

LESSON 1: How could penguins and other things living today be connected to the things that lived long ago?

PREVIOUS LESSON *There is no previous lesson.*

THIS LESSON

ANCHORING PHENOMENON

4 days



We record what we notice and wonder about penguins living today and of a fossil of a giant penguin from long ago. We develop initial explanations of how these penguins could be connected. We brainstorm possible mechanisms to help explain two things: (1) Where did all the ancient penguins go? and (2) Where did all the different types of modern penguins come from? We develop a Driving Question Board to guide future investigations.

NEXT LESSON *We will analyze data on a set of heritable characters in modern penguins to look for patterns and infer connections between them and Pedro. We will develop questions on how other heritable characters (bone related) would compare for these penguins and for other ancient penguin fossils.*

BUILDING TOWARD NGSS

MS-LS1-4, MS-LS4-1, MS-LS4-2,
MS-LS4-3, MS-LS4-4, MS-LS4-6



WHAT STUDENTS WILL DO

- 1.A **Analyze and interpret data**, to find **patterns** in penguins **that are alive today** using data cards containing photos, maps, charts, measurements, and descriptive text.
- 1.B **Develop an initial explanation and identify evidence needed to determine** what **caused the observed changes** in **the existence, diversity, and disappearance** of different kinds of penguins throughout history.
- 1.C **Ask questions that arise from initial observations of patterns** in the **images depicting anatomical similarities and differences** of penguins **that are alive today and of a fossil** of a penguin **from long ago**.

WHAT STUDENTS WILL FIGURE OUT

- There are 18 different types of penguins alive today. All have similar traits as well as some noticeable differences.
- Scientists found a giant penguin fossil that lived 36 million years old in Peru. It is bigger and it had a much longer beak than any penguins alive today.
- We have different ideas about where the penguins (and other organisms) of today come from: maybe none, some, or all of the penguins (and other organisms) of today are descendants of Pedro (or other organisms from long ago).

Lesson 1 • Learning Plan Snapshot

Part	Duration	Summary	Slide	Materials
1	5 min	OBSERVE LIVE PENGUINS Observe penguins by watching a live penguin cam. Have students share what they notice and wonder with a partner.	A	https://detroitzoo.org/penguins-live-cam/ , www.teachersopenciedfieldtest.org/penguins , computer, projector
2	12 min	MEET PEDRO, A HUMAN-SIZED PENGUIN Listen to a story and examine a photo journal about a joint team of researchers from Peru and the United States, led by Dr. Julia Clarke, who recently found a fossil of a human-sized penguin in the deserts of Peru.	B	<i>Podcast Transcript and Photo Journal</i> , www.teachersopenciedfieldtest.org/penguins , 5-6 inches of painter's tape, 1 meter stick, computer and speakers.
3	8 min	BRAINSTORM TYPES OF EVIDENCE NEEDED Brainstorm how things alive today could be connected to one another and the kinds of evidence needed to determine whether Pedro is connected to the penguins alive on Earth today.	C	Types of Connections poster, Evidence We Need poster, markers
4	15 min	MEET THREE TYPES OF PENGUINS ALIVE TODAY Observe and compare the physical traits and behaviors of three types of penguins living today.	D-J	<i>Penguin Comparison</i> , only the emperor/Adélie/southern rockhopper cards from Data Cards for Modern Penguins and Pedro, 1 Earth squish ball with countries labeled, 1 Earth squish ball with no labels, 2 paper coffee sleeves, https://www.youtube.com/watch?v=qWTwan_G6YE , https://www.youtube.com/watch?v=FwPdmK2EYEK , https://www.youtube.com/watch?v=YKqXGNNPNaQ
5	5 min	CONSIDER CONNECTIONS BETWEEN PENGUINS Discuss in small groups how the three types of penguins we observed compare to one another and to Pedro.	K	Types of Connections poster
<i>End of day 1</i>				
6	5 min	PREDICT PATTERNS IN PENGUINS Review the need for evidence to support or refute claims. Make predictions about the kinds of patterns we might see comparing similarities and differences between penguins.	L	sticky notes (optional)
7	20 min	LOOK FOR PATTERNS AMONG PENGUINS Look for patterns in the data by grouping penguin information cards in various ways. Share and discuss observations and new questions that surface.	M-N	Data Cards for Modern Penguins and Pedro, 1 Earth squish ball with countries labeled, 1 Earth squish ball with no labels, 2 paper coffee sleeves
8	3 min	PREDICT WHERE OTHER PENGUIN FOSSILS COULD BE FOUND Prompt students to make suggestions for places to look for additional penguin fossils and brainstorm what these additional fossils might look like.	O	

Part	Duration	Summary	Slide	Materials
9	7 min	PREDICTING PENGUINS FROM LONG AGO Make predictions about the characteristics other penguins living long ago would have had when they were alive.	P	<i>Predictions On Other Penguins That Lived Long Ago</i> , colored pencils, chart paper, markers, transparent tape
10	9 min	COMPARE PENGUINS AND DEVELOP A TIMELINE MODEL TO REPRESENT OUR THINKING Compare penguin characteristics that are similar and different in individual representations. Develop a timeline model of what we have figured out.	Q-R	<i>Predictions On Other Penguins That Lived Long Ago</i> , colored pencils, chart paper, markers, transparent tape
<i>End of day 2</i>				
11	5 min	NAVIGATION Brainstorm additional questions about what happened to ancient penguins and where modern penguins came from.	S	
12	16 min	WRITE AND COMPARE INITIAL EXPLANATIONS Develop an initial explanation framed around two subquestions, “(1) Where did all the ancient penguins go? and (2) Where did all the different types of modern penguins come from?” Compare initial explanations looking for similarities and differences.	T-U	<i>Initial Explanation</i>
13	13 min	INITIAL CLASS CONSENSUS DISCUSSION Develop a whole-group record of what we agree on and where we have competing ideas around the 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?	V	chart paper, markers
14	7 min	BRAINSTORM AND SHARE RELATED PHENOMENA Brainstorm and share ideas of other types of organisms that lived in the past and similar types of organism(s)”	W	Related Phenomena poster, markers
15	4 min	NAVIGATION Take stock of where we are in our thinking and begin thinking about whether the reasons for the differences in past and present organisms are the same as for the differences in the past and present penguins.	X	
<i>End of day 3</i>				
16	8 min	DEVELOP INITIAL QUESTIONS Make a list in notebooks of any questions related to what has been observed so far. Have students look back at earlier resources.	Y	<i>Predictions On Other Penguins That Lived Long Ago</i> , <i>Initial Explanation</i> , <i>Podcast Transcript</i> and <i>Photo Journal</i> , Data Cards for Modern Penguins and Pedro
17	4 min	REVISE QUESTIONS Refine questions in preparation for the Driving Question Board.	Z	sticky notes, markers, chart paper

Part	Duration	Summary	Slide	Materials
18	20 min	BUILD THE DRIVING QUESTION BOARD Develop a Driving Question Board to create a shared space for student questions.	AA	sticky notes, markers, chart paper
19	10 min	BRAINSTORM IDEAS FOR INVESTIGATIONS Use the categories of questions and have students identify the data and information that would help them answer each category of questions.	BB	Driving Question Board, Ideas for Data and Information We Need poster, markers
20	3 min	NAVIGATION Conclude the lesson by summarizing the progress made and a plan for next steps.	CC	

