A Guide to Developing Literacy Practices in Science

Engaging in Argumentation with a Science Seminar: Regional Climate in the Atacama Desert

Strategy Guide

The Learning Design Group

THE LAWRENCE HALL OF SCIENCE

Earth Science

Grades 6–8

Overview

What's in this guide? This strategy guide introduces the Science Seminar, an approach for teaching students how to engage in scientific argumentation. Students prepare for and participate in a Science Seminar (a whole-class student-run discussion) and then write a scientific argument. In the process, students learn how to analyze evidence in order to argue for competing claims about a natural phenomenon. This guide includes a plan for engaging students in a Science Seminar about factors that affect precipitation in the driest place on earth, the Atacama Desert in Chile.

Why a Science Seminar? A Science Seminar is modeled after a Socratic Seminar, a technique widely used in classrooms where discussion, critical thinking, and the social construction of knowledge are valued. In a Science Seminar, the emphasis is on supporting claims with scientific evidence and reasoning that is based on a strong understanding of science concepts. Engaging students in oral and written argumentation helps students begin to master ways of thinking and communicating that are specific to the discipline of science.

How This Fits Into Your Science Curriculum

This instructional sequence can serve as the culminating experience of a unit on weather and climate. The Science Seminar is an opportunity for students to apply their understanding of how several factors—including surface ocean temperatures, prevailing winds, and topography—affect regional climates. In order to use the evidence in the Science Seminar, students will need some prior understanding about factors that cause precipitation. They should understand that water evaporates from the ocean and precipitates as rain; ocean and air temperatures influence the amount of evaporation and precipitation; and other factors, such as latitude and topography, also impact the amount of rain in a region. Students should also have experience reading maps and diagrams and using features such as keys and legends to obtain information. Though students may not need to apply an understanding of how changes in air density affect precipitation in order to discuss the claims, such knowledge would enhance their ability to reason around the evidence.

Addressing Standards

NEXT GENERATION SCIENCE STANDARDS

Disciplinary Core Ideas

ESS2.C: The Roles of Water in Earth's Surface Processes: The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns.

ESS2.D: Weather and Climate: Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns.

Crosscutting Concepts

Patterns:

- Patterns can be used to identify cause and effect relationships.
- Graphs, charts, and images can be used to identify patterns in data.

(NGSS and CCSS continued on next page)

Addressing Standards (continued)

NEXT GENERATION SCIENCE STANDARDS

Science and Engineering Practices

Analyzing and Interpreting Data: Analyze and interpret data to provide evidence for phenomena.

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.
- 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.

COMMON CORE STATE STANDARDS FOR ELA/LITERACY

Reading Standards for Literacy in Science and Technical Subjects 6–12

RST.6–8.7: Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Writing Standards for Literacy in History/Social Studies, Science, and Technical Subjects 6–12

WHST.6–8.1b: Write arguments focused on discipline-specific content. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.

College and Career Readiness Anchor Standards for Speaking and Listening

SL #4: Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.

Science Background

The average **precipitation** levels in a **climate region** depend on the amount of **water vapor** carried in the wind. The amount of water vapor in the air is affected by several factors, including air **temperature**, surface ocean temperature, and regional **topography**. These factors can cause air in a region to become supersaturated with water vapor, as in the case of a rainforest, or almost devoid of it, as in a desert. Most water vapor enters the atmosphere when wind blows across the ocean. The amount of water vapor picked up by these winds is determined by both ocean temperature and air temperature. Ocean temperature determines the quantity of available water vapor—when the ocean is warm, more water evaporates; when the ocean is cold, less water evaporates. Air temperature determines the capacity of the wind to pick up the available water vapor. If the air temperature is high, the air can hold more water vapor; if the air is cool, it will hold less water vapor. **Prevailing winds** also move air from one region to another. Precipitation occurs when the amount of water vapor in an area reaches the air's maximum capacity at a given temperature. A specific pattern that affects mountainous regions, such as the Pacific coast of South America, is the rain shadow effect. This is where prevailing winds that are rich in water vapor hit a mountain range and are forced up to a higher, colder elevation. The air's capacity to hold water vapor quickly decreases with the temperature, and almost all the water vapor precipitates as rain on the windward slope. Once the wind reaches the other side of the mountain range, it has very little water vapor left. Hence, the leeward side of a mountain tends to be dry and have a desertlike climate.

Getting Ready: Day 1

1. Make one set of color copies of Evidence Cards A, B, and C for each student. (You can reuse the Evidence Cards in each class by having students write notes on a separate piece of paper rather than having them annotate directly on the cards.)
2. Make one copy of the Analyzing Evidence copymaster for each student.
3. On separate sheets of chart paper, record the Language of Argumentation and Why Does the Atacama Desert Get So Little Precipitation? and post them where they will be easily visible to all students.
4. On the board, write "What do you notice about this map? What do you think the map shows? Why do you think so?"

Introducing the Topic (10 minutes)

1. **Project Evidence Card A: South America: Annual Precipitation (1976–2009).** Direct students to look over the map. Draw their attention, in particular, to the key in the lower lefthand corner as well as to the labels.
2. **Pose questions.** Have students think about the prompts you wrote on the board: *What do you notice about this map? What do you think the map shows? Why do you think so?*
3. **Students respond.** Ask students to record their ideas about the questions individually. Alternatively, you could have students discuss their ideas with a partner.
4. **Debrief.** Lead a class discussion in which volunteers share their responses to the questions. Build on students' comments to point out the significance of the title. [This is about precipitation in South America.] Also point out the significance of the key. [The different colors show how much precipitation, or rain, each area receives.]
5. **Annotate wettest and driest locations.**
   - Have students help you find the areas on the map that get the most rain. Draw a circle around the purple areas near the Amazon Basin. Next to the circle, write "areas with the most rain."
   - Point out the location of Lloro, Colombia. Have students explain why this location is notable. [It is one of the wettest places on Earth.]
   - Have students help you find the areas on the map that get the least amount of rain. Draw a circle around the red areas on the Pacific coast. Next to the circle, write "areas with very little rain."
   - Point out the area of the Atacama Desert and have students explain why it is notable. [It is considered the driest place on Earth.] Explain that this is because some parts of the Atacama Desert have had no rain for hundreds of years.
6. **Emphasize the idea of patterns.** Explain that Earth scientists observe and try to understand weather patterns and the causes of those patterns. For example, they might investigate what causes the weather pattern where some areas of the South American Pacific coast get a lot of rain, and other areas get very little rain. To start investigating, they will look for patterns in the factors that usually impact the amount of rain.
7. **Introduce the question.** Wonder aloud how one of the wettest places on Earth and the driest place on Earth can be found on the coast of the same continent. Direct students' attention to the Why does the Atacama Desert Get So Little Precipitation? poster and read aloud the title/question. Explain that students will be focusing on this question.
8. **Introduce the Science Seminar.** Explain that for the next two sessions, students will work collaboratively to make a scientific argument to explain why the Atacama Desert gets so little precipitation although other areas in the region have some of the highest levels of rain on Earth. Explain that students will prepare for a discussion called a Science Seminar in which they will use evidence to discuss possible claims that could answer this question.
9. **Introduce claims.** Have a student read aloud each claim from the poster. Explain that these claims relate to three factors that scientists know can influence weather and could affect patterns of low precipitation in South America: prevailing winds, location of mountain ranges, and ocean surface temperatures.

