions "Where did the ancient penguins go? Where did all the different species of modern penguins come from?" (Teacher Edition, page 49). After constructing their explanations, students meet in small groups to compare their explanations. "Compare initial explanations. As students finish their initial explanations, project slide U and arrange students in small groups. Have students share their initial explanations in their small group, listening for similarities and differences between their explanations. Have each team member keep track of the similarities and differences between their explanations in their science notebook". This provides students with an informal opportunity to see how their responses compare with that of their peers, although no formal feedback is provided.
- Lesson 4: Students construct an explanation around the following three questions using a provided handout: "Where did all the different species of ancient penguins go?", "Where did all the different species of modern penguins come from?", and "Why are there similarities and differences in the body structures of modern and ancient penguins?" (Three Explanations Handout, page 1). The handout asks students for an explanation (which can be written or illustrated) evidence from the penguin groupings, and evidence we need. After completing this individually, students engage in a consensus discussion and are asked to update their ideas with new information gained from the discussion.
- Lesson 5: Students engage in a gallery walk to find similarities and differences in the ways other groups organized their cards compared to their approach. "Say, You're going to take a look at how other groups that worked with the same organism decided to organize their cards. As you look at their models, record how they did their organizing and how it is similar to or different from how your group organized the organism cards. Allow students to circulate around the room and take a quick look at the models of any other groups working with their same organism. Students should record in their science notebook the similarities and differences in other groups' organizations compared to their own. If students have a critique or question to leave for the models they visit, have them leave a sticky note citing the pertinent evidence from their own sort to support their critique/question. After 5 minutes, have students go back to their original groups and discuss what they recorded during the gallery walk and make any desired adjustments to their own model. Say, Consider the critiques others left on your model, and critique your own work now that you've seen how other groups organized the same data. As you adjust your group's model, support any changes you propose by citing relevant evidence you noticed from viewing other groups' models" (Teacher Edition, page 134).
- Lesson 5: Students gather into jigsaw groups to share their findings and give and receive feedback. The following teacher guidance is provided: "Organize students into mixed jigsaw groups of three students: one person representing each organism. Then, get everyone's

attention and remind students about norms for giving and receiving feedback. Ask students to share ideas for which classroom norms are especially important when both giving and receiving feedback. If necessary, display slide Q that lists classroom norms. Allow a few students to quickly share their thinking with the class and listen for ideas such as the following: We critique ideas, not people. We listen carefully and ask questions to help us understand. We value that people represent their ideas in different ways. We challenge ourselves to think in new ways. We are open to changing our minds. Say, The ideas we are talking about are very complex. These norms are all important ways to help us learn from each other. We're learning together about what is going on with many different kinds of organisms and how ancient and modern organisms may be connected to each other" (Teacher Edition, page 141).

- Lesson 6: Students write an argument answering the question "How are organisms today connected to organisms of long ago?" (Teacher Edition, page 150). The assessment asks the following: "Based on the model you have developed so far, make a claim about how ancient and modern penguins are connected over time. Use words and/or drawings to construct an argument in support of your claim. Support your argument with evidence that we have from the unit so far and scientific reasoning." ("How are penguins today connected to penguins from long ago" Argument and Self-Assessment, page 1). Students then share these ideas with a partner before discussing with the whole class in a scientists circle. "Turn and talk to share claims with a partner. Show slide E. Say, Soon we'll be sharing these claims in a whole-class discussion. First though, turn and talk to share your ideas with a partner. Make sure you each practice backing up your ideas with evidence in addition to sharing your claims" (Teacher Edition, page 150).

Suggestions for Improvement

None

II.C. BUILDING PROGRESSIONS	
Identifies and builds on students' prior learning in all three dimensions, including providing the following support to teachers: i. Explicitly identifying prior student learning expected for all three dimensions ii. Clearly explaining how the prior learning will be built upon.	
Rating for Criterion II.C. Building Progressions	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 although prior student learning is clearly identified in the unit, the information is not provided at the element level for SEPs or CCCs.

The materials explicitly state the expected level of prior proficiency students should have with individual elements of all three dimensions, as well as guidance for how and where specific elements will be used and developed. Related evidence includes:

- The Teacher Edition, provides a "What additional ideas will my students have or know from earlier grades or OpenSciEd units?" section. This section clearly outlines the knowledge students will be coming in with in relation to Disciplinary Core Idea elements and where these elements will be used and/or developed within the unit.
- Tables are provided which outline student prior knowledge and experience with specific SEP and CCC elements. The units also provide guidance around places where students will develop or use each element.

A progression of learning toward all three dimensions is outlined in the materials. However, it is not provided at the element level for SEPs or CCCS. Related evidence includes:

- The following guidance is provided for the progression of the CCC **Cause and Effect**, but it is not clear which claimed element of **Cause and Effect** it is related to: "Specifically, in Lesson 1, students develop an initial explanation, with multiple claims about what happened (causes) to the penguins from long ago and where modern penguins came from (cause). For each claim they articulate several possible mechanisms that could have contributed to these outcomes. In Lessons 7 and 8, students develop a causal model to explain multiple cases studies that involves multiple causes (trait variation in a population and environmental conditions/changes) that lead to a chain of cascading cause and effect relationships (on competitive (dis)advantage, on survival and reproduction, on the traits that appear in offspring, and on the shifts in the population). In lesson 9, students refine their definition of competitive advantage and competitive disadvantage as a probabilistic interaction. In Lesson 10, students run simulations multiple times to observe the likelihood of a certain outcome and thereby building their understanding that specific outcomes can only be predicted using probability. In Lesson 11, students use their understanding of the effects of changes in the environment on survival, reproduction, offspring and inheritance to explain the change in perch height of green anole lizards. In Lesson 12, students use the chain of cause and effect relationships in the natural selection model to predict the types of environmental interactions with traits that result in populations of organisms with very different traits over a long period of time. Finally in Lesson 15, students use the cause and effect relationships they've figured out over the course of the unit to answer their DQB and related phenomena questions" (Teacher Edition, page 17).
- The following guidance is provided for the progression of the SEP **Constructing Explanations and Designing Solutions,** but it is not clear which claimed element of **Constructing Explanations and Designing Solutions** it is related to**:** "Specifically, in Lesson 1, students develop an initial explanation to answer the questions, (1) Where did all the ancient penguins go? and (2) Where did all the different species of modern penguins come from? In this initial explanation, students make a claim, articulate a possible mechanism, and then identify types of evidence that they would need to either support or refute their claim. In Lesson 4, students revise their explanations in response to those initial two questions and construct an explanation for a third question: 'Why are there similarities and differences in the body structures of modern and ancient penguins?' To construct these explanations, students identify data that support their explanations and draw on two science ideas that have been developed in prior lessons a) modern penguins must have descended from ancient penguins and b) heritable traits are passed on from parents to offspring. In Lesson 6, students revisit these explanations and revise them to account for new data and science ideas from ancient and modern animals other than penguins.

In Lesson 7, students construct an explanation by developing an initial causal system model with their group, connecting changes in qualitative or quantitative relationships from various environmental conditions to changes in the number and distribution of individuals with different trait variations in a population. In Lesson 10, students use their general model for natural selection to construct an explanation that includes the relationships in the amount and distribution of resources in the environment and what trait variations are selected for in the population over time. In Lesson 11, students construct an explanation for changes in trait variation of a green lizard population after a change to their environment. In Lesson 12, students construct an explanation for how natural selection acting over generations has caused organisms' body structures to change over time in response to changes in environmental conditions. In Lesson 13, students use data about the similarities and differences in body structures between species to estimate the relative amount of time passed since species shared a common ancestor and construct a scientific explanation proposing how sudden changes in the environment for some populations, as well as adaptation by natural selection, can help explain the relationships between all modern penguins and ancient penguins" (Teacher Edition, page 17).

- Within the table which outlines prior experience with DCIs, specific lessons in which DCIs are developed are outlined. In addition, the "Where are we going/Not going" sections at the beginning of each lesson outline the progression of students developing DCI understandings.

Support is provided to teachers regarding possible alternate conceptions. Related evidence includes:

- "What are some common ideas students might have?" outlines some alternate conceptions students may have in relation to the DCIs being developed (Teacher Edition, page 22).
- Lesson 2: "Students will need to use the idea that the penguin structures included in the lesson are related to genes, but they may try to extend the idea that they developed in the Muscles Unit to conclude that variations between penguin species are caused by having different alleles. This has the potential to be confusing because terms used to describe and compare different individuals of the same species of penguin (e.g., traits, alleles, different versions of specific genes) are not used to describe and compare the differences between species of penguins. When comparing across species, we use the broader terms body structures and behaviors. Occasionally, we also broadly use the term characteristic. If students use the term trait instead of body structure, behavior, or characteristic, it is not important to redirect them at this point. If students are attempting to use alleles to explain differences between species of penguins, agree that there are small differences regarding the genes, and those differences cause the traits of individual penguins to be different, but reinforce the idea that we are comparing different species of penguins not different penguins of the same species. Also, you may remind students that many of the characteristics we are looking at depend on more than one gene, so it would be too complicated to try to keep track of all the alleles involved" (Teacher Edition, page 64).
- Lesson 7: "Students may also propose cause-and-effect relationships that are not supported by evidence. The color of the moths causes them to mate only with moths of the same color. This is a possible cause-and-effect relationship, but there is no evidence to support it. The plants bloomed earlier because the temperature was hotter earlier. There is no evidence that temperature affects when the mustard plants bloom. Check these statements by asking students what evidence supports their statement" (Teacher Edition, page 174).

Suggestions for Improvement
Consider providing additional information regarding prior learning for SEPs and CCCs at the element level.

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 all resources and learning throughout the unit are scientifically accurate, especially the use of authentic scientific data throughout the unit.