End of day 4

Lesson 1 • Materials List

	per student	per group	per class
Lesson materials	<ul style="list-style-type: none"> • science notebook • <i>Podcast Transcript and Photo Journal</i> • <i>Penguin Comparison</i> • <i>Predictions On Other Penguins That Lived Long Ago</i> • colored pencils • <i>Initial Explanation</i> • sticky notes • markers 	<ul style="list-style-type: none"> • only the emperor/Adélie/southern rockhopper cards from Data Cards for Modern Penguins and Pedro • 1 Earth squish ball with countries labeled • 1 Earth squish ball with no labels • 2 paper coffee sleeves • Data Cards for Modern Penguins and Pedro 	<ul style="list-style-type: none"> • https://detroitzoo.org/penguins-live-cam/ • www.teachersopenciedfieldtest.org/penguins • computer • projector • 5-6 inches of painter's tape • 1 meter stick • computer and speakers. • Types of Connections poster • Evidence We Need poster • markers • https://www.youtube.com/watch?v=qWTwan_G6YE • https://www.youtube.com/watch?v=FwPdmK2EYEK • https://www.youtube.com/watch?v=YKqXGNNPNaQ • sticky notes (optional) • chart paper • transparent tape • Related Phenomena poster • Driving Question Board • Ideas for Data and Information We Need poster

Materials preparation (30 minutes)

Review teacher guide, slides, and teacher references or keys (if applicable).

Make copies of handouts and ensure sufficient copies of student references, readings, and procedures are available.

Gather your color copies of *Data Cards for Modern Penguins and Pedro* to have enough for each student in your largest class. Put each card in its own clear, half-sheet protector. Use a binder clip to keep a set of these together. These are non-consumables that you collect and reuse in all classes.

Prepare these posters (i.e., Types of Connections, Evidence We Need, Related Phenomena, Ideas for Data and Information We Need) ahead of time.

Download the *Communicating in Scientific Ways* file from the website and use it in your classroom as a poster or add it to students' science notebooks as a handout.

Determine where to set up the Driving Question Board and posters so that students can gather around them.

Make a poster outlining the classroom's discussion norms and post it near your DQB space if you haven't already.

Test the audio recording to make sure it plays www.teachersopenciedfieldtest.org/penguins

Test the videos to make sure they play:

- www.teachersopenciedfieldtest.org/penguins
- https://www.youtube.com/watch?v=qWTwan_G6YE
- <https://www.youtube.com/watch?v=FwPdmK2EYEK>
- <https://www.youtube.com/watch?v=YKqXGNNPNaQ>

All videos and audio are also available on the field test site at: www.teachersopenciedfieldtest.org/penguins

Lesson 1 • Where We Are Going and NOT Going

Where We Are Going

This lesson elicits students' initial ideas about how living things of today could be connected to living things of the past. The word choice of “connected” is intentional, providing the broadest possible description to encourage students to propose for and look for many possible patterns.

On days 1 and 2, of this unit students compare penguins of today to one another and to a fossil of a penguin from long ago. There is lots of information on these cards, and therefore are a relatively complex data set to work with. This will be a challenging data analysis task for students, as they will be looking for patterns in the complex data sets.

Students, however, will be working with these data cards again in lesson 2 and a more complex version of them in lesson 3. So it's ok if students feel a bit overwhelmed with trying to look at all of the cards at once with this first exposure to them. There is guidance in the lesson for helping students work with a smaller number of cards at first, before looking for patterns across the entire set of data.

One pattern that will be particularly challenging for students to look for in this lesson will be the geographic distribution of different types of penguins. This is because the orientation of the maps used on the data cards use a southern hemisphere view of the globe. This view will likely be unfamiliar to students. Using the physical squishy globes to help orient students to this view of the globe will be helpful. Students will have some prior experience working with maps that reference locations in the Southern Hemisphere in *Storms Unit* including where Lima, Peru is located (a city relatively close to the fossil dig site of Pedro). The data card for Pedro includes a global map that shows the shifted location of the continents, mountain ranges, and sea levels for the Earth at that time. The idea that the continents would be in different positions millions of years ago is an idea that students built in their prior work in a previous unit, *Everest Unit*.

Where We Are NOT Going

By the end of the unit, students will be able to explain the relationships between organisms from long ago and organisms alive today in terms of how closely related they are in terms of natural selection. This lesson, however, avoids introducing the words “related” or “descended” as possible connections between Pedro and modern penguins. Some students may introduce these words themselves, but this lesson purposely avoids introducing them. Here is the reasoning behind this. The word related has multiple meanings including being related on a family tree. This meaning assumes an idea we want students to derive in the unit - that different types of organisms descend from a common ancestor at some point in the past. This idea is one we want students to develop themselves and converge on toward the end of the unit, not now in lesson 1.

When the word “descended” is used to describe connections between things living today and things living long ago, it is assuming an idea we want students to derive in the unit - that a type of thing alive today could have descended from a different kind of living thing in the past. It precludes an idea that students may hold, that the organisms alive today are not different than their ancient ancestors. It will be productive for some students to wrestle with competing ideas on their own around this. In lesson 6, they will converge on the idea that for many organisms, the traits found in a population of descendants appear to be changing over millions of generations.

This lesson refers to different “types” of penguins. The use of the word “type” in this context is synonymous with the scientific definition of “species”. The unit however, does not introduce the word “species”, nor what makes something a different species. This is a question that lends itself to exploring the mechanisms of speciation in more detail, but it is an area of inquiry that is more productive to save for high school, when it will be better aligned to the disciplinary core ideas in that grade band.

The unit does not name the mechanisms of natural selection until lesson 9, which is after students derive them from case studies themselves first. Students may come into this unit with many partial understandings about natural selection. If such ideas come up during the unit, don't be afraid to put them up as ideas to consider. But don't elevate any of these ideas yet. Remind students that we need to be able to defend our ideas with evidence. So the class can collect data and decide which ideas are best supported by evidence. Having norms in class around a growth mindset will help students know that it's okay and very productive to change our mind about our ideas. That's how we grow and learn.

LEARNING PLAN for LESSON 1

1 · OBSERVE LIVE PENGUINS

5 min

MATERIALS: <https://detroitzoo.org/penguins-live-cam/>, www.teachersopenciedfieldtest.org/penguins, computer, projector

Launch the unit by observing penguins living today. Tell students that you recently saw a live video feed of penguins in a zoo and you'd like to share it with them.* Project **slide A** and show the live penguin cam <https://detroitzoo.org/penguins-live-cam/>. Note that the penguin cam is available from 9 a.m. to 5 p.m. EST daily. If the live feed isn't on or if the penguins are relatively inactive, show a prerecorded clip of the live penguin cam: www.teachersopenciedfieldtest.org/penguins. Spend no more than 5 minutes on the penguin cam or recording. Once students have watched the penguins for 2-3 minutes, have them turn and talk with a partner to share their noticings and wonderings while they continue to watch for the remainder of the time.

While students are discussing their observations and questions, walk around the room and listen to their discussions. As you listen, encourage students to continue sharing their noticings and wonderings.*

ALTERNATE ACTIVITY

Start the live penguin cam and have it playing as students enter the classroom.

ADDITIONAL GUIDANCE

There are different types (species) of penguins in this exhibit. Students may see the following: king, southern rockhopper, macaroni, and gentoo penguins. Don't tell students that there are different types in the exhibit. They will uncover the idea of there being different types of penguins with different characteristics later in the lesson.