Analyzing Evidence (25 minutes)

1. **Give overview of the task.** Explain that today, students will identify evidence that could support the different claims. With a partner, students will carefully examine information about ocean temperature, winds, and surface features so they can consider which claim they think is best supported by the evidence.
2. **Model analyzing a map.** Project Evidence Card B: Ocean Temperature.
   - Explain that you are going to think aloud as you analyze possible evidence. Say, **"When you discuss the evidence with your partner, you should also explain your thinking. As you are listening to your partner explain his ideas, ask for clarification if needed."**
   - Direct students' attention to the map and say, **"When looking at information that is presented visually, as in this map, it is helpful to first look at the title, the key, and any captions or labels. From**

Scaffolding Argumentation Instruction

Preparing for and participating in a Science Seminar involves students in many complex tasks that require higher-order thinking. These tasks include close reading and analysis of evidence, connecting evidence to a claim, coordinating multiple pieces of evidence, evaluating competing claims based on evidence, and explaining reasoning. All these tasks can be challenging for students, so it is worth making sure that instruction is carefully scaffolded to allow students to engage with complex material in a meaningful way. Take the time to support the different aspects of analyzing evidence until students understand what to do and how to think through the relationship between the evidence and the claims. A Science Seminar is a multifaceted activity that allows students to engage at multiple levels, depending on their current understanding of the content as well as their facility with argumentation. Thus, a Science Seminar provides a rich experience that can be accessible for students at various levels of experience. If you incorporate additional Science Seminars into your science program, scaffolds can be reduced over time, and the complexity of questions and evidence with which students work can be increased.

the title, I know that this map shows the surface temperature of the ocean. The key indicates that the colors show the difference in surface temperatures of the ocean."

- Read the title and text at the top of the page and say, **"This explains a connection between surface ocean temperature, winds, and water vapor. It also explains that water vapor can become precipitation."**
- On the map, circle the area where the greatest precipitation is (the Amazon Basin) and write "wettest." Then, circle the coast area of the Atacama Desert and write "driest." Say, **"I know I need to think about precipitation in the wettest and driest places in South America, so I'm going to mark on the map where the wettest and driest areas are."**

3. **Encourage students to write their ideas on their maps (or on separate sheets of paper).** Point out that you have demonstrated one way to make a connection between the precipitation map and the ocean temperature map, but there are many ways to make connections between the maps and a great deal of information to analyze. Students should annotate their maps in the way that makes the most sense to them and that helps them consider how the information in the maps might be evidence to support claims about the Atacama Desert.
4. **Distribute materials.** Distribute one set of Evidence Cards (A, B, and C) as well as one copy of the Analyzing Evidence student sheet to each student.
5. **Point out discussion questions.** Review the steps for partner work. Remind students that partners should prompt each other to make their thinking visible and clear as they consider the possible evidence. Point out the questions for Evidence Cards B and C on the Analyzing Evidence student sheet and explain that partners should discuss these questions in order to help them analyze the evidence presented on the Evidence Cards.
6. **Students analyze evidence.** As students work, listen for comments to which you can refer back during a class discussion (e.g., examples of building on each other's ideas; strong reasoning; integrating information in the map, key, and text). It's okay, at this point, if some students arrive at partial answers while others are able to fully develop an explanation.
7. **Students record ideas.** If students have not already done so, direct them to respond in writing to the two questions at the bottom of the Analyzing Evidence student sheet.

Connecting Evidence to Claims (10 minutes)

1. **Prompt students to connect evidence to the claims.** After students have had some time to analyze each Evidence Card, regain their attention. Refer to the claims on the Why Does the Atacama Desert Get So Little Precipitation? poster and prompt students to consider how the evidence on the cards connects to one another and to the claims. Direct students to explain their reasoning to their partners and to make their thinking visible. Refer to the Language of Argumentation poster and suggest that students can use the sentence starters in their discussions.
2. **Students make preliminary selection of a claim.** After students have discussed how the

evidence connects to the claims, ask, **"When considering all the evidence, which claim do you think is best supported by the evidence? Why?"** Have partners discuss this briefly.

3. **Lead open-ended discussion of claims.** Ask a few students to explain why they selected a certain claim as best supported by the evidence. If needed, prompt students to discuss the claims they chose by asking other students if they agree or disagree. Alternatively, prompt students to refer to ideas in the Evidence Cards that shaped their thinking. Try to point out examples of strong and clear reasoning in students' responses, allowing for answers to be at different levels of complexity and accuracy.
4. **Conclude session.** Let students know that they may change their choice of claims or revise the claims as they discuss and build on one another's ideas in the Science Seminar in the next session.

Getting Ready: Day 2

1. Make a copy of the Preparing for the Science Seminar copymaster for each student.
2. On chart paper, record the Science Seminar Expectations and post them where they will be easily visible to all students.
3. For science seminars to be a productive dialogue between students, the arrangement of the classroom matters. Place the chairs, desks, or tables into two concentric semicircles so students in the inner semicircle can face inward and talk to one another instead of to the teacher. Students in the outer semicircle will be observers, so they should face inward as well. Make sure students can still see the board or wall where you will be projecting the Evidence Cards for reference, as well as the Language of Argumentation poster, the Why Does the Atacama Desert Get So Little Precipitation? poster, and the Science Seminar Expectations poster.
4. In the Science Seminar, half of the class will engage in a group discussion while the other half listens. Then, students will switch roles. To prepare, consider how you want to balance students in each group, making sure that there is a mix of students in each group who speak in class frequently as well as those that are more reticent.

Preparing for the Science Seminar Discussion (10 minutes)

1. **Set purpose.** Remind students that today they will discuss and build on one another's ideas to try to understand which claim is the strongest in explaining why the Atacama Desert gets so little precipitation.
2. **Take stock.** Distribute one copy of the Preparing for a Science Seminar student sheet to each student. Have a student read the question and the three claims aloud. Ask, **"Which claim do you currently think is best supported when considering all the evidence?"** Allow a few minutes for students to review the Evidence Cards and their notes from the previous session to think about this question.
3. **Make notes about the evidence.** Have students write which claim they think is the best supported. Then have them respond to Steps #2 and #3.
4. **Explain the purpose of a Science Seminar.** Say, **"The purpose of a Science Seminar is to use everyone's knowledge to come to a deeper understanding of a question. You don't need to agree on every point made during the seminar, but you should be willing to listen to and build upon others' ideas. During a Science Seminar, you have the chance to learn something new and change or build on your own ideas by listening to what others have to say."**
5. **Point out seminar expectations.** Point out the Science Seminar Expectations poster. Have a volunteer read these expectations aloud and ask students if they have any questions. Explain that this will be a student-run conversation as much as possible. Encourage students to talk to one another and not to you!
6. **Review Language of Argumentation.** Refer students to the Language of Argumentation

Supporting English Language Learners

If you think ELLs might feel reluctant or struggle to participate in a large-group discussion, consider having pairs practice sharing ideas with each other before the Science Seminar. Point out the Language of Argumentation sentence starters and have students use these to practice what they will say. Have one student state one claim to her partner and explain one piece of evidence that supports that claim. The partner who is listening can either ask a question or make a comment connected to the idea. Partners then switch roles, and the other partner has a turn to practice. This practice can help students feel more prepared to comment in the larger group.

poster. Suggest that they use the sentence starters during the seminar if they need help explaining their ideas.