In addition to ensuring all scientific ideas within the materials are accurate, the materials utilize data and information from real scientific studies and research. Related evidence includes:

- Lesson 2: "The trait variation data used in this lesson were compiled and merged from two resources. The first was the supporting online material for Fossil Evidence for Evolution of the Shape and Color of Penguin Feathers, published 12 November 2010 in Science, DOI: 10.1126/science.1193604. The second was the appendix published along with Paleogene equatorial penguins challenge the proposed relationship between biogeography, diversity, and Cenozoic climate change" (Teacher Edition, page 59).
- Lesson 4: "Connect to the work of Julia Clarke and Ali Altamirano. Say, So for some of these species of penguins, there is more than one individual found, and even though the number of individual fossils might be low for some others, in every case where we have only one individual, scientists like Dr. Clarke and Señor Altamirano assume there are more at the site where they found the original fossil. Dr. Clarke and Señor Altamirano look forward to going back someday and hunting for more penguin fossils where they found Pedro. But that process takes a large amount of time and money and isn't likely to be very productive without a clear clue of where another penguin fossil might be, like the foot bone sticking out of the ground for the one that Señor Altamirano originally found" (Teacher Edition, page 115).

Suggestions for Improvement
None

II.E. DIFFERENTIATED INSTRUCTION

How Could Things Living Today Be Connected to the Things That Lived Long Ago?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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

The reviewers found extensive evidence that the materials provide guidance for teachers to support differentiated instruction because differentiation strategies are provided for a variety of students, including students who are struggling with the material, multilingual learners, and students who have high interest. However, extensions opportunities are not provided for students who have already met the performance expectations.

The materials provide strategies for meeting the needs of students who might struggle. For example

- Lesson 1: Attending to Equity in margins: "Universal Design for Learning: To support students in map reading during this activity section, hold up a larger globe if you have one, to orient students to the corresponding locations on their own globes. You may want to also talk about where the North and South Poles would be on the globe as well. Providing physical objects and spatial models to convey perspective can help support representation, according to the UDL framework" (Teacher Edition, page 35).
- Lesson 4: "If you think it would benefit your students to recall the representations in the Penguin Timeline, facilitate a conversation to contextualize the following in the timeline model: Point out that the dots to the immediate left of the far-right modern penguins represent at least two parents in the population before this generation -which we know must have been the case, because some parents reproduced sexually and successfully raised an offspring. Since the current population sizes for modern penguins are in the thousands, we can assume there were many parents in the previous generation. Dots therefore imply a population greater than one individual Arrows in the timeline model represent the descendants of that generation. The arrow represents all the mating events that produced offspring that became part of the next generation. The dot on the left side of an arrow therefore represents all of the individuals in that new generation along with any others that are still alive from the prior generation" (Teacher Edition, page 105).
- Lesson 5: Callout box: Attending to Equity: "Universal Design for Learning: Students may benefit from assistance with expression and communication by using sentence starters to help them express what they know and ask clarifying questions. Consider providing some sentence or question starters (either on chart paper posted visibly in the room or on sticky notes on student

desks), such as the following: This pattern in _____ seemed related to this body structure/body structure variation because _____. The evidence that supports our organization is _____. Why did you place this organism(s) in that way in your model? How do you think that pattern is related to the _____ body structure/body structure variation? How does the world that was around when the organisms lived possibly connect to the patterns we are seeing in organisms?" (Teacher Edition, page 140).

- Lesson 7: Attending Equity: "Universal Design for Learning: All these cases are complex. However, in order for students to figure out what causes the changes in the population, some of the cases require the use of more-advanced statistical understanding or rely on an ability to synthesize information from several different sources. Consider assigning students to different cases based on their fluency in mathematical and computational thinking. Finch Data Packet is the least complex, followed by Peppered Moth Data Packet and Cliff Swallow Data Packet. Mustard Plant Data Packet and Stickleback Data Packet are the most complex. This would help calibrate the challenge for different students, which is an important dimension of supporting optimal engagement in a task" (Teacher Edition, page 166).
- Lesson 7: Attending to Equity in margins: "Universal Design for Learning: At the end of 8th grade, students should be able to analyze and interpret complex graphs and other kinds of data, including scatter plots, box plots, and histograms. The data presented in this lesson rely on students' fluency with those representations. For students who might struggle with the data analysis, it may be helpful to assign them to analyze the same data subset as another member of their group. There are multiple opportunities to share their thinking about their data analysis within the group, and having multiple people working on the same data subset would create a natural support for students who might struggle with the data analysis. This would result in groups of more than 5 students per case. For some students, this may help provide support for decoding the data using by hearing alternate representations of what the data means from other students" (Teacher Edition, page 167).
- Lesson 7: Callout box, Supporting Students in Engaging in **Analyzing and Interpreting Data**: "At this point at the end of 8th grade, students should be familiar with and able to identify and interpret information presented in various kinds of graphs and tables that they will encounter in their data subsets. See 'Where we are going' for examples of where they have used scatter plots, lines of best fit, histograms, and box plots in their previous work in middle school. Understanding these graph types as well as the statistical concepts of mean, median, mode, proportion, range, distribution, and frequency falls within the common core standards for middle school starting in 6th grade. If students are unfamiliar with any of these data presentations or mathematical concepts, you may want to consider providing students with a review or summary of them before they engage in analyzing their assigned data subsets. Students also have had experience with using the I-squared data analysis routine, identify (what I see) and interpret (what it means), across multiple units in prior grades in data analysis work and should be able to use it independently" (Teacher Edition, pages 167–168).
- Lesson 8: Attending to Equity in margin: "Universal Design for Learning: Using sentence starters and graphical scaffolding are powerful ways to support action and expression for diverse learners" (Teacher Edition, page 194).
- Lesson 8: Attending to Equity: "Universal Design for Learning: Students vary in the amount of scaffolding they need for memory and transfer of information in order to improve their ability to access their prior learning. All learners can benefit from assistance in how to transfer the information they have to other situations. The use of these hand signals helps anchor instruction

by linking to and activating relevant prior knowledge in a memorable and transferable way. Furthermore, by using these hand signals as an additional representation of these ideas, we are providing visual, nonlinguistic supports for vocabulary clarification, which helps promote understanding across multiple languages" (Teacher Edition, page 197).

- Lesson 11: "If some of your students need additional scaffolding for their green lizard explanations, you may provide Model Scaffold for Green Lizard Explanation, which displays the general model scaffold used in previous lessons" (Teacher Edition, page 247).
- Lesson 13: "Two versions of this assessment are made available: Attending to Equity in margins: 'Universal Design for Learning: Students will use various forms of expression to transfer the ideas they developed while creating their models into a written explanation. Version 2: Ancient and Modern Penguin Explanation is provided for students you think would benefit from additional scaffolding. Also, if students are struggling to put their ideas in words encourage them to include a drawing or model sketch as part of their response to help clarify their writing'" (Teacher Edition, page 292).

Differentiation strategies are provided for multilingual learners. For example:

- Lesson 1: Attending to Equity: "Supporting Emergent Multilinguals: 'Modern penguins' and 'ancient penguins' are phrases we will use going forward to keep the distinction between penguins that are alive now vs. those that are found in the fossil record and were alive millions [sic]years ago. The Spanish word for modern is 'moderna/o', and the Spanish word for ancient is 'antiguo/a'. Additionally, the Spanish word for Penguin is pingüino. Using cognates is a helpful strategy to support emerging multilingual students" (Teacher Edition, page 45).
- Lesson 1: Attending to Equity in margins: "Supporting emerging multilingual students: Remember to use the words that students use whenever possible. Allow and encourage students to speak using both content specific and everyday words and phrases when expressing their ideas. This helps students fully express themselves, allowing others to question, evaluate, and build off their ideas. Switching back and forth between different registers is especially important for emerging multilingual students because it helps them draw on their full range of meaning-making resources" (Teacher Edition, page 50).
- Lesson 5: Attending to Equity in margins: "Emerging Multilingual Learners: Students will work with these groups for several activities in this lesson that involve thinking and rethinking. It may be helpful to intentionally put together emerging multilingual students with peers whose English language development is similar to theirs. As students sort cards to show relatedness, encourage them to express their reasoning using linguistic and nonlinguistic modes such as drawings, symbols, and gestures" (Teacher Edition, pages 132–133).
- Lesson 5: Attending to Equity in margins: "Universal Design for Learning: These small group discussions provide opportunities to support student engagement in meaningful, accountable talk by using a socially safe grouping structure. This is especially beneficial to emergent multilingual students. Allowing students to share their thinking with a small number of students before a whole group conversation increases confidence" (Teacher Edition, page 136).
- Lesson 11: Attending to Equity in margins "Supporting Emerging Multilingual Learners: To support Emerging Multilingual Learners and/or other students who need additional support with writing in science, consider providing sentence starters. If the whole class needs support, consider posting a list of sentence starters on chart paper for everyone to use. If only some students need support, write sentence starters on strips and put them in an envelope that you can provide to individuals or groups of students who would benefit from the additional support.

Example sentence starters [sic]My evidence for this is ...I know this because ... Changes in traits happen when ... The environment played a role because... The _____ was an advantage because..." (Teacher Edition, pages 247–248).

Differentiation strategies are provided for learners with disabilities. For example:

- Lesson 1: "As a reminder about supporting students with visual disabilities: This unit in general and this lesson specifically use images as data. So, you will need to make accommodations so that students with visual disabilities can access these data. Depending on your students' needs, suggested modifications include enlarging and/or brightening the provided digital versions of these photos or using alternate text descriptions. Your students' IEP or 504 case leaders should also be able to provide you with specific resources and possible modifications to use. If you have students who are color blind, the conversations in this lesson around color variations in a group of organisms may pose a unique challenge. If you haven't already done so, take some time to talk with your student(s), familiarizing yourself with their way(s) of seeing the world, and ask how you can best support them as they investigate differences among organisms, including but not limited to their color patterns" (Teacher Edition, page 29).
- Lesson 5: Attending to Equity in margins: "Universal Design for Learning: As a reminder, to support representation help students clarify the map symbols. On the maps, the blue color indicates water. The very light blue color indicates shallow seas or lakes. Deeper water is darker blue. Green or brown color indicates land. Green areas are covered with plants. Darker green indicates denser vegetation. Brown areas are drier with sparse vegetation. White areas indicate ice. During ice ages, the ice can cover large areas of land and water. Even in warmer climates, some areas, like Antarctica, may remain ice covered. While color coding is a useful way to quickly reference the parts of the map, letter or number coding helps ensure accessibility for any student who may be color blind. Consider adding additional coding to support these students" (Teacher Edition, page 137).