* ATTENDING TO EQUITY

Watching a live penguin cam gives all students the experience of watching live penguins at a zoo, whether or not they have ever visited a penguin exhibit at a zoo.

2 · MEET PEDRO, A HUMAN-SIZED PENGUIN

12 min

MATERIALS: science notebook, *Podcast Transcript and Photo Journal*, www.teachersopenciedfieldtest.org/penguins, 5-6 inches of painter's tape, 1 meter stick, computer and speakers.

Introduce the phenomenon. Tell students that you recently heard about a really amazing discovery made in Peru of a 36 million years old giant penguin fossil discovered in Peru. The penguin was the size of a human! Using a meterstick against a wall, measure approximately 5 feet (about 1.5 meters) up from the ground. Place a 5-6 inch piece of painters tape at the 5-foot mark to show students how big the penguin was.

Foreground the purpose of the recording and photo journal. Project **slide B** and say, *What is really cool is that this was we were able to get in touch with two members of the research team to learn more about their discovery. And what is also really great is that they shared with us some of the photos they took of their work.*

Distribute *Podcast Transcript and Photo Journal* to students. Explain that students can follow along with these resources while they listen to the recording. Before playing the recording, instruct students to listen carefully for any ideas that stand out to them as particularly interesting and any questions that they have in their notebooks.

Listen to the recording of the story about Pedro's discovery for the first time. Play www.teachersopenciedfieldtest.org/penguins while students jot down notes in their notebooks.*

After listening to the recording, have a few students share some of the ideas that they found particularly interesting or exciting.

* ATTENDING TO EQUITY

Universal Design for Learning: Reading the transcript of the podcast as they are listening to it, provides students multiple *representations* (audio, photos, and text) of the information, which could be harder to interpret from audio alone. Consider posting a digital copy of the podcast and transcript 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,

ADDITIONAL GUIDANCE

Another name for Pedro is *Inkayacu*, or water king. This word is derived from *Inka* and *yacu*. Both of these words are part of the indigenous language family spoken by the Quechua peoples, living primarily in the Peruvian Andes, which are where the fossil was found. *Inka* means emperor or king and *yacu* means water.

Some students may wonder why the scientists nicknamed the fossil Pedro. The backstory on this from Ali Altimirano, is that after he and Dr. Rodolfo Salas discovered the scales on this giant fossilized penguin foot sticking out of the ground, they tried to picture what the penguin would have been like walking around. They both immediately thought of a character from a popular telenovela series at the time, who was often referred to as “Scaley Pedro”. The character was portrayed as well-meaning, but was also quite large and clumsy, which led to much physical comedy. If you watch penguins move on land for a bit, that physical awkwardness in some of their movements often stands out.

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.

SCIENCE NOTEBOOK



This is the first use of the science notebook for this unit. You may need time to organize a new section in the notebook. It is recommended to have students do the following:

- Reserve a blank page at the start of the unit, to be titled on day 3 of this lesson when students are given the unit question.
- After the title page, reserve 2 pages (4 pages front and back) for the table of contents (unless all tables of contents are at the front of the notebook).
- Reserve 10 pages (20 pages front and back) for the Progress Tracker pages.
- Number the pages so that everyone begins the first investigation of the unit on the same page number.

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.

3 · BRAINSTORM TYPES OF EVIDENCE NEEDED

8 min

MATERIALS: Types of Connections poster, Evidence We Need poster, markers

Lead a class Initial Ideas Discussion about potential connections between Pedro and penguins alive on Earth today. Project slide C and say, *In the interview, the question was raised how the penguins alive today might be connected to the penguins that lived long ago, like Pedro. Let’s consider this as a class to see if we can help make some progress on this question.*

KEY IDEAS

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.

Listen for these ideas:

- Living things can be connected in many different ways, such as they may live in the same place, live in the same time period, share similar genetic information, or be related like a sibling, parent, grandparent, and so forth.
- There are gaps in our understanding that we want to know more about.

Suggested prompt	Sample student response
<p><i>What are different ways that living things could be connected to one another?</i></p>	<p><i>They might live in the same place.</i></p> <p><i>They might live during the same time period.</i></p> <p><i>They could be siblings or cousins or parents.</i></p> <p><i>They could share similar traits.</i></p> <p><i>They share similar behaviors.</i></p> <p><i>They eat the same things.</i></p> <p><i>They could share similar DNA.</i></p> <p><i>They could live in the same environment or climate (even if they don't live in the same place).</i></p> <p><i>They could have some kind of living thing that mutually interacts with them in a common way (e.g., a tick could bite a deer or a human).</i></p>

Create a class chart of initial ideas and asterisk “likely” ideas. Hang the Types of Connections poster. As students share their ideas, list them on the poster. Say, *It sounds like living things can be connected in a lot of different ways. Let's think about the most likely ways that Pedro might be connected to the penguins alive on Earth today.*

Suggested prompt	Sample student response
<p><i>Which of these types of connections do you think Pedro might have with penguins alive today?</i></p>	<p><i>They might live in the same place.</i></p> <p><i>One could be an ancestor to another.</i></p> <p><i>They could share similar traits.</i></p> <p><i>They could share similar DNA.</i></p> <p><i>They could live in the same environment or climate.</i></p> <p><i>They share similar behaviors.</i></p> <p><i>They eat similar things.</i></p>

As students share their ideas, place an asterisk next to any of the connections that the class identifies as a “likely” type of connection between Pedro and penguins alive today. At this point, accept all student ideas.

Lead a class discussion about the evidence needed to determine a connection. Say, *It sounds like there might be some kind of connection between Pedro and the different kinds of penguins alive today, but we aren't really sure how they might be connected, or even if they are connected!*

Suggested prompt

What kinds of data would you need to determine whether penguins alive today are connected to Pedro?

Sample student response

We would need to know where the modern penguins live.

We would need to know more about where Pedro and other kinds of penguins like Pedro used to live.

We would need to know more about the traits of the modern penguins and of Pedro.

We would need to know more about the DNA of modern penguins and of Pedro.

We would need to know what other kinds of critters Pedro and the modern penguins interact with (predator, prey, symbiotic relationships).

Begin a running list of evidence we need. 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 there are Pedro is similar in some important ways to all the different types of penguins today. Maybe we can start by looking at a few of these kinds of penguins.*

4 · MEET THREE TYPES OF PENGUINS ALIVE TODAY

15 min

MATERIALS: science notebook, *Penguin Comparison*, only the emperor/Adélie/southern rockhopper cards from Data Cards for Modern Penguins and Pedro, 1 Earth squish ball with countries labeled, 1 Earth squish ball with no labels, 2 paper coffee sleeves, https://www.youtube.com/watch?v=qWTwan_G6YE, <https://www.youtube.com/watch?v=FwPdmK2EYEK>, <https://www.youtube.com/watch?v=YKqXGNNPNaQ>

Prepare to meet three types of penguins alive today. Project slide D and say, *Let's get ready to document some of what we observe about the kinds of penguins alive today.* Share that you have some videos and information cards about three different types of penguins alive today.

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 types and the columns of the table for adding details about specific physical traits and behaviors noticed for each penguin type.