7. **Explain the procedure.** Explain that students will sit in two nested semicircles, with all students facing inward. We suggest semicircles so students will be able to see one another and also be able to see claims or evidence projected at the front of the classroom. Explain that students in the outer semicircle will listen and take notes while students in the inner semicircle will present and discuss. After a certain amount of time—approximately 10 minutes—students in the semicircles will switch positions and roles.
8. **Explain listener role.** Explain that members of the outer semicircle will have responsibilities, too. They will be expected to listen carefully to the discussion. They should take notes in the space provided at the bottom of the Preparing for a Science Seminar student sheet, especially when they hear new or interesting ideas presented by their peers. You may wish to state that you expect to see at least two ideas written by each student when they are in the outer circle, although they can certainly write more.

Engaging in the Science Seminar (25 minutes)

1. **Have students take seats in semicircles.** Divide students into two groups—the inner semicircle will be the first group to discuss; the outer semicircle will be the second group to discuss—and have students arrange their chairs to form two concentric semicircles, if this hasn't been done yet.
2. **Review question and claims.** Remind students that they will be discussing specifics about the evidence in order to develop a fuller understanding of the possible answers to the question *Why does the Atacama Desert get so little precipitation?*
3. **Begin Science Seminar.** Engage students in a deep discussion of the evidence before they begin to evaluate the claims. Guide the discussion by using the following prompts, but try to have students guide the conversation as much as possible.
    - **Discuss Evidence Card A.** Project Evidence Card A and ask students to discuss what the information on Evidence Card A suggests about precipitation levels in the Atacama Desert.
    - **Discuss Evidence Card B.** After a few minutes, project Evidence Card B and ask students to discuss how they think ocean currents affect precipitation in the Atacama Desert. If needed, prompt students to compare Cards A and B, using their notes from the Analyzing Evidence student sheet.
    - **Discuss Evidence Card C.** After a few minutes, project Evidence Card C and ask students to discuss the impact they think the rain shadow effect has on the Atacama Desert.
    - **Evaluate the claims.** Reserve a few minutes for the first group to evaluate the claims. Refer back to the claims on the Why Does the Atacama Desert Get So Little Precipitation? poster and prompt students to explain which claim they think is strongest. If needed, direct students to

Facilitating Student-Led Discussions

A primary goal of the Science Seminar is to turn over to students as much of the conversation as possible. This provides opportunities for students to develop skills in building knowledge collaboratively and disagreeing productively. It has the additional benefit of helping students see their peers as intellectual resources and their class as a learning community. However, if this type of collaborative discussion is new to your students, it will probably take extra encouragement from you to get students to take charge of the discussion. During the Science Seminar, it is important for you to step out of the discussion as much as you can—some teachers stand away from the semicircles or behind students so they are visually removed from the discussion. A Science Seminar may have some periods of silence, which can feel uncomfortable. However, these periods of silence can create an important space for students to take the initiative and step into the discussion. If the discussion feels stalled or if students turn to you for answers, you can turn the discussion back over to them by asking questions. For example, you could ask questions such as:

- "Do you agree or disagree with that idea? Why?"
- "What other evidence could support the claim?"
- "Is there another way we could explain this claim?"
- "What other claims could you make? Based on what evidence?"

the Language of Argumentation poster to help them explain their ideas.

4. **Groups switch roles.** After about 10 minutes, bring the first half of the discussion to a close. Have the two groups switch seats.
5. **Continue the Science Seminar.** Suggest that the second group review and share ideas about each Evidence Card before they discuss the claims, just as the first group did.
   - **Project each Evidence Card as students discuss.** With Evidence Card A projected, ask whether the second group agrees or disagrees with how the first group analyzed the evidence. After a few minutes, project Evidence Card B and have students agree, disagree, or build on the ideas of the first group. Do this again for Evidence Card C. Suggest that students think about how the ideas on the Evidence Cards connect to one another.
   - **Evaluate the claims.** Highlight one or two important points you heard during the first group's discussion of the claims. You might ask some of the following questions:
     - **"Are there other claims you would like to discuss that the first group did not discuss?"**
     - **"The first group agreed on Claim __. What additional evidence supports this claim?"**
     - **"How sure can we be about this claim?"**
     - **"Are any of the claims related? How would one of these factors affect the other?"**
6. **Give reminders as needed.** You may want to remind students that they are responsible for presenting ideas, discussing the evidence, and asking one another questions. At times, you might also need to prompt students to refer to the projected evidence, to respond to one another's ideas directly, or to explain how their evidence connects to the cause for extremely low precipitation in the Atacama Desert.

Concluding the Science Seminar (10 minutes)

1. **Prompt revising of claims.** If students do not raise the issue of revising the claims, prompt them to do so as the discussion draws to a close. Provide an opportunity for students to consider if there is a way to combine the claims. Ask the inner circle to think about and discuss the question *How could we revise one or more of these claims so it is more complete?* Then, allow the outer circle to add a few thoughts. On the board, record ideas for revised claims. Students may also wish to write revised claims in their notes.
2. **Summarize.** Highlight one or two important examples of strong reasoning and coordination of evidence and claims that you heard in the second discussion. Say, **"Your work in the Science Seminar helped us more fully answer the question *Why does the Atacama Desert get so little precipitation?* As you discussed, there are a number of ways that surface ocean temperature, winds, and location of mountain ranges can affect precipitation."** Explain that in the next session, students will develop their ideas further in writing.
3. **Highlight argumentation as a practice.** Explain that students' preparation for and discussions during the Science Seminar are similar to what happens in the scientific community. Point out that scientists work together to figure out answers to questions about the world, such as the question about why the Atacama Desert gets so little precipitation. Just as students did, scientists examine available evidence and try to make the most complete argument they can.

Getting Ready: Day 3

1. For each student, make one copy of each of the following three copymasters: Comparing Two Arguments, Argument About the Atacama Desert, and Peer Feedback Checklist—Scientific Argument.
2. On chart paper, record the Guidelines for Writing a Scientific Argument and post them where they will be easily visible to all students.

Preparing to Write (15 minutes)

1. **Set purpose.** Explain that today, students will communicate their most complete and persuasive thinking in a written argument about why the Atacama Desert is the driest place on Earth. Point out that writing arguments is a way that scientists clarify and strengthen their thinking and communicate their ideas to persuade others. Explain that students

Providing More Support for Writing

The Science Seminar provides excellent support for helping students engage with scientific-argumentation writing. Students have done extensive preparation for writing by thinking through and making notes about the evidence, considering claims carefully, and discussing their arguments during the Science Seminar. If students need additional support, specifically with writing, consider some of the following options: 1) You could provide a graphic organizer for students to collect ideas—some students may benefit from making additional notes in order to process the Science Seminar discussion before they start writing. A graphic organizer could include a place for the claim, for evidence that supports the claim, and for connecting ideas with reasoning. 2) You could post key vocabulary words in the room or provide a word bank from which students can draw as they write. 3) You could provide students with additional sentence starters to help them begin their arguments. While this provides some language for students to use in order to organize their arguments, it still requires them to provide their own ideas.

will prepare for writing their own scientific arguments by comparing two example arguments.