Differentiation strategies are provided for students who have high interest in the subject matter. However, there is no support provided for students have already met the performance expectations. For example:

- Lesson 3: Attending to Equity in margins: "Universal Design for Learning-Extension Opportunity: If students may ask whether the default data set they are working with on Data strips for ancient penguin fossils is a complete set of data from all the penguin fossils found so far, say, No, there are more, but they are relatively incomplete, often just one or a few bones, and therefore harder to interpret. You can then offer those students an opportunity to analyze these as well, if they are interested. This data set is on Extension: Data strips for more-incomplete ancient penguin fossils. But encourage those students to work with the data set on Data strips for ancient penguin fossils first and then, and after they find a set of patterns in these, add the more-incomplete data set from Extension: Data strips for more-incomplete ancient penguin fossils [sic]For some students, working with this additional data set may support the relevance of task by either (a) increasing the cognitive demand and increasing the challenge of the data analysis or (b) providing them a larger and therefore more-comprehensive sample of the types of fossil data that paleontologists use" (Teacher Edition, page 89).
- Lesson 9: "While no attempt is made to explore the underlying code of the simulation during the class period, some students may find it interesting to inspect and modify it on their own. It is recommended, however, that you not show students how to do this until after the next lesson. If students discover this feature themselves by clicking on the purple 'NetLogo Code' bar,

encourage them to reserve tinkering with the underlying modeling assumptions in the simulation (computer) code until after this lesson or the next lesson. Though it can be highly motivational for some students to recode the underlying assumptions, rules, and representations in a computer model, it can also be a distraction for those students to be doing this during class time focused on other learning goals. Students may be able to generate some really interesting additional scientific investigations by tinkering with the code. More information on how to change and recompile the code for this simulation can be found at https://ccl.northwestern.edu/netlogo/" (Teacher Edition, page 215).

- Lesson 9: "If students are interested in connecting their learning back to the penguins at this point, Part B of the home learning provides an opportunity for this connection. The whole class will have the opportunity in upcoming lessons to explain changes in the penguins, so this is an optional part of the home learning for students with a high level of interest" (Teacher Edition, page 230).
- Lesson 13: "Extension opportunity: If you have students who are curious about the environmental factors that influenced changes in the ancient penguins millions of years ago, Penguin Environments -Ancient and Modern is provided. You might also choose to assign this reading as a home learning opportunity, or ask students to use these details about the environment to further explain the changes we see among penguins using the General Model for Natural Selection" (Teacher Edition, page 292).

Differentiation opportunities are provided for students who read below grade level. For example:

- Lesson 12: "If you think any or all of your students would benefit from using a less-complex text, Reading v2: Horses -Ancient and Modern is provided as an alternative to the more-complex Reading v1: Horses -Ancient and Modern. Both texts contain the same information, but the alternate uses simplified sentence structure and vocabulary" (Teacher Edition, page 260).
- Lesson 12: "If you think any or all of your students would benefit from using a less-complex text, Reading v2: Horseshoe Crabs -Ancient and Modern is provided as an alternate to the more-complex Reading v1: Horseshoe Crabs -Ancient and Modern. Both texts contain the same information, but the alternate uses simplified sentence structure and vocabulary" (Teacher Edition, page 264).

Suggestions for Improvement

In addition to the extension opportunities for high interest students provided, consider providing additional extensions for students who have already met the performance expectations.

II.F. TEACHER SUPPORT FOR UNIT COHERENCE

How Could Things Living Today Be Connected to the Things That Lived Long Ago?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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

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

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

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

The reviewers found extensive evidence that the materials support teachers in facilitating coherent student learning experiences over time because strategies for linking student engagement across lessons are frequently provided and strategies are provided to ensure students see their learning across all three dimensions as linked to the phenomenon. Frequent guidance is provided for teachers to support linking student engagement across lessons by either providing explicit connections between lessons or by cultivating student questions.

Teacher support is provided for linking engagement across lessons and making connections across all three dimensions. Related evidence includes:

- Lesson 2: The Progress Tracker is introduced to track student progress toward explaining the phenomenon. Teacher prompts outline how this tool can be used to use the CCC of **Patterns** to build coherence across the unit. “Say, When we were creating our explanation at the end of the last lesson, we realized we would need to collect a lot more evidence. If we had a place to keep track of all the ideas and patterns that we might eventually use as evidence to support our claim, that would be really helpful. Let’s title the second column for that purpose. What did I see or uncover in the data?” (Teacher Edition, page 65).
- Lesson 2: Teacher guidance is provided to help connect the next data analyzed to questions raised by the students. “Share new questions with the whole class. Have students retrieve the sticky note on which they recorded their new question at the end of Day 1. Present slide R. Summarize by saying, Last time, we looked at external structure and behavior variations in modern penguins and Pedro. Allow students a minute or two to look back at their question. Then ask students to share their responses to the following questions that are listed on the slide: What new questions did this investigation raise for you? How might examining bone structures across different species of penguins help us make progress on some of these questions?” (Teacher Edition, pages 75–76).
- Lesson 3: Students share the questions they generated at the end of the previous lesson. These questions are then used to motivate the learning in this lesson. The following suggested prompt is provided: “How could analyzing these data from fossils of other ancient penguins help us make progress on some of our questions?” (Teacher Edition, page 88).
- Lesson 4: Guidance is given for facilitating a discussion to analyze the consensus conversations constructed. The following teacher guidance is provided: “Purpose: To identify the weaknesses in our current explanations in order to identify additional information or evidence that we need

to strengthen our explanations. ”Suggested questions and sample student responses are provided to guide this discussion.

- Lesson 4: “Use related phenomena to determine what we should investigate next. Say, OK, we said that we needed more data from the fossil record. Unfortunately, we know that scientists have not found very many ancient penguin fossils; we have already looked at all the penguin data we have until other scientists find more. However, we had some ideas in Lesson 1 about related phenomena to Pedro. Point students to the related phenomena chart from Lesson 1. Prompt students to turn and talk with a partner about these questions: How we could use our related phenomena to see if what we have figured out can apply to more than just penguins? OR How could we get more information about what was happening to penguins by looking at some other fossil records? Ask each pair to share one idea about how related phenomena could help us with either of these goals. Conclude the lesson by looking forward to the next lesson. Refer to the definition of fossil record added to the Word Wall. Say, OK, so we’ve explored some of the fossil record, but we’ve only been looking at the penguin-related part of it. It sounds like it would be really productive to check out some other species of living things found in the fossil record to see if we can find some patterns that are more complete than those we found for penguins. Let’s pick up there next time” (Teacher Edition, page 122).
- Lesson 5: “Summarize by saying, After our last lesson, we were thinking that populations of organisms could be connected by similarities in their body structures. We ended the class by reviewing our DQB and noticed that we had some questions whether the patterns we see in penguins hold for other organisms from our list of related phenomena. Let’s see if we can try to figure out if what happened with the penguins was unique or if we see similar patterns in other organisms, such as from our list of related phenomena” (Teacher Edition, page 131). Students then are then lead through a discussion about how looking at other organisms can help them see if what they saw with penguins was unique. “Say, Let’s do that by looking at some additional examples of both ancient and modern organisms just like we did with the penguins. We will not have time to look at all of the exact organisms we listed on our related phenomena, but we have substantial data sets for three organisms that might be similar to some we have on our list” (Teacher Edition, page 132).
- Lesson 6: “Look ahead to the next lesson by thinking about how to answer some of our new questions. Show slide L and say, OK, we’ve got a whole new set of questions to explore, motivated by trying to figure out what is causing these changes in a whole population. If we want to figure out how this happens over many generations, then we need some more data. Refer back to your class Ideas for Investigation and Data We Need poster. Your class may have already listed ideas about data from shorter time scales or more recent change in populations since that might be easier data to gather. If so, point back to that now. If not, say something like, We have worked with data from enormous timescales--ancient to modern--let’s try looking for similar changes happening over a smaller timescale (over fewer generations), since that might be easier to collect more data for. Continue, Turn to your partner to answer the following question: How could investigating whether such changes happen over a shorter timescale (fewer generations in any population) help us make progress on parts of our expanded DQB? After a moment of talk time, close today’s work by saying something like, Let’s start there next time” (Teacher Edition, page 157).
- Lesson 7: “Remotivate the need for analyzing cases we can inspect more closely. Display slide A. Say, At the end of our last class we had a lot of questions related to what could be causing changes in the traits in a whole population over many, many generations, and whether that really happened. We know we can’t go back and look at what happened in the past, but we

were thinking that if it happened in the past, it must be happening now, too. So we were wondering whether scientists have ever directly observed changes in a whole population happening currently. Let's think for a minute about this question: How could investigating whether such changes happen over a shorter time scale (fewer generations in any population) help us make progress on understanding what happened over a long period of time?" (Teacher Edition, page 165).