Introduce the emperor penguin. Share that the first type of penguin we are going to observe is an emperor penguin. This is the first of three videos of penguins students will watch to make observations about the penguins. Play all of these videos with the sound off. * Show https://www.youtube.com/watch?v=qWTwan_G6YE on slide E.

* ATTENDING TO EQUITY

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.

* ATTENDING TO EQUITY

If time permits, consider asking students to share with a partner their responses to the following questions, "Which of the penguins that we just observed was your favorite? Why?" This gives students more time to

Name: _____ Date: _____

Penguin Comparison

PENGUIN TYPE	Physical traits	Behaviors

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ADDITIONAL GUIDANCE

Universal Design for Learning: We want students to make observations of the penguins in their natural environment, just as Ali Altamarano and Dr. Julia Clarke do. In the first video (https://www.youtube.com/watch?v=qWTwan_G6YE) and the third video (<https://www.youtube.com/watch?v=YKqXGNNPNaQ>), background music has been added that could potentially lead to anthropomorphizing, or attributing human traits to, the penguins. Students are observing the penguins in these videos to make noticings of their features, their movements, their environment, and their interactions. The background music could lead to some of these being *misrepresented* and students attributing characteristics or traits to the penguins that may not be true. For example, the music in the background could lead one to think the penguins are awkwardly waddling around the area in the video. Whereas, in reality penguins may move the way they do around the area because it is more efficient and less accidentally prone on the ice or rocks they move across. Or it could be a by-product of leg structures better suited for fast movement in the water. Having students make their observations without the music will allow them to make more objective observations which will serve them well as they move through the unit to figure out more about penguins of today and long ago.

The second video (<https://www.youtube.com/watch?v=FwPdmK2EYEK>) includes narration explaining the presence of a robotic penguin used for video taping the penguins. One of these robotic penguin cameras is a submersible and one is on land. For that reason you may want to leave the video on. If you choose to mute the audio for this video too, make sure to explain that to students.

process the information they just heard and read about the three different types of penguins. It also gives students a safe space to begin going public with their ideas in this unit.

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.

Say, This penguin card and other penguin cards you will get will include maps of where that type of penguin lives. This map is not a typical view of the earth you often see, as it is only showing the Southern Hemisphere. Let's orient to that view a bit using some globes, which you can keep at your desks as you work with your groups to help visualize where these locations are on earth.

Orient to locations on the globe.* Distribute both squish ball globes and 2 coffee sleeves to each group. Hold up a squish ball globe (or larger globe) and instruct students to demonstrate the following with their own squish ball globes:

- Place each Earth squish ball on its own sleeve so that the northern pole is pointed to the ceiling
- Ask each person to point to where we live on both globes.
- Find Peru.
- Locate South America, the Southern tip of African, Australia, New Zealand, and Antarctica
- Flip Earth squish ball on the stand of that Antarctica is pointed toward the ceiling.

Say, Looking downward on your globe from above your table gives you a view of the Southern Hemisphere. That is shown on the map on the data card, and is the kind of map you will see on other penguin data cards.



ADDITIONAL GUIDANCE

As students look at the penguins cards, they may notice that skuas or giant petrels are listed as predators. Tell students that skuas and giant petrels are carnivorous birds--birds that tend to eat the eggs or young of other birds. You may wish to pull up photographs to show them.

Introduce the southern rockhopper penguin, followed by the Adélie penguin. Use the same process as for the emperor penguin. First, show <https://www.youtube.com/watch?v=FwPdmK2EYEK> on **slide G**. This can be with the sound off or on, your choice. Then project the penguin card on **slide H**. Next, show <https://www.youtube.com/watch?v=YKqXGNNPNaQ> with the sound off on **slide I**, and then project the penguin card on **slide J**. Give students time after each penguin introduction to add information from the videos and penguin cards to the data table. Spend about 4 minutes with each type of penguin.*

5 · CONSIDER CONNECTIONS BETWEEN PENGUINS

5 min

MATERIALS: Types of Connections poster

Discuss how the three types of penguins we observed compare to one another and to Pedro. Project **slide K** and say, *Remember the question that we started considering at first, "Could Pedro somehow be connected to the penguins alive today?" Let's revisit that question now.*

Instruct students to look back at the list for how living things could be connected to one another on the Types of Connections poster *and* the comparisons that they made among the penguins on *Penguin Comparison*. Give students time in small groups to discuss the questions on the slide.

Suggested prompt

What claims can you now make about how the emperor, southern rockhopper, and Adélie penguins are connected to one another?

Sample student response

The penguins have similar features and eat similar food.

All three penguins live in the Southern Hemisphere.

All three penguins appear to be black and white.

All three penguins lay eggs.

The rockhopper and Adélie eggs are incubated by both parents, while the emperor egg is only incubated by the father.

All the penguins swim, but the emperor dives the deepest.

The Adélie and emperor penguins live in and around Antarctica.

All three penguins eat fish, krill, crustaceans, and squid.

All three penguins have similar predators (carnivorous birds, leopard seals, killer whales).

Suggested prompt	Sample student response
<p><i>What ideas do you have about how these 3 types of penguins might be connected to Pedro, but you would need additional evidence to support or refute?</i></p>	<p><i>The three penguins (or maybe just one or two of the types of penguins) could be distant relatives of Pedro--like a great, great, great, great grandchild. We would probably need to compare their traits to support or refute this claim.</i></p> <p><i>The three penguins (or maybe just one or two of the types of penguins) could be connected to Pedro because they live (or lived) in similar environments. We would need to know more about the environment that Pedro lived in to support or refute this claim.</i></p> <p><i>The three penguins (or maybe just one or two of the types of penguins) could be connected to Pedro by interacting with the same kinds of other living things (predators and prey). We would need to know if similar kinds of predators and prey were alive when Pedro was living.</i></p>

Emphasize that it sounds like we are going to want to look at more data in order to figure what additional connections might exist between penguins and Pedro.

ADDITIONAL GUIDANCE

Students will likely bring up the idea that the penguins could be connected through “lines of descent.” Embrace this as an idea that we can pursue. It is important, though, to neither confirm nor deny this idea at this point in the process so that students are motivated to further investigate their ideas about “lines of descent.”

ADDITIONAL GUIDANCE

Students enter this unit with many different ideas about how living things from the past could be connected to living things today. These connections, the associated evidence, and the underlying science ideas are complex. In order to help students develop strong, evidence-based explanations that incorporate key science ideas, it is important to work with developing student ideas and root the development or change of ideas over time in evidence. We have developed extensive guidance in the *Teacher Background Knowledge for the Unit* document to help you navigate these complexities at critical moments throughout the unit. Within lessons, we call out these critical moments and reference the *Teacher Background* document.

Before leaving, have students turn in their *Data Cards*, their 2 squish globes, 2 paper coffee cup sleeves, and *Podcast Transcript and Photo Journal*, for use in the next class and the next day.

End of day 1

6 · PREDICT PATTERNS IN PENGUINS

5 min

MATERIALS: sticky notes (optional)

Review the need for evidence. Remind students that they have already made some claims about the ways that the three types of penguins living today we looked at are connected to one another and how those three types of penguins might be connected to Pedro. Tell students that in addition to the three types of penguins they already explored, there are 15 other types of penguins for a total of 18 different types of penguins living today. Show **slide L** to prompt a turn and talk around these questions:

- What patterns do you expect to find among the penguins alive today?
- How might those patterns help us consider other possible connections between the penguins of today and Pedro?