2. **Students read two versions of an argument.** Project Kauai: Sea Surface Temperature and Prevailing Winds and explain that students will read example arguments about the climate in Kauai, one of the Hawaiian Islands. Explain that the map being projected will help them understand the argument. Distribute one copy of the Comparing Two Arguments student sheet to each student and have them read the two arguments to themselves.
3. **Students respond.** Have students respond to the prompts by writing notes or annotations on the arguments.
    - How are the two arguments similar?
    - How are the two arguments different?
    - Which argument is more persuasive?
4. **Discuss responses.** Encourage students to share their analyses of Argument A and Argument B. Guide students in discussing the similarities and differences they notice between the two arguments.
5. **Discuss Argument B further.** Use Argument B to highlight a few key elements that students should include in their own writing. When possible, build on and incorporate students' comments from the discussion about what makes the argument strong.
    - **Start with a claim.** Point out that Argument B started by clearly stating a claim that answered the question. When students' write their arguments about the Atacama Desert, they can start with one of the three claims they have been considering, or they can write their own revised claims.
    - **Support all parts of the claim with evidence.** Remind students that all parts of a claim should be supported with evidence. Have students point out examples of evidence in Argument B that support the claim.
    - **Explain reasoning to show how the evidence supports the claim.** Point out that in Argument A, there is evidence provided about warm ocean water, but it does not explain how this relates to precipitation. Ask students to explain in their own words how Argument B explains how warm ocean currents and precipitation are related. Explain that students should be sure to explain all their ideas clearly and logically when they write their own arguments.
6. **Summarize difference between the arguments.** Focus on Argument B and conclude that it is stronger because, in addition to including evidence about ocean temperature and prevailing winds, it explains reasoning about *how* these affect precipitation. On the other hand, Argument A simply states that the map indicates that these are factors.
7. **Discuss elements of a scientific argument.** Refer to the Guidelines for Writing a Scientific Argument that you posted on the wall. Explain that these guidelines are characteristics of a strong scientific argument that students may have noticed were present in Argument B. Say, **"A scientific argument is persuasive. Your job today is to clearly explain how your claim about the Atacama Desert is connected to and supported by the evidence. You should explain all the evidence clearly and logically**

Formative Assessment Opportunity

An important and often challenging part of argumentation is logically connecting pieces of information together to support a claim. Information becomes evidence by clearly stating how it connects to the claim. The writing assignment that students complete in this session is intended to draw out their understanding of how ocean temperatures, topography, and wind currents affect regional climates. Reading students' writing provides a window into their understanding of these ideas. Arguments can also be evaluated in terms of their organization and clarity. You can refer to the Rubric for Writing a Scientific Argument to evaluate students' written arguments. The rubric can provide useful information about students' written argumentation skills, which you can incorporate into future sessions on argumentation. Note that the criteria reflected in the rubric are simplified and condensed in the Peer Feedback Checklist—Scientific Argument that students use to evaluate one anothers' writing. The criteria are also summarized in the Guidelines for Writing a Scientific Argument. You might also consider sharing the rubric with students before they write to help communicate expectations or to help students give more detailed comments to their peers.

so that someone reading your argument will understand why the evidence you included is important."

Writing Arguments (20 minutes)

1. **Students review notes.** Remind students that they have notes from the Science Seminar to help them when they write their arguments. Give students a few minutes to review their notes and the Evidence Cards and think about what they will write.
2. **Encourage students to be open minded.** Explain that scientists are open to changing their claims if they are presented with convincing evidence. In the same way, students' ideas of why the Atacama is so dry may have changed over the past few days. Remind students that they are free to make changes to their original claims, or they can combine or revise claims if they feel it will make their arguments stronger.
3. **Students write.** Distribute one copy of the Argument About the Atacama Desert to each student. Have students write their claims and then start to write their arguments. Circulate as students write, offering assistance as necessary.

Revising Arguments (10 minutes)

1. **Introduce the Peer Feedback Checklist—Scientific Argument student sheet.** When most students have finished writing, project the Peer Feedback Checklist. Explain that students will now have a chance to get feedback from a partner so they can strengthen their arguments.
2. **Organize students into pairs and have them exchange their written arguments.** Distribute one copy of the Peer Feedback Checklist to each student. Have pairs exchange their written arguments, carefully read each other's arguments, and complete their checklists.
3. **Students revise as time allows.** Encourage students to carefully read the feedback they received from their partners and spend a few minutes making changes based on that feedback. You may wish to allow more time for students to revise and then make final drafts of their arguments in another session.

Connecting to Standards

Engaging in argumentation through a Science Seminar is an approach that capitalizes on the overlap between the science practices in the Next Generation Science Standards (NGSS) and the Common Core State Standards (CCSS) for English Language Arts. One way a Science Seminar addresses these standards is by integrating central practices around argumentation and the use of evidence. For example, as students analyze and interpret maps, diagrams, and text data about the Atacama Desert (NGSS Science Practice 4: Analyzing and Interpreting Data), they integrate information expressed in words with information expressed visually (CCSS.ELA-Literacy.RST.6–8.7). Further, participating in oral and written scientific argumentation (NGSS Science Practice 7: Engaging in Argument from Evidence) requires students to write arguments focused on discipline-specific content that supports claims with data, evidence, and logical reasoning (CCSS.ELA-Literacy.WHST.6–8.1b).

Generalizing This Practice

A Science Seminar is an approach that can be used throughout your science curriculum with a variety of evidence and topics. A Science Seminar works best as the capstone experience in an instructional sequence so students can bring deep knowledge of concepts to the discussion and to their writing. One benefit of having students engage in argumentation through a Science Seminar is that the multimodal nature of this approach (reading, using visual representations and data, discussing, and writing) allows for a rich experience in which there are multiple ways for students to engage with the ideas. A Science Seminar also puts the onus for constructing arguments on students, since they are responsible for the discussion. Along the way, students learn general strategies for analyzing evidence, supporting claims, and explaining their reasoning. Use the following steps to conduct a Science Seminar with other science content.

Preparing for a Science Seminar

1. **Select a focus.** Select a natural phenomenon for students to explain that requires them to apply core concepts from the current unit of study. Try to find an interesting or surprising phenomenon that you think will spark student interest as well as draw upon their background knowledge.
2. **Write a question.** Develop the question that students will discuss in the Science Seminar. It's best if the question legitimately has more than one correct answer or more than one way that it could be explained. "Why" or "how" questions tend to work well for Science Seminars.
3. **Write claims.** Craft two or three claims that could answer the explanatory question. To ensure rich discussion, it is important to have at least two of the claims be plausible and well-supported by evidence—if one claim is obviously correct, this will dampen the discussion.
4. **Find evidence.** Identify sources of evidence that could support the claims. The evidence should push students to reason in a way that involves applying the core concepts. Evidence can come from students' firsthand investigations; from texts; from visual representations, such as diagrams or charts; from videos; or from other sources.
5. **Plan to support students in discussing the evidence.** Most students need support in analyzing individual pieces of evidence before they consider how multiple pieces of evidence may be coordinated to support claims. You may want to create materials such as discussion questions (see the Analyzing Evidence copymaster included with this guide for examples), sentence starters (see the Language of Argumentation poster), or graphic organizers that will support students in analyzing the evidence and provide ways for them to keep track of their ideas and engage in peer discussion.