- Lesson 7: "Orient to crosscutting concepts. Display slide M. Say, Since we're learning about these cases so we can apply what we learn to other organisms, we will need to think about more general ways to understand each case. The models that you are developing represent complex natural systems of individual organisms and whole populations of organisms, their survival and reproduction, as well as their environment and what happens to them over time. In order to understand what changes occur in complex systems in more general ways as well as what caused those changes to occur, scientists often use the lens of different crosscutting concepts. Crosscutting concepts can help them think more clearly about what is happening in any complex system when they are trying to understand in a general way that could apply to other systems as well. Let's take stock of some of the different categories of crosscutting concepts we've used in the past" (Teacher Edition, page 171).
- Lesson 8: The lesson begins with a brief discussion about next steps. The following suggested teacher prompt is provided: "How could developing a general model for explaining all five of our cases help us answer some of the questions we had about ancient and modern penguins, horses, and so forth?" (Teacher Edition, page 185). After this discussion, the following guidance is provided: "Tell students this will be our mission then for the next two class periods. We will try to develop as general a model as possible for explaining the changes in traits in any population over time" (Teacher Edition, page 185).
- Lesson 8: "Propose a test of the model. Remind students that a scientific model is more powerful the more types of phenomena it can explain and that, so far, our model has been developed using only 5 cases for something that we've already seen occur in the past. Propose that in order to test the generalizability of the model it should also be able to predict outcomes in new cases as well" (Teacher Edition, page 208). In addition, the following teacher guidance is provided: "Supporting Students In Engaging In Developing And Using Models: Here is an opportunity to further emphasize that one major goal of developing scientific models is to develop ones that are very generalizable and hold over long periods of time and for as large a class of phenomena as possible. You could make an explicit connection here to eventually needing to see if the model can be used to explain the changes we observed in penguin populations happening over millions of years. Applying the model to that class of phenomena will require working with the assumption that theories and laws that describe the natural world" (Teacher Edition, page 208).

Suggestions for Improvement

None

II.G. SCAFFOLDED DIFFERENTIATION OVER TIME

How Could Things Living Today Be Connected to the Things That Lived Long Ago?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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. Although scaffolds and supports are provided for developing some targeted SEP elements, is not clear that supports over time are gradually adjusted so that students are increasingly responsible for their learning.

Teacher scaffolding is provided for some targeted SEP elements. However, it is not always clear that scaffolding is reduced over time, and consistent guidance is not provided for when to add and remove supports. For example:

- **Analyzing and Interpreting Data:** *Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.*
    - Lesson 14: Students look at drawings of various organisms to identify similarities and differences to begin exploring possible relationships between organisms. While this is an element of an identified focus SEP, this is the only instance in which the practice is used, and thus scaffolding is not reduced over time.
- **Analyzing and Interpreting Data**: *Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships*.
    - Lesson 1: Students watch videos and look at data cards of three modern species of penguins to determine how these penguins might be connected. Students are provided with a chart to record their observations about three modern penguin species. "Distribute a copy of Penguin Comparison to each student and have them tape it into their notebook. Tell students that the data table will help to organize our thinking about three kinds of penguins living today. Orient students to the features of the table, pointing out the row at the top for listing the penguin species and the columns of the table for adding details about specific physical traits and behaviors noticed for each penguin species" (Teacher Edition, page 35). When looking at the penguin data cards, the following guidance is provided: "Then project slide F, which shows the emperor penguin card, and provide each pair of students with a copy of the emperor penguin card from Data Cards for Modern Penguins and Pedro. Students may wish to share their ideas with their partner prior to adding to their data tables. Give students several minutes to examine the card information for the emperor penguin and add to their data tables" (Teacher Edition, page 36).
    - Lesson 1: Students look at additional penguin data cards. The following guidance is provided: "Say, First, let's explore what's on these cards a little more before we try to sort them. Instruct students to examine the cards, paying close attention to potential categories for groupings. Have students share several of their ideas for categories. List these ideas on the board. Groupings may include the following: size number of eggs location diving depth Instruct students to work in groups and come up with several different ways to sort the cards. Remind students that each group member should take

a turn deciding how to sort Data Cards for Modern Penguins and Pedro. You may choose to have the groups each work together to sort all their cards in three different ways. Or, if the number of cards is overwhelming to students, instruct groups to divide the cards equally among group members. Have each group agree on one way to sort the cards (one grouping). Then have each group member sort their subset of cards according to the grouping. The group can then combine their cards to look at all 18 penguins. As a group, they can then subdivide again to try to find a different way to group the penguins" (Teacher Edition, page 40).

  - Lesson 3: Students work in groups of three to organize penguin data cards by time period and look for any resulting patterns. The following teacher guidance is provided: "Supporting Students in Analyzing and Interpreting Data: In this process students are developing and using graphical displays of a large data set to identify temporal relationships. The size of this data set (32 data strips with 17 or 36 variables on each one) and the sub organization of groups within the data set make this a challenging data (re)organization and analysis task. It is well aligned to elements of the practice of analyzing and interpreting data in the middle school grade band. Students will need to work with these data again in Lesson Set 3 to make evidence arguments for lines of descent and common ancestors. This lesson provides an opportunity for students to develop fluency in working with these sorts of data in this way that they will need to leverage in those later lessons" (Teacher Edition, pages 90–91).
  - Lesson 5: Students are provided with cards for either horseshoe crabs, whales, or horses and are asked to sort by similarities or differences in small groups. Before sorting the cards, students are lead through a discussion about the purpose of the sort and how they should be arranged. Some sample prompts include: "We'll have groups working with horseshoe crabs, whales, and horses today. What is the question we're trying to answer as you analyze the data we have about these modern and ancient organisms?", "Like we did with the penguins, I have data cards for various types of these ancient and modern whales, horses, and horseshoe crabs. How will you use those cards to help you answer your question about how they're connected?"

- **Engaging in Argument from Evidence**: *Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.*
  - Lesson 5: Students engage in a gallery walk to find similarities and differences in the ways other groups organized their cards compared to their approach. "Say, You're going to take a look at how other groups that worked with the same organism decided to organize their cards. As you look at their models, record how they did their organizing and how it is similar to or different from how your group organized the organism cards. Allow students to circulate around the room and take a quick look at the models of any other groups working with their same organism. Students should record in their science notebook the similarities and differences in other groups' organizations compared to their own. If students have a critique or question to leave for the models they visit, have them leave a sticky note citing the pertinent evidence from their own sort to support their critique/question. After 5 minutes, have students go back to their original groups and discuss what they recorded during the gallery walk and make any desired adjustments to their own model. Say, Consider the critiques others left on your model, and critique your own work now that you've seen how other groups organized the same data. As you adjust your group's model, support any changes you propose by citing

relevant evidence you noticed from viewing other groups' models" (Teacher Edition, page 134).

- Lesson 5: Students gather into jigsaw groups to share their findings and give and receive feedback. The following teacher guidance is provided: "Organize students into mixed jigsaw groups of three students: one person representing each organism. Then, get everyone's attention and remind students about norms for giving and receiving feedback. Ask students to share ideas for which classroom norms are especially important when both giving and receiving feedback. If necessary, display slide Q that lists classroom norms. Allow a few students to quickly share their thinking with the class and listen for ideas such as the following: We critique ideas, not people. We listen carefully and ask questions to help us understand. We value that people represent their ideas in different ways. We challenge ourselves to think in new ways. We are open to changing our minds. Say, The ideas we are talking about are very complex. These norms are all important ways to help us learn from each other. We're learning together about what is going on with many different kinds of organisms and how ancient and modern organisms may be connected to each other" (Teacher Edition, page 141).
- Lesson 8: Students work with a partner to continue developing the generalized model. The following guidance is provided: "Remind students that when they are talking with their partners, they should be citing relevant evidence and posing and responding to questions when more detail is needed" (Teacher Edition, page 194). Specific guidance or prompts are not provided to students for engaging in this discussion.
- Lesson 11: "Students pair up and share with a partner their Green Anole Lizard Transfer Task. Show slide C. Distribute Peer Feedback Guidelines if desired. This can be taped into notebooks. Using Peer Feedback Guidelines, explain how students will give each other feedback in a conversation. Point out that students may want to take notes during this feedback partner talk. If students were already able to give feedback in Lesson 5, consider forgoing using Peer Feedback Guidelines in order to support their developing independence in giving feedback" (Teacher Edition, page 248).
- Lesson 14: Students engage in a class discussion to talk about the ideas which were generated when looking at the embryos. The following teacher guidance is provided: "Ask student volunteers to share initial ideas or questions. Emphasize the importance of restating what others have shared to check for understanding first before following-up with a related idea or question. It is suggested that at this point in the unit and year, you step more to the side and join the class as part of the circle, and encourage/support the students to discuss with and coordinate calling on each other. View this discussion similar to a forum where the space is open to hearing all ideas and working to link into each other's ideas, whether to agree, disagree or build onto the new ideas on the table. Encourage and support students in using the productive talk strategies they have been using all year as they listen to and respond to their peers' ideas (eg:[sic] I agree with _____'s idea because…; I disagree with _____'s ideas because…. , etc.)" (Teacher Edition, page 304).

- **Engaging in Argument from Evidence:** *Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.*
  - Lesson 6: Students write an argument answering the question "How are organisms today connected to organisms of long ago?" (Teacher Edition, page 150). The assessment asks the following: "Based on the model you have developed so far, make a

claim about how ancient and modern penguins are connected over time. Use words and/or drawings to construct an argument in support of your claim. Support your argument with evidence that we have from the unit so far and scientific reasoning" ("How are penguins today connected to penguins from long ago" Argument and Self-Assessment, page 1). Students then share these ideas with a partner before discussing with the whole class in a scientists circle. "Turn and talk to share claims with a partner. Show slide E. Say, Soon we'll be sharing these claims in a whole-class discussion. First though, turn and talk to share your ideas with a partner. Make sure you each practice backing up your ideas with evidence in addition to sharing your claims" (Teacher Edition, page 150). After these discussions, students engage in self assessment and revise their argument. "Individually revisit our arguments. Display slide H. Give students 2 minutes to complete Part 3 of 'How are penguins today connected to penguins from long ago?' Argument and Self-Assessment using a different color to revise or add to their argument with words or pictures based on the discussion you had with the class." (Teacher Edition, page 153). While this is identified as an element of a focus SEP, there is not evidence of scaffolding over time, as the first use of it is independently.

- Lesson 9: Students engage in a classroom discussion to talk about the results of their two experiments and how they support their model for natural selection. Teacher support is provided for facilitating this conversation. While teacher guidance is provided to facilitate this discussion, this seems to be a re-addition of a scaffold after students have completed the task individually in an earlier lesson.