ADDITIONAL GUIDANCE

Students might be surprised to hear that there are 18 different types of penguins living today. If it comes up, capture students' thoughts as questions on sticky notes. For now, post these questions to the board. Later, you can add them to the Driving Question Board. Possible student questions might include the following:

- (1) Where did all the different types of ancient penguins go?
- (2) Where did all the different types of modern penguins come from?
- Are the penguins alive today really *that much* different from each other that we can call them different types?

Predict patterns in penguins. Direct students to turn and talk with a partner about the questions on **slide L**.

Suggested prompt

What patterns do you expect to find among the penguins alive today?

How might those patterns help us consider other possible connections between the penguins of today and Pedro?

Sample student response

The penguins alive today are all likely good swimmers.

The penguins alive today probably all eat the same kinds of food and are eaten by the same kinds of predators.

There might be some types of penguins that are bigger than others and some types of penguins that are smaller than others.

There might be some types of penguins that dive deeper than others and some types of penguins that dive shallower than others.

Most penguins alive today probably live in the Southern Hemisphere.

Some penguins alive today might live on Antarctica, while others might live further North.

Accept all responses. Have a few students share their ideas with the class.

Motivate finding out more about the penguins alive today. Say, *We don't have time to watch videos for all 15 different types of penguins, but we can take a look at the penguin cards for the other penguins. Let's see what we notice.*

7 · LOOK FOR PATTERNS AMONG PENGUINS

20 min

MATERIALS: science notebook, Data Cards for Modern Penguins and Pedro, 1 Earth squish ball with countries labeled, 1 Earth squish ball with no labels, 2 paper coffee sleeves

Setup the two globes again. Redistribute each of the two types of Earth squish balls and two paper coffee sleeves to students. Remind students to flip the globes so that Antarctica is facing upward on each.

Examine penguins alive today and Pedro. 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.* Hand out one set of 19 penguin cards to every 3 students. Each set should include all 18 penguins alive today (red background header boxes on them) and a Pedro card (a grey header background box on it).

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. 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.

ASSESSMENT OPPORTUNITY

Building towards: 1.A Analyze and interpret data, to find **patterns** in penguins **that are alive today** using data cards containing photos, maps, charts, measurements, and descriptive text.

What to look/listen for: Each student leading at least one of the three ways their small group tries to sort the cards and co-facilitating the discussion about the patterns they notice as they do this. Students will get to work with these data sets multiple times over the course of the early lessons in the unit, so look for growth in fluency with this sort of data analysis over the next four lessons.

What to do: Though students will have had prior experience with this element, this will be the most complex and largest data set that students will have worked with so far in OpenSciEd. So if some students find it overwhelming to look at all of the cards at once, suggest that they start with fewer cards (e.g. half the deck) to simplify sorting and looking for patterns. It helps to have a few penguins of various sizes and from various geographical areas.

Share groupings, observations, and new questions that surfaced. After students have had sufficient time to sort the cards, have several groups share what they noticed, how they sorted the cards, and any new questions that came up. As students share their ideas, take note of the groupings; consider writing the groupings on the board.

Suggested prompt	Sample student response
<p><i>How did you sort your cards? What connections did you discover?</i></p>	<p><i>We sorted based on geographic location. We noticed that most penguins are in Antarctica, but some are in slightly warmer climates. We also noticed that all penguins live in the Southern Hemisphere.</i></p> <p><i>We sorted based on penguin size. We noticed that there are clearly some very large penguins and some small penguins, but most penguins seem to be medium-sized.</i></p> <p><i>We sorted based on how deep the penguins can dive. We noticed that the bigger penguins can dive deeper.</i></p>
<p><i>What new questions came up?</i></p>	<p><i>Accept all responses.</i></p>

Emphasize that we have already made some big progress in finding connections amongst these penguins just by looking for patterns in these different categories of data.

Examine the pattern of geographic location more closely using a map. Refer to any suggestion that came up regarding patterns related to geography and say, *Patterns in geographic location can be tricky to visualize without a map. Let's discuss that one further by referencing a map of the southern hemisphere we can all see at once and then let's discuss (again) some of the patterns you noticed.*

Project the world map on **slide N**. At this point, accept all student ideas. Some anticipated responses are listed below.

Suggested prompt	Sample student response
<p><i>What patterns did you notice in the geographic location of different types of penguins?</i></p>	<p><i>All penguins live in the Southern Hemisphere.</i></p> <p><i>All penguins live on or near a coast.</i></p> <p><i>Some penguins lived closer to the center of the map (the South Pole) than others.</i></p> <p><i>The largest penguins lived closer to the South Pole.</i></p> <p><i>There was an overlap in the areas where some of the penguins lived.</i></p> <p><i>Pedro was in the same place as some of the Penguins of today.</i></p>
<p><i>What questions do you have now?</i></p>	<p><i>Why do the bigger penguins live further south?</i></p> <p><i>Why don't any penguins live in the Northern Hemisphere?</i></p> <p><i>Are there other "Pedros" out there?</i></p> <p><i>Are there fossils of other kinds of penguins?</i></p>

Suggested prompt	Sample student response
<p><i>continued from previous page...</i></p> <p><i>What questions do you have now?</i></p>	<p><i>Where would other penguin fossils be found?</i></p> <p><i>Are there fossils of other kinds of animals that lived at the time of Pedro that were the predators or prey of penguins?</i></p>

Summarize by saying, *Just from considering geographic connections we came up with new questions. And many came from thinking about where Pedro's fossil was found. So far, we have only looked at Pedro's fossil, but we heard the ideas and questions related to where else penguin fossils might be found. Let's dig into that line of thinking a bit more too.*

8 · PREDICT WHERE OTHER PENGUIN FOSSILS COULD BE FOUND

3 min

MATERIALS: None

Brainstorm where other fossils would be found. Project slide O and say, *Where might it be most productive to hunt penguin fossils anywhere else on Earth. Let's gather some of our initial thoughts on those questions. Ask, Where on Earth do you think we'd be likely to find more penguin fossils?*

Suggested prompt	Sample student response
<p><i>Where do you think we should dig to find more penguin fossils?</i></p>	<p><i>Probably on coastlines or slightly in from the coast, like where Pedro was found.</i></p> <p><i>Maybe on different continents slightly in from the coastline, like New Zealand or Australia.</i></p> <p><i>All living penguins seem to be in the Southern Hemisphere, so we should probably dig there.</i></p> <p><i>A lot of penguins seem to be in Antarctica, so let's dig there, though it might be hard because of all the ice.</i></p> <p><i>Penguins spend a lot of time in the water, so I would want to dig under the ocean, but that would be really hard.</i></p> <p><i>Pedro was found in a desert inland in Peru. Maybe we should dig there or in other similar deserts.</i></p>

Start considering what kinds of fossils we might find. Next, ask students what they think we would find if we dig in the places they mentioned. As a class, get a few alternate possible locations to think about. Say, *If we dig [here - pick one of the locations] and found a penguin fossil, what would that type of penguin looked like when it was living? And what if we dug in another spot [here - pick another one of the locations] and found a penguin fossil, what would that penguin have looked like when it was living? Let's take a moment to put our predictions on paper.*

9 · PREDICTING PENGUINS FROM LONG AGO

7 min

MATERIALS: science notebook, *Predictions On Other Penguins That Lived Long Ago*, colored pencils, chart paper, markers, transparent tape

Draw or describe a penguin from long ago. Project slide P and distribute *Predictions On Other Penguins That Lived Long Ago*. Say, *Let's think a little more specifically about any one of the dig sites that we identified earlier. Let's be really specific about what we think we would find if we dug in one these locations.*

Instruct students to individually pick one of the dig site locations that they can recall from their previous discussion or a new dig site location that they might be interested in exploring and describe that location on *Predictions On Other Penguins That Lived Long Ago*. Ask students to imagine that they found a penguin fossil at that location and then imagine the characteristics that penguin would have had when it was alive and to identify those that they predict would be the same or different than penguins living today.