Implementing a Science Seminar

Day 1: Gathering and Analyzing Evidence

1. **Activate background knowledge.** Pose and briefly discuss an opening question that helps students activate their knowledge about a challenging aspect of the seminar content or process of argumentation. This surfaces existing ideas and possible misconceptions.
2. **Introduce students to a phenomenon.** Introduce the phenomenon that will be the focus of the science seminar. You might do this through a visual representation, a video, a text, etc.
3. **Introduce the question and possible claims.** Explain how argumentation helps scientists build science knowledge together. Pose the question that students will try to answer as well as the possible claims.
4. **Model how to analyze evidence.** Introduce the evidence. Think aloud about how you would analyze an aspect of the evidence. Remind students to make their own thinking clear as they work with partners.

(continued on next page)

Generalizing This Practice (continued)

5. **Students analyze evidence.** Give students time and support to consider what each piece of evidence tells them before they try to connect it to claims. Prompt students to annotate the evidence or record notes.
6. **Students connect the evidence to the claims.** Prompt students to consider how the pieces of evidence may connect to one another and to the claims. You might model how to coordinate evidence and develop justifications or call out strong examples when students do this on their own.
7. **Students consider the claims.** Toward the end of the session, prompt students to select which claim they currently think is best supported when considering all the evidence.
8. **Foster class discussion.** Conclude the session by having volunteers explain their reasons for picking one claim over the other(s). Prompt them to explain what makes one claim more convincing. Allow for different levels of accuracy and complexity in students' understanding at this point and support students in engaging one another's ideas.

Day 2: Engaging in the Science Seminar

1. **Review purpose.** Remind students that today they will discuss and build on one another's ideas to try to understand possible answers to the question.
2. **Students review notes.** Have students review the claims and the evidence they think supports the claims. Ask students to identify evidence they will use in the Science Seminar and to make notes that will help them during the discussion.
3. **Set expectations.** Emphasize that the goal is to build on and engage one another's ideas respectfully in order to develop a strong answer to the focus question for the seminar. Explain that during the Science Seminar, students should talk to one another rather than to you.
4. **Provide language for students to use.** Consider providing sentence starters or a word bank with language that students can use during the discussion to help them explain their ideas.
5. **Review process.** Explain how the Science Seminar will work. One group of students will start by being participants while a second group will be active listeners. Then, groups will switch places and roles. Review your expectations for listeners.
6. **Students take seats in semicircles.** Divide students into two groups— the inner semicircle is the first group to discuss; the outer semicircle is the second group to discuss. Make sure students have all their notes in hand and that they can see the Science Seminar question and claims as well as any visuals to which they can refer during the discussion.
7. **Begin the Science Seminar.** Ask a volunteer to start by reviewing what the evidence shows or connecting evidence to the claims. At times, you might need to prompt students to refer to evidence, respond to one another's ideas, or explain how their evidence connects to the claims. It may be helpful to project evidence and prompt each group to share ideas about the evidence for a period of time before they discuss how the evidence connects to the claims and what makes one claim more convincing than another. Although you may guide the discussion by asking students to consider the evidence and then the claims, try to let students run the discussion as much as possible.
8. **Groups switch roles.** After about 10 minutes, bring the first half of the discussion to a close. Have the two groups switch seats.

(continued on next page)

Generalizing This Practice (continued)

9. **Continue the discussion.** Highlight one or two important points you heard during the first discussion. You might ask questions that prompt students to build on or respond to comments from the first group or that ask students to consider evidence or claims that have not yet been thoroughly discussed.
10. **If needed, prompt revising of claims.** Toward the end of the second group discussion, you may wish to provide an opportunity for students to think about the claims and try to adjust them based on the discussion. Students might propose combining the claims, revising one or more of the claims, or offering alternative claims. Allow some students from the outer semicircle to add their thoughts to this part of the discussion as well.
11. **Conclude seminar.** Highlight one or two important examples of strong reasoning and coordination of evidence and claims that you heard during the second discussion.