- **Constructing Explanations and Designing Solutions**: *Construct an explanation using models or representations.*
  - Lesson 4: As a class, students create a consensus model for grouping penguins. The following teacher guidance is provided for creating the model: "Tell students that we will use the following pattern to reach consensus: One student proposes a potential penguin grouping and justifies the grouping decision with evidence. Other students agree, disagree, or propose a modification to the grouping (based on evidence). Repeat this process until all the penguins are grouped in a way that the class can agree on (for now)" (Teacher Edition, page 106).
  - Lesson 7: Students create an initial model in their group which explains what happened in the case their groups studied and why they think it happened that way using the note cards they created. The following additional teacher guidance is provided: "Supporting Students in Engaging in Constructing Explanation and Designing Solutions: 'At this point, students may perceive that they have several pieces of unconnected information and have not been shown the whole story. They are correct. In their data packets, they have in fact not been told the whole story but, rather, been provided with all the same information that scientists had with which to put an explanation together. They will need to make reasonable connections among the pieces of evidence they have in order to develop a model that could explain all the things that happened in their case. Making inferences involves choosing the most likely explanation from the evidence that is available. Students should be familiar with making inferences of this type as they construct explanations based on their prior work in other OpenSciEd units. Encourage them to consider multiple possibilities and make some educated guesses about what makes sense for the story of how and why things are changing in the system for their case. Remind them that this is a preliminary model and they'll have opportunities to reconsider and revise their model later'" (Teacher Edition, page 170).

- Lesson 7: "Revisit system models individually. Display slide Q. Distribute Develop a System Model to each student. Have them work individually to articulate their own understanding of the system model for the case they're investigating. Remind them that they are trying to tell the whole story of what's going on in their case and explain how and why the changes happened in their system model. If they finish the 'CCC: Systems and System Model' section, they should go on to the 'CCC: Scale, Proportion, and Quantity' section. Some students may not get to the second section. This is OK. For details of what students are likely to include in their answers on Develop a System Model, see the key in Key for Develop a System Model" (Teacher Edition, page 173). The key provides a sample student response.
- Lesson 7: "Have students create posters. Display slide U. The goal is to have them revise their Initial Case System Model and annotate it in a way that will be useful as they talk with classmates in the next lesson about what caused the changes in their case. Students can produce their poster in any way they would like within the time frame allowed, but they should reuse the five color index cards from their Initial Case System Model. They may choose to draw, write, use a box-and-arrows model like that depicted on the slide, present graphs, and so forth. Students should leave these posters in the classroom at the end of class. These will be referred to as their Revised Case System Models from this point forward" (Teacher Edition, page 175).
- Lesson 11: Students take the Green Anole Lizard Transfer Task as an assessment. "Administer assessment individually to students. Display slide B and hand out one copy of Green Anole Lizard Transfer Task to each student. Note to students that they have a choice in modality for sharing their answers, which include oral, written or pictorial or a combination of the two" (Teacher Edition, page 247). The following question is found on the assessment: "2. Construct an explanation: How does natural selection explain the changes in the green lizard population over time? Take out your general model for natural selection and any completed examples of organisms changing over time in your notebook. Use words or pictures (or a combination) for your explanation. Use the key parts of the general model to explain the cause and effect of the changes in the green lizard population over time. In your explanation make sure to include: The key parts of the model Cause and effect to describe how the population changed over time. The data about the green and brown lizard populations that support your explanation" (Green Anole Lizard Transfer Task, page 3).

- **Constructing Explanations and Designing Solutions**: *Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena*.
  - Lesson 4: Students complete an exit ticket independently at the end of the lesson to answer the following prompt: "Select another body structure or behavior that the Galápagos and king penguins share. Using information from the penguin cards, describe what you predict the variation in that body structure or behavior looks like between the Galápagos penguins and king penguins and within each population" (Lesson 4, Slide S).
  - Lesson 13: "Now you will get a chance to write your own explanation using the model you created with your small group [...] " In the student groups' responses, the teacher looks for ideas such as that "the relationship between differences in body structure and lengths of time to claim a penguin species was either a direct ancestor of a certain modern penguin or group of penguins, or that a species of ancient penguin went

extinct" (Teacher Edition, page 293). However, students do not perform this element independently by the end of the unit.

Some guidance is provided for how to support students with diverse needs and abilities in developing the SEPs. For example:

- Lesson 2: Students sort penguin data cards to identify similarities and differences in characteristics across different penguin species. The following teacher guidance is provided in the Supporting Students in Engaging in **Analyzing and Interpreting Data** section in the margins: "Students need to find patterns in this rather large set of data. While they have been working with progressively more complex sets of data throughout middle school, the volume of information here may still intimidate some students. If students are struggling to group the strips, make sure they are laying them all out to view simultaneously. There are many structures and behaviors that are shared, so encourage them to notice the differences first, and then they can look for the shared differences, i.e., things that are similar between them but different than the rest of the penguin groups. For example, it isn't necessarily productive to focus on the external body structures and behaviors that are shared by all the penguins (like scaly feathers), have them focus on differences and then find out who shares those same differences" (Teacher Edition, pages 70–71).
- Lesson 5: Supporting Students in **Engaging In Argument from Evidence** in margins: "As students discuss what they noticed and make adjustments to their organizational models, everyone should share ideas and ask questions of their group members to understand their thinking. Students should respectfully ask probing questions. Provide sentence starters to help students understand the thinking and ideas of their group members: Why do you think _____? Can you explain why you think these two organisms are more similar/less similar? Can you show us what evidence from the card supports your idea?" (Teacher Edition, page 134).
- Lesson 7: Supporting Students in Engaging in **Analyzing and Interpreting Data** in margin: "At this point at the end of 8th grade, students should be familiar with and able to identify and interpret information presented in various kinds of graphs and tables that they will encounter in their data subsets. See 'Where we are going' for examples of where they have used scatter plots, lines of best fit, histograms, and box plots in their previous work in middle school. Understanding these graph types as well as the statistical concepts of mean, median, mode, proportion, range, distribution, and frequency falls within the common core standards for middle school starting in 6th grade. If students are unfamiliar with any of these data presentations or mathematical concepts, you may want to consider providing students with a review or summary of them before they engage in analyzing their assigned data subsets. Students also have had experience with using the I-squared data analysis routine, identify (what I see) and interpret (what it means), across multiple units in prior grades in data analysis work and should be able to use it independently" (Teacher Edition, pages 167–168).

Suggestions for Improvement

Consider providing more explicit teacher guidance related to how specific SEP elements are developed and when scaffolds should be used and when they should be removed over time to develop all SEP elements.

How Could Things Living Today Be Connected to the Things That Lived Long Ago?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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

CATEGORY III

MONITORING NGSS STUDENT PROGRESS

How Could Things Living Today Be Connected to the Things That Lived Long Ago?

EQuIP RUBRIC FOR SCIENCE EVALUATION

III.A. MONITORING 3D STUDENT PERFORMANCES

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

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

The reviewers found extensive evidence that the materials elicit direct, observable evidence of students using practices with core ideas and crosscutting concepts to make sense of phenomena and/or design solutions. The materials routinely elicit evidence of students using grade-level appropriate elements of all three dimensions for the purpose of sense-making.

Materials routinely elicit direct, observable evidence that students are using all three dimensions in service of making sense of phenomenon. For example:

- Lesson 2: After sorting the initial penguin data cards based on heritable characteristics and behaviors and discussing skeletal features of penguins, students are provided with an opportunity to ask questions as an exit ticket. The following teacher guidance is provided: "Collect student sticky notes to formatively assess the questions students are raising at this point in the lesson. If you haven't already done so, also collect the paper in which students recorded the structure and behavior patterns earlier in the lesson. Be prepared to return the sticky notes to students for the beginning of day 2" (Teacher Edition, page 75). In this task, students integrate the following three dimensions:
    - SEP: **Asking Questions**
    - CCC: **Patterns**
    - DCI: **LS4.B**
- Lesson 2: Students are provided a handout at the end of the lesson which asks them to answer the question using the patterns from the data they have analyzed "Do you think Pedro could be an ancient ancestor of any of the modern penguins? Why or why not?" (New Questions & Ideas for Data We Need Handout, page 1). In this task, students integrate the following three dimensions:
    - SEP: **Analyzing and Interpreting Data**
    - CCC: **Patterns**
    - DCI: **LS4.B**
- Lesson 3: At the end of Day 2, students complete an exit ticket. "Use an exit ticket to reflect on patterns in the data. Present slide M. Have students individually complete Ancient Penguin Sorting Exit Ticket using what they just figured out from the Ancient Penguin Data Cards sort and what they wrote in their Progress Trackers during the gallery walk on Day 1. Collect student exit tickets to review before next class. Review students' Ancient Penguin Sorting Exit Ticket as a formative assessment. These will give you important information about the types of ideas you can draw on in the next lesson" (Teacher Edition, page 94). In this task, students integrate the following three dimensions:
    - SEP**: Analyzing and Interpreting Data**