Encourage students to put any of the data cards of the penguins they have analyzed so far in front of them as a reference if they wish. Emphasize though that after a couple of minutes they should move on to the other boxes on the handout to explain their reasons for their predictions and to talk about whether they think it would have been the only type of penguin living on Earth.**

The handout is titled "Predictions On Other Penguins That Lived Long Ago". It includes a "Name:" and "Date:" field at the top. Below the title is a "Dig location:" field. The main body of the handout is divided into two columns. The left column has a header: "Draw, list, or describe characteristics it would have had (size, bone shape) that would be the same or different than penguins living today." The right column has a header: "Why do you think that?" Below these columns is a large box with a header: "When the penguin you described above was alive, do you think it was the only type of penguin living on Earth? Why?" At the bottom of the handout, it says "openstax.org Lesson 10-23 Page 1".

* ATTENDING TO EQUITY

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.

* SUPPORTING STUDENTS IN ENGAGING IN ARGUMENT FROM EVIDENCE

It is important that students focus on the justification for the decisions they made in their penguin drawing, list, or description of characteristics. This focuses students on explaining why there are commonalities and differences in the characteristics of living things rather than simply itemizing features.

ADDITIONAL GUIDANCE

If students want to draw a picture, but don't understand how they could draw a picture of something that no one has ever seen, it might help to refer to the image of the artist's rendering of Pedro on his data card. Explain that Dr. Clarke and her team didn't know exactly what Pedro looked like, but they had some evidence that they could use to share with an artist. The artist then took that evidence (bone size, bone length, beak shape) into consideration when they developed an outline of the penguin first, to show the relative size of these structures.

10 · COMPARE PENGUINS AND DEVELOP A TIMELINE MODEL TO REPRESENT OUR THINKING

9 min

MATERIALS: science notebook, *Predictions On Other Penguins That Lived Long Ago*, colored pencils, chart paper, markers, transparent tape

Look for differences in characteristics. Show slide Q. Give students two minutes to compare the ways their penguins might have been similar to or different than penguins living today.

Develop an initial consensus model. Show slide R. Ask students to share some of the possible differences they identified in the characteristics of penguins from long ago. Then follow-up with discussing whether they think there were other types of penguins in the past.

* 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 years ago. The Spanish word for *modern* is "moderna/o", and the Spanish word for *ancient* is "antiguo/a". Using cognates is a helpful strategy to support emerging multilingual students.

Suggested prompt

Let's talk about some of the ways that you predicted penguins from long ago might have looked different from penguins of today. What were some of those differences you identified in the predictions you and your partner made?

Do you think there would have been other types of penguins living on Earth too when your type of penguin was living? Why?

Sample student response

They might all have been bigger than the emperor penguin

Maybe some were even smaller.

Maybe they all had pointier beaks and bigger feet.

They all would have looked like Pedro.

Some might have looked a little bit like Pedro and a little bit like the ones of today.

No they all would have been like Pedro.

No there were less types of penguins in the past than now.

Yes, there must have been all the types of penguins alive today in the past too.

Yes, there were many different kinds of dinosaurs, so maybe there were probably different kinds of penguins.

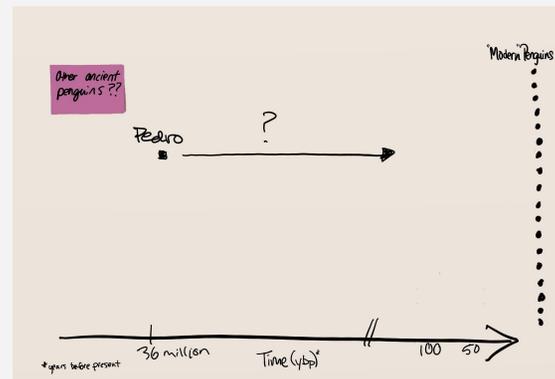
There are different types living now so doesn't that mean there would have to have been different types living at some point in the past too?

Motivate capturing these competing ideas. Say, *Since we have some ways the penguins that lived long ago might have similar to and different than the penguins of today, and there are some differences in the claims we are making about whether there was more than one type of penguin or many types of penguins at a certain point in the past, let's take some time to represent our current thinking about the type or types of penguins living at different points in time.*

Create a timeline on chart paper. Start by drawing and labeling an arrow as time (years before present) with a long gap in time between the recent past and the past from very long ago. Add labels for 50 and 100 years ago. Say, *This axis will represent the years before present. So 50 and 100 are the more recent past. This break in the line represents a jump back to millions of years ago. I will label a point on the far left side of the arrow as 36 million years ago, which is when Pedro lived.*

Ask students how many types of penguins are living today. They will say 18. Say that you are going to represent each of these types with a dot on the far right side of the timeline to emphasize that they are living today.

Add Pedro at 36 million years ago and an arrow with a question mark over it pointing forward in time. Suggest that this line shows that we don't know how long Pedro type of penguins lived on Earth, but we do know that at some point in the past they no longer were living on Earth, because they aren't alive today. Tell students that we will refer to this image as our initial timeline model.



Introduce a way to distinguish “modern” vs. “ancient” penguins. Say, *We just considered what penguins from long ago might have looked like. When we are considering penguins from millions of years ago, let’s refer to any of those penguins as “ancient” penguins. When we are referring to penguins of today, let’s call those “modern” penguins.*

Add labels to the navigation model. Add a label “ancient penguins” over the section of the timeline on the left. Add a label over the 18 dots that says “modern penguins”.*

Revisit the area(s) of uncertainty around other types of ancient penguins. Say, *So what did we think about millions of years ago? Do we know if there are any other types of penguins that lived when Pedro lived?* Students will say no. Suggest that we add lots of question marks around Pedro to represent this.

Say, *So let’s think about this. Pedro was an ancient penguin. But what happened to the Pedro type penguin? Where did they go? And if there were other types of ancient penguins besides Pedro then where did they go? And let’s also consider the reverse. Today there are 18 different types of modern penguins. Where did these modern penguins come from?* Give students a minute to think on their own about these questions and then say, *Let’s pick up there next time and try to figure out so we can fill in some of this area where there is a big gap in our model and we have all of these question marks.*

Have students tape their penguin drawing into their notebook. If time permits, you may also wish to have students add the navigation model to their notebook.

End of day 2

11 · NAVIGATION

5 min

MATERIALS: None

Turn and talk to share initial ideas about where ancient penguins went and where the modern penguins came from. Point to the question marks around Pedro on the timeline model that represent questions we had about how long Pedro’s type of penguin lived and if there were other types of penguins living before, during and after when he did.