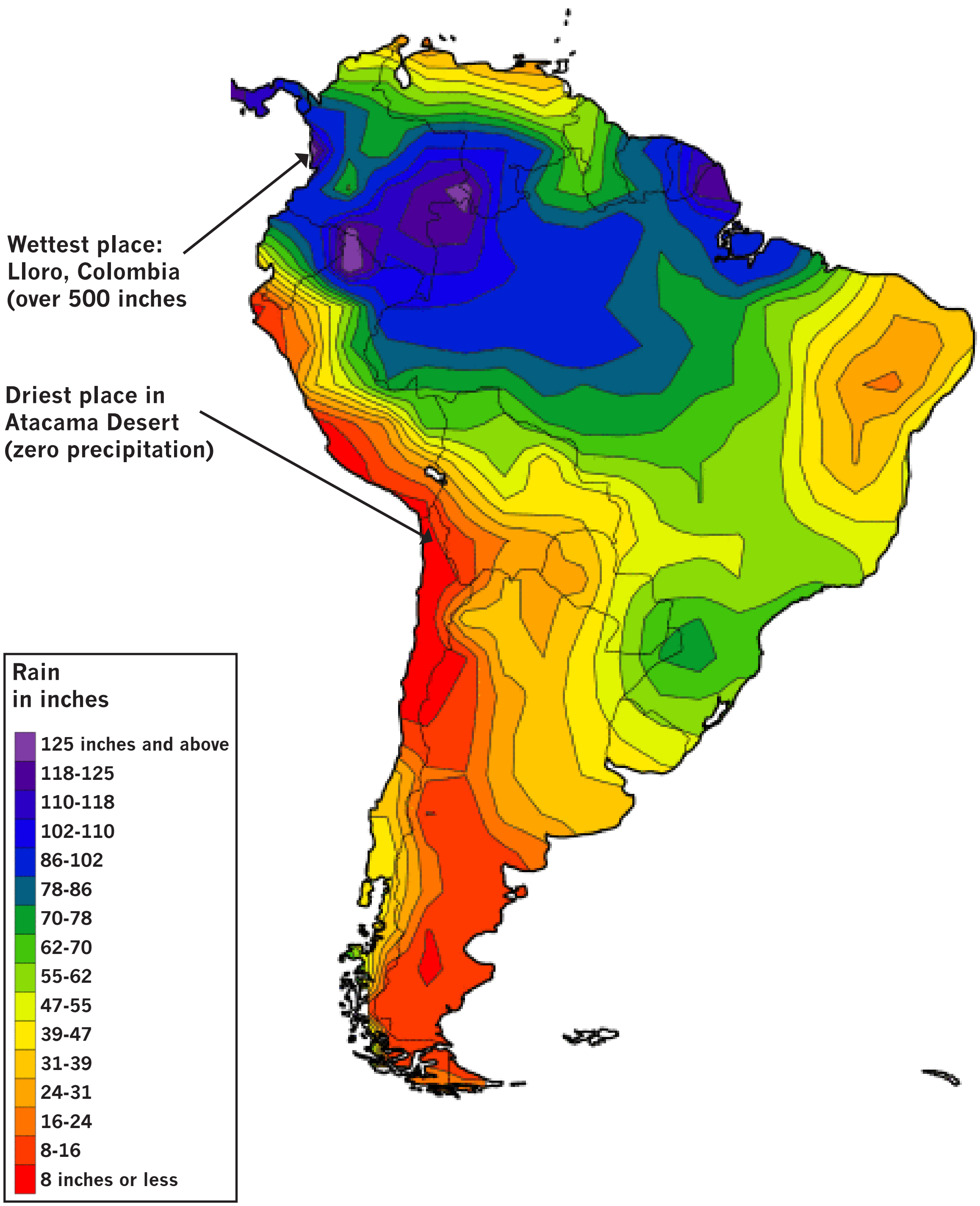
Day 3: Writing an Argument

1. **Review the claims.** Pose and briefly discuss an opening question that helps students activate their knowledge about the topic and the claims under consideration.
2. R**eview an example.** Depending on students' experience with argumentation, select an aspect of argumentation on which you would like them to particularly focus their writing. Provide an example that helps them understand the skill (e.g., how to make clear connections between evidence and claims).
3. **Review guidelines for scientific arguments.** Have guidelines posted so they are visible for students while they write.
4. **Students write.** Circulate and provide help as students write.
5. **Provide time for peer feedback.** It may be helpful to provide students with a rubric or checklist that will support them in providing specific feedback to one another, particularly as related to the skill you focused on in the example.
6. **Students revise.** If possible, refer to or project a strong example that you noticed while observing students writing.
7. **Conclude session.** It is helpful to provide some supportive comments about areas or examples of growth in students' skills.

Evidence Card A

South America: Annual Precipitation

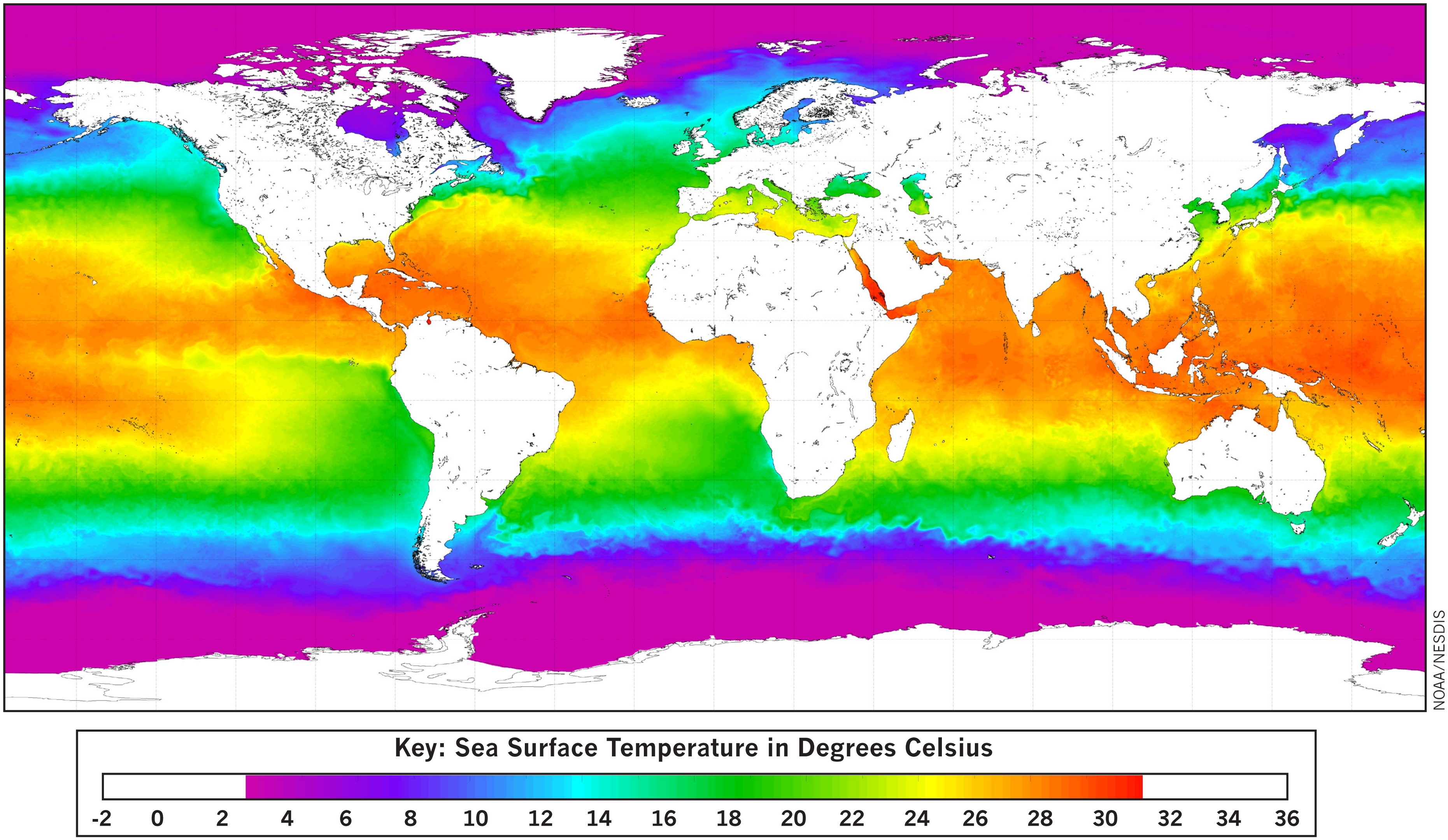
(1976–2009)



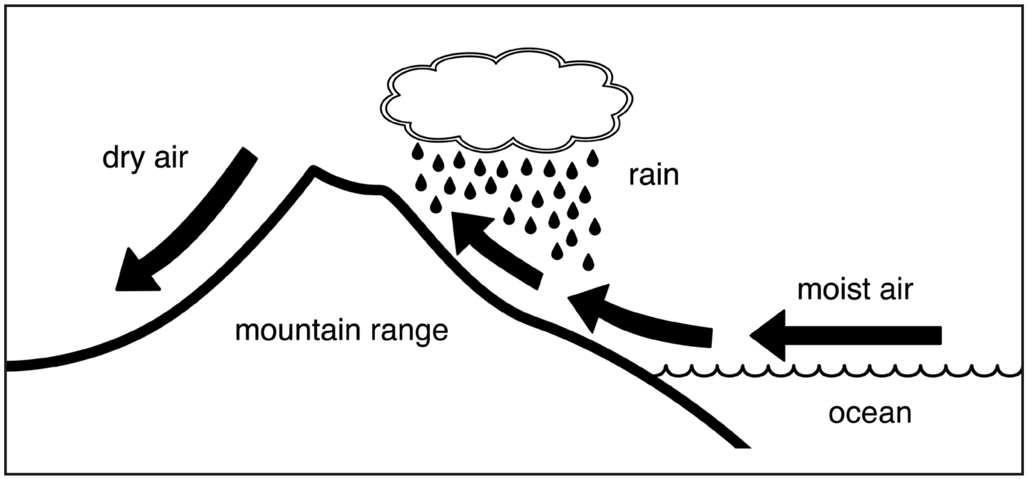
NOAA/Liebmann, B., and D. Allured, 2005: Daily precipitation grids for South America. Bull. Amer. Meteor. Soc., 86, 1567-1570.

Evidence Card B
Ocean Temperature

The amount of ocean water that evaporates varies with surface temperature. Cold ocean water evaporates more slowly than warm ocean water, forming less water vapor. Water vapor can condense into precipitation. Therefore, less water vapor leads to less precipitation. Ocean water that evaporates is carried in the direction of prevailing winds.