  - CCC: **Patterns**
  - DCI: **LS4.B**
- Lesson 6: Students write an argument answering the question "How are organisms today connected to organisms of long ago?" (Teacher Edition, page 150). The assessment asks the following: "Based on the model you have developed so far, make a claim about how ancient and modern penguins are connected over time. Use words and/or drawings to construct an argument in support of your claim. Support your argument with evidence that we have from the unit so far and scientific reasoning." ("How are penguins today connected to penguins from long ago" Argument and Self-Assessment, page 1). In this task, students integrate the following three dimensions:
  - SEP: **Engaging in Argument from Evidence**
  - CCC: **Cause and Effect**
  - DCI: **LS4.B**
- Lesson 10: Students use the "My Model for Changes in Bacteria Populations" handout to explain how and why different environments caused the changes they observed. In this task, students integrate the following three dimensions:
  - SEP: **Constructing Explanations**
  - CCC: **Cause and Effect**
  - DCI: **LS4.B**
- Lesson 11: Students take the Green Anole Lizard Transfer Task as an assessment. The following question is found on the assessment: "2. Construct an explanation: How does natural selection explain the changes in the green lizard population over time? Take out your general model for natural selection and any completed examples of organisms changing over time in your notebook. Use words or pictures (or a combination) for your explanation. Use the key parts of the general model to explain the cause and effect of the changes in the green lizard population over time. In your explanation make sure to include: The key parts of the model Cause and effect to describe how the population changed over time The data about the green and brown lizard populations that support your explanation" (Green Anole Lizard Transfer Task, page 3). In this task, students integrate the following three dimensions:
  - SEP: **Constructing Explanations**
  - CCC: **Cause and Effect**
  - DCI: **LS4.B**
- Lesson 13: "Respond individually to prompts to make connections between modern and ancient penguins. Show slide J. Give each student a copy of Version 1: Ancient and Modern Penguin Explanation or Version 2: Ancient and Modern Penguin Explanation. Say, Now you will get a chance to write your own explanation using the model you created with your small group. Answer these prompts as completely as you are able using what you have figured out as you created your Penguin Ancestry Model. What does your model show in terms of answering these questions? Where did the penguins of today come from? Where did the penguins of long ago go? How are the things living today connected to the things that lived long ago?" (Teacher Edition, page 292). This assessment asks students to use patterns in the data in their explanation. In this task, students integrate the following three dimensions:
  - SEP: **Constructing Explanations**
  - CCC: **Patterns**
  - DCI: **LS4.A**

Suggestions for Improvement
None

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 formative assessments for all three dimensions are embedded frequently throughout the unit with teacher guidance provided for modifying instruction based on results. However, this guidance is typically only provided for a limited number of responses and teachers are not provided with guidance to follow-up or change instruction.

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

- Lesson 2: After sorting the initial penguin data cards based on heritable characteristics and behaviors and discussing skeletal features of penguins, students are provided with an opportunity to ask questions as an exit ticket. The following teacher guidance is provided: "Collect student sticky notes to formatively assess the questions students are raising at this point in the lesson. If you haven't already done so, also collect the paper in which students recorded the structure and behavior patterns earlier in the lesson. Be prepared to return the sticky notes to students for the beginning of day 2" (Teacher Edition, page 75).
- Lesson 2: At the end of the lesson, students generate questions and ideas for data needed to answer those questions. The following teacher guidance is provided: "Collect New Questions & Ideas for Data We Need to formatively assess the questions they are raising at this point in the lesson and what claims they made earlier in the second day of this lesson. When you return it to students, have them trim it and tape it into their notebooks so they still have a record of this thinking" (Teacher Edition, page 79).
- Lesson 3: At the end of Day 2, students complete an exit ticket. "Use an exit ticket to reflect on patterns in the data. Present slide M. Have students individually complete Ancient Penguin Sorting Exit Ticket using what they just figured out from the Ancient Penguin Data Cards sort and what they wrote in their Progress Trackers during the gallery walk on Day 1. Collect student exit tickets to review before next class. Review students' Ancient Penguin Sorting Exit Ticket as a formative assessment. These will give you important information about the types of ideas you can draw on in the next lesson" (Teacher Edition, page 94).

- Lesson 7: Students analyze data and make annotations for assigned portions of their packet. The following teacher guidance is provided: "Collect completed work. Collect the data packets of students who have completed their analysis. Students' writing and annotations can be used as a formative assessment. Those students who have not completed the analysis of their subset should take their data packet home and complete their analysis for home learning" (Teacher Edition, page 168). In addition, the following note is provided concerning students who are not yet finished: "If students finish their analysis as home learning, collect and assess their analyses after day 2" (Teacher Edition, page 168).
- Lesson 7: Students complete a Using the CCC Lens handout with a partner for **Structure and Function** and **Cause and Effect**. The following teacher guidance is provided: "Collect completed work. Collect any completed copies of Using the CCC Lens. Their writing on the handouts can be used as a formative assessment to assess their fluency in using different crosscutting concepts to explain different relationships and interactions in their case study" (Teacher Edition, page 172).
- Lesson 8: "Say, You've done some amazing work across the last lesson and today. I am excited for us to pool together for our next class all these generalized model ideas you have worked on today. Before we have you share those, I want you to reflect on the discourse you participated in today and the role you had in shaping each other's thinking. Provide students a copy of Argumentation Self-Assessment and ask students to complete this and turn in as they leave class" (Teacher Edition, page 195).
- Lesson 10: Students individually choose environmental conditions to test on their simulation and carry out an investigation to find out how the change in environmental conditions affects the distribution of traits in an environment. The following teacher guidance is provided: "Individually carry out the investigation and record data. Present slide H and instruct students to use their individual explorations of the simulation to guide their investigation and record data. All student responses should be recorded on Different environmental conditions and results which you can collect as a formative assessment at the end of class today. Students will need to use Different environmental conditions and results at the start of day 2, so have them ready to hand back if you have collected them" (Teacher Edition, page 238).

Formative assessment opportunities are aligned to three-dimensional learning outcomes derived from grade-appropriate elements from all three dimensions. In addition, sample student responses including ways to respond provided throughout the materials. However, the student responses provided are not varied and the responses are not based on multiple possible levels of response or proficiency. Also, while guidance is provided for adjusting instruction, the guidance is typically related primarily to students' completion of the assigned task rather than adjusting future instruction. 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". Some samples are below:
    - Lesson 2: "What to look for: Look for any line of new questions that emerge related to how similar internal structure will be in the ancient penguins (or in other organisms). This implies the need for comparing the same sort of data next time that they looked at today, but for ancient fossils. What to do: If you see no internal structure or bone-related questions, it is appropriate to leave a question on the sticky note, such as this: What sort of questions do you have that could help connect Pedro and modern

penguins? How might exploring data for those body structures help answer your questions?"

- Lesson 5 "What to look and listen for: By this final unit of 8th grade, students should be very familiar with classroom norms that guide respectful conversations. Closely listening and trying to make sense of their peers' ideas should be a well-established practice in small-group argument sharing. Though students are not yet building mechanistic explanations, they should be supporting their ideas and organizational models with patterns in the data sets that their peers shared. Students should also be posing and responding to questions to elicit additional details or to clarify the patterns in these models when there is something they don't understand. What to do: If you see or hear students struggling to maintain a respectful tone of voice or failing to support their critiques with ideas from the data cards, point them back to the classroom norms and other expectations you have set for productive discussions. As needed, provide sentence starters such as from the Communicating in Scientific Ways poster from Lesson 1. You might use sentence starters such as: I see, I notice, The reason I think my evidence supports my claim because, and the model shows that."
- Lesson 7: "Building towards: 7.A Analyze and interpret data representing mean, median, mode, or variability to examine patterns of changes over time that affect the predominance of certain traits in a population." (Teacher Edition, page 168). "What to look for: In the data subsets students analyzed that include interpretations using concepts of statistics and probability, look for evidence that they can identify their data in the 'Identify: What do I see in the data?' section of the table at the end of the subset and that they can interpret their data in the 'Interpret: What does this mean?' section of that same table. The type of data and the interpretation of them will vary across cases and across data subsets within cases. For some students who analyzed data subsets that did not include using concepts of statistics and probability, an assessment of their work with group members' data subsets on day 2 may be necessary. Look for answers that directly and accurately address the questions asked in each table. For more-specific details of what to look for in each section of a specific case, refer to the keys in Key for All Data Packets. What to do: If students are struggling to describe or interpret the data in their subset, encourage them to be guided by the specific questions in the table at the end of their data subset. Provide feedback pointing out if students have neglected to consider the specific questions in their answers. If so, ask them to revise their answers to more closely answer the specific questions in the table. If students finish their analysis as home learning, collect and assess their analyses after day 2."

While numerous opportunities for formative assessment are found throughout the materials, the assessment processes do not frequently call out aspects of student responses that might be tied to issues of equity and access.

- Lesson 1: Attending to Equity in margins: "Universal Design for Learning: Allow students to use multiple ways of expression in describing ancient penguins. If students prefer, they can use words instead of drawings to describe what they think their penguin looked like" (Teacher Edition, page 45). This provides an opportunity for students who are not yet comfortable with a written explanation to demonstrate their current thinking.
- Lesson 1: Attending to Equity in margins: "Universal Design for Learning: Allow students to use multiple ways of expression in describing ancient penguins. If students prefer, they can use

words instead of drawings to describe what they think their penguin looked like" (Teacher Edition, page 45).

- Lesson 1: Attending to Equity in margins: "Universal Design for Learning: Allow students to use multiple ways of expression in describing ancient penguins. If students prefer, they can use words instead of drawings to describe what they think their penguin looked like" (Teacher Edition, page 45).

Suggestions for Improvement

Consider providing a variety of strategies in the "What to Do" section of the assessment callout boxes to address a variety of response and proficiency levels.

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

The reviewers found adequate 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-for 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 most of the targeted standards is not provided and most assessments are limited to only a single sample student response.

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:

- Lesson 6: "Assessment Opportunity: Building towards: 6.B Ask questions related to what is causing changes in a whole population of organisms? What to look and listen for: Ideas that include wondering about variation in the population, where new traits come from, and in particular, mechanisms related to how things change. Such mechanisms may include the following ideas: ideas: environment changes or differences such as Climate availability or distribution of food, water, shelter type and number of predators availability of mates disease or absence of disease something that happens within the individual in response to the environment learning or experience in acquiring new traits changes in genes passed on (e.g., mutation) or inherited (recombination of genes through sexual reproduction) some thing that time causes (e.g., long periods of time always lead to some change, change is constant) something that is random" (Teacher Edition, page 156).