Project **slide S** and point out these main ideas that have been raised so far:

- Pedro is a type of ancient penguin that does not live on Earth today.
- We wondered if there were other types of ancient penguins that lived long ago.
- There are 18 different types of penguins that live on Earth today

Emphasize that we had two questions that came out of the gaps we had in our model as we started considering connections over time at the end of the last class:

- Where did the ancient penguins go?
- Where did all the different types of modern penguins come from?

Give students several moments to turn and talk with a partner about these questions. At this point, students should just be sharing their initial ideas. If you have time, select a few students to share their ideas with the class. Accept all student ideas. Say, *It sounds like these two questions--Where did all the ancient penguins go? Where did modern penguins come from?--is helping us consider other ways that Pedro could be connected to the penguins alive today.*

12 · WRITE AND COMPARE INITIAL EXPLANATIONS

16 min

MATERIALS: science notebook, *Initial Explanation*



Write an initial explanation. Project **slide T** and distribute *Initial Explanation* to each student. Remind students of the big question we are trying to figure out: Could Pedro be connected to the penguins alive today and if so how? Remind them that we identified two questions that could help us figure out connections between any ancient penguins and penguins of today. Ask students to take a few minutes to consider these two questions on their own: (1) Where did all the ancient penguins go? and (2) Where did all the different types of modern penguins come from?

Say, *I think we need to take some time to gather our initial ideas on these questions.* Instruct students to use the handout to develop an initial explanation in response to each of these questions. Show students that there are multiple places to add multiple claims. Say, *We might find that there are multiple different things going on here! For each claim, though, try to identify a possible mechanism and the evidence that would be needed to either support or refute their claim.*

The handout is titled "Initial Explanation" and includes fields for "Name" and "Date". It contains two tables for student responses.

Table 1: Where did all the ancient penguins go?

Claim	Mechanism	Evidence that supports the claim	Evidence that refutes the claim

Table 2: Where did all the different types of modern penguins come from?

Claim	Mechanism	Evidence that supports the claim	Evidence that refutes the claim

ASSESSMENT OPPORTUNITY

Building towards: 1.B Develop an initial explanation and identify evidence needed to determine what caused the observed changes in the existence, diversity, and disappearance of different kinds of penguins throughout history.

What to look/listen for: (1) Students make more than one claim about what happened to the penguins from long ago and where the modern penguins came from, (2) students support their claim by providing a possible mechanism, (3) students articulate evidence needed to either support or refute their claim.

What to do: If students are struggling you can allow them to work with a partner and/or use the following prompts to push them in their thinking:

- What evidence would you need to support your claim?
- What evidence would you need to refute the claim?
- How might that piece of evidence support (or refute) your claim?
- Why would that evidence convince you? What other kinds of evidence might you need?

ADDITIONAL GUIDANCE

If students struggle with the word *mechanism*, restate the idea of a mechanism as identifying the “working parts” or steps that could make something happen.

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, looking 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.

13 · INITIAL CLASS CONSENSUS DISCUSSION

13 min

MATERIALS: science notebook, chart paper, markers

Build an initial class consensus explanation.* Project **slide V** and gather students in a Scientists Circle to build an initial class consensus explanation through discussion of the two subquestions: (1) Where did all the different types of ancient penguins go? and (2) Where did all the different types of modern penguins come from?

KEY IDEAS

Purpose of this discussion: Develop an initial class consensus explanation to capture the ideas we agree and disagree on regarding what happened to penguins of the past and the possible connections between penguins of long ago and penguins alive today. Help students realize that, while we have common agreement with some ideas, we still have many questions.

Listen for these ideas

1. Where did all the ancient penguins go?

Areas of agreement

- Some type(s) (like Pedro) that were alive in the past aren't alive today.
- Everything dies.

Possible areas of disagreement or uncertainty

- how many types were alive at any one time
- how similar or different these types were
- whether the penguins alive long ago were *exactly* like the penguins alive today
- whether some penguin descendants changed over many generations vs. there were just a lot of kinds of penguins long ago, and only some kinds had descendants that have survived into the modern day.
- whether some penguins from long ago became modern penguins

2. Where did all the different types of modern penguins come from?

Areas of agreement

- They came from other living things (they had parents and grandparents who looked like them)
- There must be a line of ancestors they came from that stretches back millions of years.

Possible areas of disagreement or uncertainty

- whether modern penguins are a “new” kind of penguin or just a very different looking penguin from long ago
- how modern penguins look so different from ancient penguins
- why (and how) there are so many different types of modern penguins

SCIENTISTS CIRCLE



You will form a Scientists Circle in many lessons. If this is your first time forming one, you will need longer than 10 minutes to coordinate it. If your class is familiar with the Scientists Circle, the movement in and out of the circle can happen fairly quickly. Setting up the norms and logistics for forming, equitably participating in, and breaking down that space is important to do if this is your first time forming such a space. Having students sit in a circle so that they can see and face one another can help build a sense of shared mission and a community of learners working together. Returning to this Scientists Circle throughout the course of the unit to take stock of what the class has figured out and where students need to go next will be an important tool in helping the class take on greater agency in steering the direction of their learning. This circle will also help build a sense of pride in their work. You may want to inform students that professional scientists also collaborate with one another to brainstorm, discuss, and review their work.

14 · BRAINSTORM AND SHARE RELATED PHENOMENA

7 min

MATERIALS: science notebook, Related Phenomena poster, markers

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?*

You may want to do an example together before having students brainstorm additional examples. The most common example of a type of organisms that students will say lived long ago will be dinosaurs. Once they raise just one example pause and cue students to continue brainstorming examples for a couple of minutes with a partner.

After discussing in pairs, have students share their ideas with the class. Accept all student responses. Try to draw out a wide variety of related phenomena. Related phenomena will likely include organisms from across many different time periods and scales (single lifetime to millions of years), which is okay.

Keep a public record on the Related Phenomena poster. An example is provided below.

Organism from the past	Similar organism alive today
wooly mammoth	elephant
saber-toothed tiger	tiger
dinosaurs	reptiles (e.g., alligators) and/or birds
wild dog	domestic animals (e.g., pets)
Neanderthal	human
giant fern	small fern

You may also want to prompt students to keep a record of the related phenomena in their science notebook.

* ATTENDING TO EQUITY

Generating related phenomena is a key element of the Anchoring Phenomenon routine. Tapping into prior knowledge and experiences broadens students' thinking related to this phenomenon and helps to make the unit phenomenon become more personally meaningful to each student. It is OK at this point if students share related phenomena that are not all that related.

15 · NAVIGATION

4 min

MATERIALS: None

Discuss new questions. Project **slide X** and prompt students to consider possible reasons for these differences between the ancient and modern type of organisms they brainstormed and shared with the class.

After students discuss in pairs, have a few share their ideas and highlight new questions raised. Summarize by saying, *There are many different organisms that seem like they might be connected—just like Pedro and modern penguins. Maybe looking into Pedro and modern penguins can help us figure out how living things today could be connected to things that lived long ago.*

End of day 3

16 · DEVELOP INITIAL QUESTIONS

8 min

MATERIALS: science notebook, *Predictions On Other Penguins That Lived Long Ago*, *Initial Explanation*, *Podcast Transcript and Photo Journal*, Data Cards for Modern Penguins and Pedro

List new questions. Display **slide Y**. Tell students to add a “Questions” section to their science notebook and jot down any questions they have related to what we have observed so far. Instruct students to look back at all their resources from this lesson, including the following items:

- *Podcast Transcript and Photo Journal*
- sketch of ancient penguin on *Predictions On Other Penguins That Lived Long Ago*
- *Initial Explanation*
- list of similarities and differences in initial explanations
- list of Related Phenomena

17 · REVISE QUESTIONS

4 min

MATERIALS: science notebook, sticky notes, markers, chart paper

Prepare for the Driving Question Board (DQB). Find a place where all students can gather around the DQB. Keep all the chart paper from the lesson near the DQB.