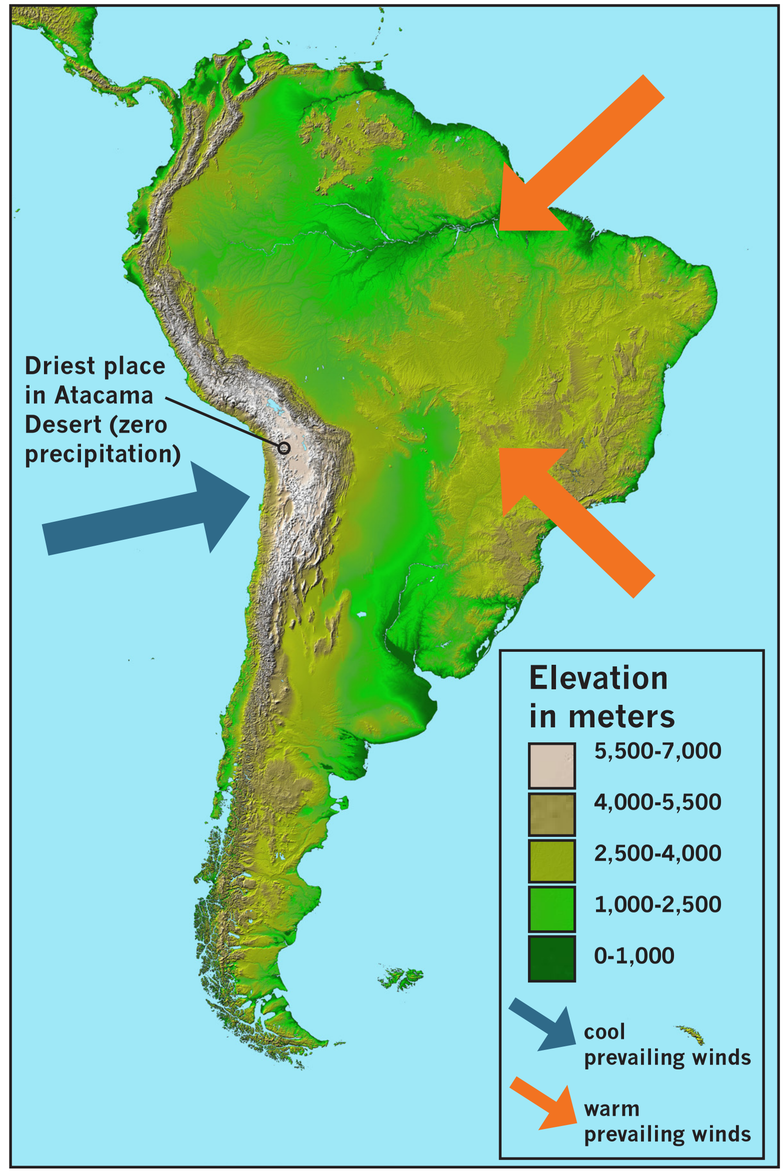
Evidence Card C
Rain Shadow Effect



Learning Design Group/UC Regents

When winds carrying moist air move up the side of a high mountain range, the air cools as it rises. The water vapor in the air condenses and falls as precipitation. After the wind passes the top of the mountain range, it no longer has much water vapor. The way that high mountains block water vapor from getting to the opposite side of the mountain range is called the rain shadow effect.

South America: Elevation and Winds



NASA/JPL/NIMA

Name: ______________________________ **Date:** ______________

Analyzing Evidence

Discuss the following questions with your partner.

Card B
1. What do the colors on the map tell you?
2. What is similar about the areas of South America that get **a lot** of precipitation?
3. What is similar about the areas of South America that get **very little** precipitation?

Card C
1. What does the diagram of the rain shadow effect show?
2. What does the map show?
3. What do you notice about the areas that get **very little** precipitation?

Write your ideas about the following questions.

How does ocean surface temperature affect precipitation?

____

____

____

____

How do the rain shadow effect and the location of mountain ranges affect precipitation?

____

____

____

____

Language of Argumentation

- I think this evidence shows . . . because . . . .
- Could you explain your thinking?

- Claim . . . is more convincing because . . . .
- Claim . . . is weaker because . . . .
- This evidence supports the claim because . . . .

- I agree because . . . .
- I disagree because . . . .

Why Does the Atacama Desert Get So Little Precipitation?

- **Claim 1:** Prevailing winds on the Pacific coast cause extremely low precipitation in the Atacama Desert.

- **Claim 2:** The location of mountain ranges causes extremely low precipitation in the Atacama Desert.

- **Claim 3:** Surface temperatures of the ocean cause extremely low precipitation in the Atacama Desert.

Name: ______________________________ Date: ______________

Preparing for the Science Seminar

Question: Why does the Atacama Desert get so little precipitation?

Review your notes from last session to see which claim you picked and the evidence you thought supports that claim. Explain your choice below.

Claim 1	Claim 2	Claim 3
Prevailing winds on the Pacific coast cause extremely low precipitation in the Atacama Desert.	**The location of mountain ranges causes extremely low precipitation in the Atacama Desert.**	**Surface temperatures of the ocean cause extremely low precipitation in the Atacama Desert.**

1. The claim I currently think is best supported by the evidence is Claim _____.

2. The strongest evidence that supports this claim is: ______________________________

   ____

   ____

   ____

3. This evidence supports the claim because: ______________________________

   ____

   ____

   ____

Notes (for when you are in the outer semicircle):
As you listen to your peers discuss during the Science Seminar, write at least one new and convincing idea that you heard.

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Science Seminar Expectations

Goal: Work together to better understand the possible answers to the question.

- Students lead the conversation.
- Use evidence to support ideas.
- Explain your thinking as clearly as possible.
- Listen to one another.
- Respond to one another.
- Build on one another's ideas.
- Be open to changing your mind.

Name: ____ Date: ______________________

Comparing Two Arguments

Read the question and the two arguments below. As you read, think about the following questions: How are the two arguments similar? How are the two arguments different? Which argument is more persuasive? You can write notes or annotations on the arguments.

Why does Mt. Waialeale get so much precipitation?

Argument A

Mt. Waialeale gets a lot of precipitation because it's near a warm part of the ocean, it's a tall mountain, and the prevailing winds blow from the ocean toward the mountain. According to the map, the part of the ocean on the east coast of Kauai is warm, and the temperature of surface ocean waters can affect precipitation.

Argument B

According to the map, the surface temperature of the part of the ocean on the east coast of Kauai is warm. This is important because warm surface temperatures allow water to evaporate more easily. When winds blow over the ocean off Kauai, the air fills up with a lot of water vapor. We can also see from the map that Mt. Waialeale is a tall mountain. As the air in the wind moves up the side of Mt. Waialeale, it cools. When the air cools, the water vapor it holds condenses into precipitation, and it begins to rain on the mountain.

Name: ______________________________ Date: ______________

Argument About the Atacama Desert

Question: Why does the Atacama Desert get so little precipitation?

Claim:

Support the claim with evidence and explain how all the evidence is connected to the claim.

Name: ______________________________ **Date:** ____________________

Peer Feedback Checklist—Scientific Argument

❒ The argument was persuasive.

Which part of the argument was the most persuasive? Why do you think so?

____

____

____

❒ The argument was clearly organized.

What could make this argument more organized and easier to understand?

____

____

____

❒ The argument explained how all the evidence was connected to the claim.

Which ideas could be better explained or connected together?

____

____

____

❒ The science ideas were accurate.