- Lesson 8: "Assessment Opportunity: Building towards 8.A.1: Respectfully provide and receive critiques about one's explanations and model ideas related to what in the system is remaining stable (e.g., traits within individuals and patterns of inheritance) and what is changing (e.g., distribution of traits) and what causal mechanisms (e.g., competitive advantages, selection events) are at work on different populations in different (eco)systems. What to look and listen for: Students proposing statements that could work across both cases, asking questions to clarify the meaning of those statements, and critiquing the statements in order to make them better fit the evidence from both cases. When students are doing this you are likely to hear them saying things like this: Does this work for your case too? How should we rephrase this so it takes into account X? I have an idea of how we modify that idea slightly so that it also captures what is happening in my case Though I can see how X is happening in your case, something different was happening in mine. This (X) seems really similar to something that was going on in my environment. In my case, Y was happening. So how can we best describe what it is that is similar in X and Y?" (Teacher Edition, page 195).
- Guidance for evidence to look for in student responses for individual elements of all three dimensions provided for the key assessments in the unit (Lessons 6, 11, and 13). For example:
    - Lesson 6 Answer Key: "7.1 Much of science deals with constructing explanations of how things change and how they remain stable. Evidence that demonstrates students are using these concepts in their written response includes: Making connections between the patterns of differences in the body structures of certain types of organisms over really long periods of time (multiple generations) and across different environments" (Teacher Edition, page 341).
    - Lesson 11 Answer Key: "Natural selection leads to the predominance of certain traits in a population, and the suppression of others. (MS-LS4-4) Students should use their understanding of natural selection to explain how a trait variation in a population changes over time as a result of an environmental change. To explain the is, students should bring the ideas that trait variations exist in a population before the change in the environment and individuals with trait variations that increase their probability of surviving and reproducing are likely to pass those variations on to the next generation. This can lead to certain traits increasing in prevalence in a population, and other less advantageous traits decreasing in the population" (Teacher Edition, page 399).
    - Lesson 13 Answer Key: "Construct an explanation that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena. Evidence that demonstrates students are using the is practice in their written response includes: Using natural selection in differing environments as well as the accumulation of mutations to explain the differences in body structures they observe Using the relationship between differences in body structure and lengths of time to justify which penguin species share recent ancestors the relationship between differences in body structure and lengths of time to claim a penguin species was either a direct ancestor of a certain modern penguin or group of penguins, or that a species of ancient penguin went extinct" (Teacher Edition, page 416). Answer keys are provided containing a sample student response for assessments in lessons 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, and 14, however only a single sample student response is provided.

Suggestions for Improvement
Consider providing multiple sample student responses representing a variety of possible student responses.

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 assessments are fair and unbiased, and scaffolds are provided to help students complete tasks successfully.

Vocabulary and text volume in student assessments are grade-level appropriate. Related evidence includes:

- A Word Wall is used throughout the unit to assist with scaffolding and development of vocabulary.
- Lesson 1: Attending to Equity in margins: "Supporting Emergent Multilinguals: 'Modern penguins' and 'ancient penguins' are phrases we will use going forward to keep the distinction between penguins that are alive now vs. those that are found in the fossil record and were alive millions [sic]years ago. The Spanish word for modern is 'moderna/o', and the Spanish word for ancient is 'antiguo/a'. Additionally, the Spanish word for Penguin is pingüino. Using cognates is a helpful strategy to support emerging multilingual students" (Teacher Edition, page 45).
- Lesson 12: Two different versions of the horse and horseshoe crabs texts are available for students. The two texts contain the same information, but the alternate is written with a simpler structure and vocabulary. Representations and scenarios are fair and unbiased and provide some scaffolds to help students complete the task successfully.

Students are provided with choice in the modality of how they complete many assessment tasks.

- Lesson 1: Attending to Equity in margins: "Supporting emerging multilingual students: Remember to use the words that students use whenever possible. Allow and encourage students to speak using both content specific and everyday words and phrases when expressing their ideas. This helps students fully express themselves, allowing others to question, evaluate, and build off their ideas. Switching back and forth between different registers is especially important for emerging multilingual students because it helps them draw on their full range of meaning-making resources" (Teacher Edition, page 50).

- Lesson 3: At the end of Day 2, students complete an exit ticket. "Use an exit ticket to reflect on patterns in the data. Present slide M. Have students individually complete Ancient Penguin Sorting Exit Ticket using what they just figured out from the Ancient Penguin Data Cards sort and what they wrote in their Progress Trackers during the gallery walk on Day 1. Collect student exit tickets to review before next class. Review students' Ancient Penguin Sorting Exit Ticket as a formative assessment. These will give you important information about the types of ideas you can draw on in the next lesson" (Teacher Edition, page 94).
- Students are provided with choice as to how to convey their answer to the provided question: "Use your Progress Tracker entry from earlier in this lesson and recall what you figured out from your work with Ancient Penguin Data Cards to answer the question: How do the body structures of other ancient penguins compare to modern penguins? Use words and/or pictures to support your thinking" (Ancient Penguin Sorting Exit Ticket, page 1).
- Lesson 4: "Reflect on trait variations in an exit ticket. Show slide S. Say, So height is an example for which there is a lot of variation across the different penguin populations. Of course [sic]you could probably think of other examples too where a lot of variation can be seen in a body structure or behavior, even when the general body structure or behavior is considered 'the same' for a population. Distribute Reference: Analyzing and Interpreting Fossil Data. Ask students to complete the exit ticket: Select another body structure or behavior that the Galápagos and king penguins share. Using information from the penguin cards, describe what you predict the variation in that body structure or behavior looks like between the Galápagos penguins and king penguins and within each population. Use words or pictures to share your thinking" (Teacher Edition, page 121).
- Lesson 7: "Have students create posters. Display slide U. The goal is to have them revise their Initial Case System Model and annotate it in a way that will be useful as they talk with classmates in the next lesson about what caused the changes in their case. Students can produce their poster in any way they would like within the time frame allowed, but they should reuse the five color index cards from their Initial Case System Model. They may choose to draw, write, use a box-and-arrows model like that depicted on the slide, present graphs, and so forth. Students should leave these posters in the classroom at the end of class. These will be referred to as their Revised Case System Models from this point forward" (Teacher Edition, page 175).
- Lesson 10: Students individually choose environmental conditions to test on their simulation and carry out an investigation to find out how the change in environmental conditions affects the distribution of traits in an environment. The following teacher guidance is provided: "Individually carry out the investigation and record data. Present slide H and instruct students to use their individual explorations of the simulation to guide their investigation and record data. All student responses should be recorded on Different environmental conditions and results which you can collect as a formative assessment at the end of class today. Students will need to use Different environmental conditions and results at the start of day 2, so have them ready to hand back if you have collected them" (Teacher Edition, page 238). A key with sample student responses is provided.
- Lesson 11: Students take the Green Anole Lizard Transfer Task as an assessment. "Administer assessment individually to students. Display slide B and hand out one copy of Green Anole Lizard Transfer Task to each student. Note to students that they have a choice in modality for sharing their answers, which include oral, written or pictorial or a combination of the two" (Teacher Edition, page 247).

- Lesson 13: "Respond individually to prompts to make connections between modern and ancient penguins. Show slide J. Give each student a copy of Version 1: Ancient and Modern Penguin Explanation or Version 2: Ancient and Modern Penguin Explanation."

Suggestions for Improvement
Consider providing choice in modality for major assessments throughout the unit, for example, by providing choices to provide drawing or verbal answers.

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.

The materials contain pre-assessments. For example:

- Lesson 1: Students use a graphic organizer to develop initial explanations to the questions "Where did all the different types of ancient penguins go?" and "Where did all the types of modern penguins come from?" The graphic organizer uses the following headings: Claim, Possible Mechanism, Evidence we need to support our claim, and Evidence we need to refute our claim. This serves as a pre-assessment. Due to the structure of the assessment, this can be utilized not only as a pre-assessment for DCI understanding, but also as a pre-assessment for the SEP of **Constructing Explanations and Designing Solutions**.

The materials contain formative assessments that measure three-dimensional learning. For example:

- Lesson 4: Students construct an explanation around the following three questions using a provided handout: "Where did all the different species of ancient penguins go?", "Where did all the different species of modern penguins come from?", and "Why are there similarities and differences in the body structures of modern and ancient penguins?" (Three Explanations Handout, page 1). The handout asks students for an explanation (which can be in pictures or words), evidence from the penguin groupings, and evidence we need. After completing this individually, students engage in a consensus discussion and are asked to update their ideas with new information gained from the discussion. This serves as a formative assessment of student progress.

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

- Lesson 11: Students take the Green Anole Lizard Transfer Task as an assessment. "Administer assessment individually to students. Display slide B and hand out one copy of Green Anole Lizard Transfer Task to each student. Note to students that they have a choice in modality for sharing their answers, which include oral, written or pictorial or a combination of the two" (Teacher Edition, page 247). The following question is found on the assessment: "2. Construct an explanation: How does natural selection explain the changes in the green lizard population over time? Take out your general model for natural selection and any completed examples of organisms changing over time in your notebook. Use words or pictures (or a combination) for your explanation. Use the key parts of the general model to explain the cause and effect of the changes in the green lizard population over time. In your explanation make sure to include: The key parts of the model Cause and effect to describe how the population changed over time The data about the green and brown lizard populations that support your explanation" (Green Anole Lizard Transfer Task, page 3).
- Lesson 13: "Respond individually to prompts to make connections between modern and ancient penguins. Show slide J. Give each student a copy of Version 1: Ancient and Modern Penguin Explanation or Version 2: Ancient and Modern Penguin Explanation. Say, Now you will get a chance to write your own explanation using the model you created with your small group. Answer these prompts as completely as you are able using what you have figured out as you created your Penguin Ancestry Model. What does your model show in terms of answering these questions? Where did the penguins of today come from? Where did the penguins of long ago go? How are the things living today connected to the things that lived long ago?" (Teacher Edition, page 292). The "Attending to Equity" section in the margins states: "Universal Design for Learning: Students will use various forms of expression to transfer the ideas they developed while creating their models into a written explanation. Version 2: Ancient and Modern Penguin Explanation is provided for students you think would benefit from additional scaffolding. Also, if students are struggling to put their ideas in words encourage them to include a drawing or model sketch as part of their response to help clarify their writing" (Teacher Edition, page 292).