Reference the questions students jotted down in their notebook. Say, *We’ve brainstormed a lot of questions about Pedro, penguins alive today, other penguins from long ago, and other similar phenomena. Now we’re going to post our questions to our Driving Question Board and begin thinking about how we’re going to investigate to figure out if Pedro could be connected to modern penguins and our two sub questions: (1) Where did all the ancient penguins go? and (2) Where did all the different types of modern penguins come from?*



Develop two questions for the DQB.* Project **slide Z** and instruct students to use the question starters on the slide to draft two questions to contribute to the class Driving Question Board. These questions can be ones they already brainstormed, perhaps revised based on the suggested question starters, or they can be new questions. Ask students to write their questions in marker on index card–sized sticky notes (or index cards), one per note. They should write their questions so they are big and bold—we want to be able to see the questions, and they need to be large enough to view when we come in the classroom door. Remind students that it is part of our mission to try to answer these questions.

* ATTENDING TO EQUITY

A DQB provides a public representation of the class’s joint mission. Students can share their questions and wonderings with one another, and the visual representation offers another modality for students to access science in the classroom. It should be centrally located in the classroom so that it can be referenced and added to throughout the unit.

ASSESSMENT OPPORTUNITY

Building towards: 1.C Ask questions that arise from initial observations of patterns in the images depicting anatomical similarities and differences of penguins that are alive today and of a fossil of a penguin from long ago

What to look/listen for

- It is important that *all* questions posed by students be placed on the DQB regardless of whether they are open-ended or close-ended.
- Make note of any close-ended questions and use navigation time throughout the unit to turn close-ended questions into open-ended ones that necessitate a need to examine additional evidence.
- As you move into the discussion of ideas for future investigations and data we need, have students focus on categorizing their questions and then identifying the kinds of data and additional information that would be helpful in answering a category of questions.

What to do: If students are struggling to generate questions connected to their previous observations, direct them back to their sketch of a penguin from long ago, related phenomena, and other resources. If students are struggling to seek information that could inform their explanations, point them back to specific places in their initial explanation and ask, *What would you need to know more about to figure this out?*

18 · BUILD THE DRIVING QUESTION BOARD

20 min

MATERIALS: science notebook, sticky notes, markers, chart paper

Share questions to develop the Driving Question Board. Instruct students to bring their two sticky notes along with their science notebook and meet in a Scientists Circle around the DQB. Share slide AA and say, *We have generated a lot of really good questions that will help us figure out if Pedro could be connected to modern penguins. Right now, we're still working on figuring out our two subquestions: (1) Where did all the ancient penguins go? and (2) Where did all the different types of modern penguins come from?*

It is important that we hear everybody's questions, and we might find that we have questions similar to some of our classmates' questions. In order to help us group similar questions, we are going to create a Driving Question Board. Our DQB will guide our investigations as we attempt to answer the question: How could things living today (like penguins) be connected to the things that lived long ago?

Instruct students to share their questions, one by one, with the whole group. Project slide AA and explain to students how you will create the DQB:*

- The first student reads his or her question aloud to the class, then posts it on the DQB.
- Students who are listening should raise their hand if they have a question that relates to the question that was just read aloud.
- The first student selects the next student whose hand is raised.
- The second student reads his or her question, says why or how it relates, and posts it near the question it most relates to on the DQB.
- That student selects the next student.
- Continue until everyone has at least one question on the DQB.

If the question is a new question and doesn't fit with any questions that are already on the board, students should create a new cluster.

Cluster the questions. After all students have shared their questions, you will end up with a DQB that has several different clusters of questions. As a class, decide on "umbrella" questions or topics for the clusters of questions.

* ATTENDING TO EQUITY

A DQB provides a public representation of the class's joint mission. Students can share their questions and wonderings with one another, and the visual representation offers another modality for students to access science in the classroom. It should be centrally located in the classroom so that it can be referenced and added to throughout the unit.

Here are some examples of the kinds of questions students might come up with:

- 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?

ADDITIONAL GUIDANCE

If there seems to be a cluster of questions about heritable traits, be sure to officially name the cluster on the Driving Question Board. This will be a large focus in Lesson 2. If the cluster doesn't emerge, don't force it. The navigation at the end of this lesson will help us pursue an investigation of heritable traits at the beginning of Lesson 2.

19 · BRAINSTORM IDEAS FOR INVESTIGATIONS

10 min

MATERIALS: science notebook, Driving Question Board, Ideas for Data and Information We Need poster, markers

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. Hang 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?*

Prompt students to use the categories of questions from the DQB to identify types of data and information that would help them answer the category of question that they selected. Students may also wish to look back to their initial explanations at the “Evidence we need to support our claim” and “Evidence that would refute our claim” columns.

Have students turn and talk about their ideas before sharing out with the whole group. Assign each small group a category of questions.

Make a class record of future investigations and data we need. Have small groups share their ideas with the whole group. Make sure that all groups get to share at least a few ideas. As students share, create a class record of the ideas on the Ideas for Data and Information We Need poster. You may also want to prompt students to keep a record of proposed investigations in their science notebook.

Here are some examples of student responses:

- We need to find out what the environment of Pedro was like.
- We want information on other penguins.
- We want to see a map of the location in the past.
- We want to know temperatures in the past.
- We want to look into other animals that had similar effects.
- We want to look into their diet (what they were eating) now vs. in the past.
- We want to look at their poop to see what they ate .
- We want to look at more fossils similar to Pedro.
- We want to look at other animals that lived in the area where Pedro lived.

MATERIALS: None

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.

Additional Lesson 1 Teacher Guidance

SUPPORTING STUDENTS IN MAKING CONNECTIONS IN ELA

CCSS.ELA-Literacy.RST.6-8.2: Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

On day 1, students gather additional information from an audio recording and transcript about a giant penguin fossil that was discovered in the desert of Peru and use it to glean important insights about the traits and characteristics of the penguin fossil that was discovered.

CCSS.ELA-Literacy.SL.6.1.c: Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

When the class is building the Driving Question Board, if a student forgets to explain why or how their question is linked to someone else's question, press that student to try to talk through their own thinking. This is a key way to emphasize the importance of listening to and building off of one another's ideas and to help scaffold student thinking.

If students can't figure out which question to connect theirs to, encourage them to ask the class for help. After an idea is shared, ask the original presenter if there is agreement and why, and then post the question.

Today's activities rely on students communicating and articulating their thinking. One tool that may support classroom discussion is the *Communicating in Scientific Ways* sentence starters. This one-page document can be blown up and printed as a class poster, printed on 8.5"-x-11" paper and posted near students' desks, and/or scaled down and taped into students' science notebooks. To support discussion, reference the sentence starters on the poster and encourage students to use those sentence starters to help them communicate. The sentence starters can be especially useful for helping students engage in scientific talk, particularly students who may feel reluctant to contribute.