Are there any ideas in the argument that you are not sure were scientifically accurate? If so, which ideas should be checked for accuracy?

____

____

____

Guidelines for Writing a Scientific Argument

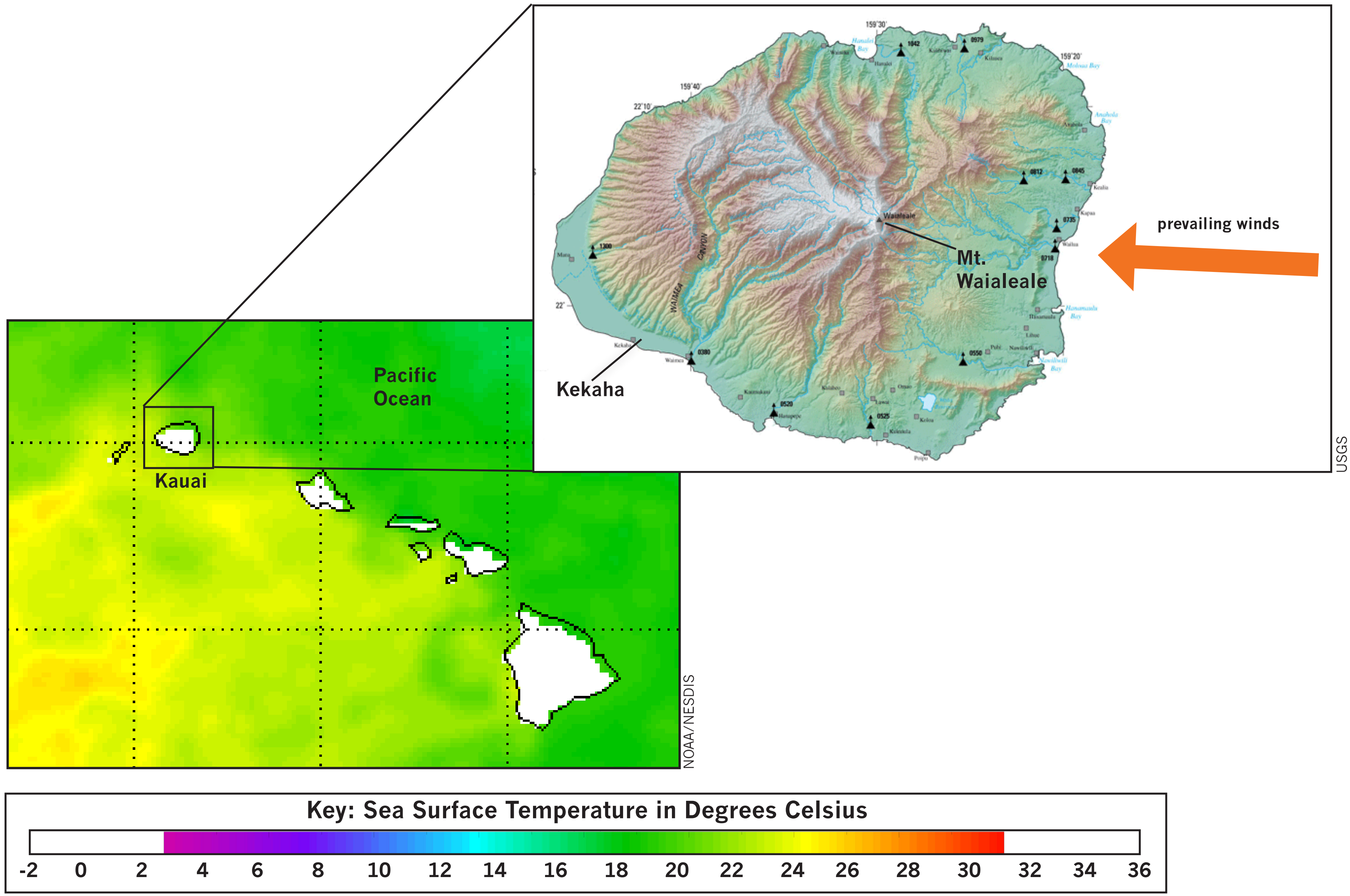
- **Be persuasive.** Show the reader how your claim is clearly supported by the evidence.

- **Include a claim** that answers a question about the natural world.

- **Include evidence** that supports the claim.

- **Explain your reasoning** to show how the evidence supports or connects to the claim.

Kauai: Sea Surface Temperature and Prevailing Winds



Rubric for Writing a Scientific Argument

weaker <---> stronger

ORGANIZATION **Are all aspects of a scientific argument included?**	Does not state a claim or claim does not address the question being considered.	States a claim that responds to the question but no additional information is included as evidence to support the claim.	States a claim and lists or describes information as evidence but does not connect evidence to different parts of the claim.	States a claim and connects evidence with different parts of the claim but ideas are not clearly organized to help reader follow the overall argument.	States a claim, connects evidence with different parts of the claim, and ideas are clearly organized to help reader follow the overall argument.
CONNECTIONS **Are the ideas well connected?**	No evidence is included.	Includes evidence but does not indicate how evidence connects to other evidence or to parts of the claim.	Clearly states some connections between evidence and the claim.	Clearly states most connections between evidence and the claim.	Each part of the claim is supported by evidence, and connections between all evidence and the claim are clearly stated.
ACCURACY **Are the ideas scientifically accurate?**	Claim is an inaccurate answer, or ideas and conclusions (stated or suggested) are inaccurate.	Claim is an accurate but partial answer. The ideas are accurate, but one or more is used inaccurately to support the claim.	Claim is an accurate but partial answer to the question. Each idea is accurate, but at least one is used in a way that is not scientifically relevant.	Claim is an accurate but partial answer to the question. All ideas that are stated and used to support the claim are scientifically sound.	Claim is an accurate and thorough answer to the question. All ideas that are stated and used to support the claim are scientifically sound.

About Disciplinary Literacy

Literacy is an integral part of science. Practicing scientists read, write, and talk, using specialized language as they conduct research, explain findings, connect to the work of other scientists, and communicate ideas to a variety of audiences. Thus, the Next Generation Science Standards (NGSS) and the Common Core State Standards (CCSS) alike call for engaging students in these authentic practices of science. Through analyzing data, evaluating evidence, making arguments, constructing explanations, and similar work, students engage in the same communicative practices that scientists employ in their profession. Through supporting and engaging students in science-focused literacy and inquiry activities that parallel those of scientists, students master discipline-specific ways of thinking and communicating—the disciplinary literacy of science. Strategy guides are intended to help teachers integrate these disciplinary literacy strategies into the science classroom.

About Us

The Learning Design Group, led by Jacqueline Barber, is a curriculum design and research project at the Lawrence Hall of Science at the University of California, Berkeley. Our mission is to create high-quality, next-generation science curriculum with explicit emphasis on disciplinary literacy and to bring these programs to schools nationwide. Our collaborative team includes researchers, curriculum designers, and former teachers as well as science, literacy, and assessment experts.

THE LAWRENCE HALL OF SCIENCE
UNIVERSITY OF CALIFORNIA, BERKELEY

The Learning Design Group

These materials are based upon work partially supported by the following:
Bill & Melinda Gates Foundation under grant number OPPCR060
Carnegie Corporation of New York under grant number B 8780
National Science Foundation under grant numbers DRL-0822119 and DRL-1119584