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

- Lesson 6: Students complete a self-assessment on argumentation.
- Lesson 11: Students complete a Peer Feedback Self-Assessment.

The assessment purpose and rationale are coherent across the materials and is explicitly described for all three dimensions.

- The Assessment system overview document provides information regarding each assessment in the materials, as well as which CCC and SEPs they are aligned to. However, specific elements of SEPs and CCCs are not specified on this document. For example:
    - Lesson 2: "2.A Analyze and Interpret Data; Patterns When to check for understanding 1. On day 1, when students record their groupings of penguins based on similarities in the data. 2. On day 2, when students make a claim about whether Pedro is related to modern penguins. What to look for 1. Some types of structures and behaviors are shared across all the penguins and/or certain species of penguins share many more structures and behaviors in common than others. 2. Any claim is acceptable (e.g., Pedro is an ancestor, is not an ancestor, is related in some other way to modern penguins or

other ancient penguins, and so forth). Justification should include citing patterns in the heritable structure and behavior data. See examples in the related assessment callout box" (Assessment System Overview, page 5).

Suggestions for Improvement
None

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 core ideas and crosscutting concepts because students are provided with many opportunities to demonstrate claimed learning in all three dimensions in the unit for some of the claimed learning.

For some of the claimed learning in the unit, there are multiple opportunities for students to demonstrate their growth in proficiency over time. For example:

- For key claimed learning in the DCI of **LS4.B Natural Selection**, SEP of **Constructing Explanations**, and CCC of **Patterns** and **Cause and Effect**:
    - Lesson 1: Students construct an initial explanation to answer the questions "Where did the ancient penguins go? Where did all the different species of modern penguins come from?" (Teacher Edition, page 49). After constructing their explanations, students meet in small groups to compare their explanations. "Compare initial explanations. As students finish their initial explanations, project slide U and arrange students in small groups. Have students share their initial explanations in their small group, listening for similarities and differences between their explanations. Have each team member keep track of the similarities and differences between their explanations in their science notebook." This provides students with an informal opportunity to see how their responses compare with that of their peers.
    - Lesson 4: Students construct an explanation around the following three questions using a provided handout: "Where did all the different species of ancient penguins go?", "Where did all the different species of modern penguins come from?", and "Why are there similarities and differences in the body structures of modern and ancient penguins?" (Three Explanations Handout, page 1). The handout asks students for an explanation (which can be in pictures or words), evidence from the penguin groupings, and evidence we need. After completing this individually, students engage in a

consensus discussion and are asked to update their ideas with new information gained from the discussion.

- Lesson 6: Students write an argument answering the question "How are organisms today connected to organisms of long ago?" (Teacher Edition, page 150). The assessment asks the following: "Based on the model you have developed so far, make a claim about how ancient and modern penguins are connected over time. Use words and/or drawings to construct an argument in support of your claim. Support your argument with evidence that we have from the unit so far and scientific reasoning." ("How are penguins today connected to penguins from long ago" Argument and Self-Assessment, page 1). Students then share these ideas with a partner before discussing with the whole class in a scientists circle. "Turn and talk to share claims with a partner. Show slide E. Say, Soon we'll be sharing these claims in a whole-class discussion. First though, turn and talk to share your ideas with a partner. Make sure you each practice backing up your ideas with evidence in addition to sharing your claims" (Teacher Edition, page 150).
- Lesson 11: Students take the Green Anole Lizard Transfer Task as an assessment. "Administer assessment individually to students. Display slide B and hand out one copy of Green Anole Lizard Transfer Task to each student. Note to students that they have a choice in modality for sharing their answers, which include oral, written or pictorial or a combination of the two" (Teacher Edition, page 247). The following question is found on the assessment: "How does natural selection explain the changes in the green lizard population over time? Take out your general model for natural selection and any completed examples of organisms changing over time in your notebook. Use words or pictures (or a combination) for your explanation. Use the key parts of the general model to explain the cause and effect of the changes in the green lizard population over time. In your explanation make sure to include: The key parts of the model Cause and effect to describe how the population changed over time [sic]The data about the green and brown lizard populations that support your explanation" (Green Anole Lizard Transfer Task, page 3).

Students receive feedback which they can apply to claimed learning:

- Lesson 1: Students construct an initial explanation to answer the questions "Where did the ancient penguins go?" and "Where did all the different species of modern penguins come from?" (Teacher Edition, page 49). After constructing their explanations, students meet in small groups to compare their explanations. "Compare initial explanations. As students finish their initial explanations, project slide U and arrange students in small groups. Have students share their initial explanations in their small group, listening for similarities and differences between their explanations. Have each team member keep track of the similarities and differences between their explanations in their science notebook." This provides students with an informal opportunity to see how their responses compare with that of their peers, although no formal feedback is provided.
- Lesson 2: After sorting the initial penguin data cards based on heritable characteristics and behaviors and discussing skeletal features of penguins, students are provided with an opportunity to ask questions as an exit ticket. The following teacher guidance is provided: "Collect student sticky notes to formatively assess the questions students are raising at this point in the lesson. If you haven't already done so, also collect the paper in which students

recorded the structure and behavior patterns earlier in the lesson. Be prepared to return the sticky notes to students for the beginning of day 2" (Teacher Edition, page 75).

- Lesson 5: Students engage in a gallery walk to find similarities and differences in the ways other groups organize their cards compared to their approach. "Say, You're going to take a look at how other groups that worked with the same organism decided to organize their cards. As you look at their models, record how they did their organizing and how it is similar to or different from how your group organized the organism cards. Allow students to circulate around the room and take a quick look at the models of any other groups working with their same organism. Students should record in their science notebook the similarities and differences in other groups' organizations compared to their own. If students have a critique or question to leave for the models they visit, have them leave a sticky note citing the pertinent evidence from their own sort to support their critique/question. After 5minutes, have students go back to their original groups and discuss what they recorded during the gallery walk and make any desired adjustments to their own model. Say, Consider the critiques others left on your model, and critique your own work now that you've seen how other groups organized the same data. As you adjust your group's model, support any changes you propose by citing relevant evidence you noticed from viewing other groups' models" (Teacher Edition, page 134).
- Lesson 5: Students gather into jigsaw groups to share their findings and give and receive feedback. The following teacher guidance is provided: "Organize students into mixed jigsaw groups of three students: one person representing each organism. Then, get everyone's attention and remind students about norms for giving and receiving feedback. Ask students to share ideas for which classroom norms are especially important when both giving and receiving feedback. If necessary, display slide Q that lists classroom norms. Allow a few students to quickly share their thinking with the class and listen for ideas such as the following: We critique ideas, not people. We listen carefully and ask questions to help us understand. We value that people represent their ideas in different ways. We challenge ourselves to think in new ways. We are open to changing our minds. Say, The ideas we are talking about are very complex. These norms are all important ways to help us learn from each other. We're learning together about what is going on with many different kinds of organisms and how ancient and modern organisms may be connected to each other" (Teacher Edition, page 141).
- Lesson 6: Students write an argument answering the question "How are organisms today connected to organisms of long ago?" (Teacher Edition, page 150). The assessment asks the following: "Based on the model you have developed so far, make a claim about how ancient and modern penguins are connected over time. Use words and/or drawings to construct an argument in support of your claim. Support your argument with evidence that we have from the unit so far and scientific reasoning." ("How are penguins today connected to penguins from long ago" Argument and Self-Assessment, page 1). Students then share these ideas with a partner before discussing with the whole class in a scientists circle. "Turn and talk to share claims with a partner. Show slide E. Say, Soon we'll be sharing these claims in a whole-class discussion. First though, turn and talk to share your ideas with a partner. Make sure you each practice backing up your ideas with evidence in addition to sharing your claims" (Teacher Edition, page 150).
- Lesson 7: Students analyze data and make annotations for assigned portions of their packet. The following teacher guidance is provided: "Collect completed work. Collect the data packets of students who have completed their analysis. Students' writing and annotations can be used as a formative assessment. Those students who have not completed the analysis of their subset should take their data packet home and complete their analysis for home learning" (Teacher Edition, page 168). In addition, the following note is provided concerning students who are not

yet finished: "If students finish their analysis as home learning, collect and assess their analyses after day 2" (Teacher Edition, page 168).

- Lesson 7: Students share the results of their data analysis with their groups. The following guidance is provided: "Have students share the results of their analysis within their groups. Display slide. Return to students any data packets that you collected at the end of the last class. Review the instructions on the slide with students. The student who analyzed data subset 1 should begin by describing the data that are in their subset, what the data show, and what they think they mean. The student who annotated that subset can then share their noticings and wonderings and agree or disagree with or add to the analysis. Other group members can ask any clarifying questions and raise any new ideas. Everyone who did not analyze that data subset should then fill in a brief summary of what the data show and what they mean in the chart at the end of that data subset. Continue until all students in the group have had a chance to share and discuss their analysis" (Teacher Edition, page 169). Students then use notecards to provide a summary of what their data means. The following guidance is provided: "The index card should summarize what their data subset means. They can simply copy onto the card their summary from the 'What does this mean?' section for the data subset that they analyzed. Or they may want to add to or revise their summary based on the conversations they had with group members regarding what their data subset means in the context of the emerging story of what happened with their organism" (Teacher Edition, page 170).
- Lesson 13: After participating in a gallery walk of the different models which are developed and having an opportunity to share ideas, ask questions, and engage in a class discussion, students are provided with an opportunity to revise their written explanations.

Suggestions for Improvement

Consider providing increased opportunities for students to receive and respond to direct teacher feedback.

How Could Things Living Today Be Connected to the Things That Lived Long Ago?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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

SCORING GUIDES

SCORING GUIDES FOR EACH CATEGORY

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

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

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

OVERALL SCORING GUIDE

Scoring Guides for Each Category

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

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

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

How Could Things Living Today Be Connected to the Things That Lived Long Ago?

EQuIP RUBRIC FOR SCIENCE EVALUATION

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