Strand: 6.3.3

Emphasis: Uneven heating of the Earth’s surface (Atacama Desert)

Anticipated Time Required (assuming 50 minute class periods):

Episode 1: Why So Dry? 20 minutes
Episode 2: What’s in a Desert System? 20 minutes (Episodes 1 & 2 can be taught together in one day)
Episode 3: The Convection Connection 90 minutes (2 class periods)
Episode 4: It’s All About the Interactions 20 minutes
Episode 5: Defining the Cause 50-70 minutes (Can be taught over 2 days as needed)
Episode 6: Now I Know Why the Atacama is SO Dry! 30 minutes

Dominant CCC:
Systems and Systems Models, Energy and Matter, Cause and Effect

Dominant SEP:
Develop and use a Model

Management Strategies to support equitable access to content:

1. Use exit tickets for quick formative feedback to see where students are having problems. Ask questions that will reveal depth of understanding and misconceptions.
2. Students should be doing most of the work throughout this storyline. That means that the teacher must move around and listen to what students are thinking. Adjust instruction, pacing and grouping of students based on what you are hearing and observing. All students can work in groups, but it may take a few tries to find the right combination of learners.
3. Assess student models as they are developing them. You do not need to “grade” every task your students record, but walk around with a stamp or pen and acknowledge progress, thinking and effort. This will keep students on task, as they will know that their work and thinking is important. You will be able to give immediate feedback and see errors early on.

Shopping list:
Glue Sticks
Chart Paper and Markers (group sets)
Colored pencils (red and blue)
Post-it Notes
Plastic shoe boxes (one per group) half full of water
Blue and red food coloring
Ice cube tray
Red food coloring
Hot pot (electric kettle) or access to microwave
Small bottles or containers for hot red water (one per group)

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## Anchor Phenomenon: The Atacama Desert is the driest desert on Earth

Student Performance Expectation: Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates. Emphasize how warm water and air move from the equator toward the poles. Example of models could include Utah regional weather patterns such as lake-effect snow and wintertime temperature inversions.

<table>
<thead>
<tr>
<th>Dominant DCI</th>
<th>Dominant CCC</th>
<th>Dominant SEP</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems.</td>
<td>Patterns Systems and Systems Models Energy and Matter</td>
<td>Develop and use a model Analyze and interpret data</td>
</tr>
<tr>
<td>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.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global movements of water and its changes in form are propelled by sunlight and gravity. Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Science Experiences

<table>
<thead>
<tr>
<th>CCC/SEP</th>
<th>What are students doing? (This should match your SEP!)</th>
<th>What specific understandings should students get from this experience? (What pieces of the performance expectation does the experience provide?)</th>
<th>New questions students have to propel us to the next science experience</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Patterns Analyzing and</strong></td>
<td>There are patterns of global climates. Most deserts are located either above or below the equator at</td>
<td>Why are there patterns? What causes the patterns? Why is the Atacama so dry?</td>
<td>Exit Ticket: Group questions about the Atacama Desert</td>
</tr>
<tr>
<td></td>
<td>Analyze and interpret data about global climates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ask questions about patterns on map of</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

C. Penrod
<table>
<thead>
<tr>
<th><strong>Interpreting Data</strong></th>
<th><strong>global climate</strong></th>
<th><strong>about the same distance.</strong></th>
<th></th>
</tr>
</thead>
</table>

| **2 Systems and Systems Models** | **Define the parts of the Atacama system to begin developing a model**<br>**Parts of the system- read about desert**<br>**Ask questions** | **The Atacama Desert is a system including the atmosphere, the hydrosphere, the geosphere and the biosphere. These systems interact on global and local scales.** | **How do these systems interact?**<br>**Systems Model of Atacama Desert** |

| **3 Energy and Matter Systems**<br>**Carry out an investigation**<br>**Analyze and Interpret data** | **Carry out an investigation to test a prediction on how energy effects the movement of matter in two of Earth’s systems- the atmosphere and in the hydrosphere (ocean).**<br>**Analyze and Interpret data to find patterns in energy flow and matter cycling between Earth’s systems (hydrosphere, atmosphere, geosphere).** | **Heat causes matter to become less dense and rise. This is true of any fluid-water or air. Salt can cause differences in densities in fluids. Differences in density cause movement in fluids. There are colder and warmer parts of the ocean. There are colder and warmer parts of the land. There is a predictable pattern of air currents in the atmosphere known as Global circulation.** | **How do ocean current patterns effect the Atacama Desert?**<br>**How do atmospheric circulation patterns effect the Atacama Desert?**<br>**How does the matter flow and energy cycle through the various systems around the Atacama Desert? (systems interactions).**<br>**Clearest Point Muddiest Point** |

| **4 Energy and Matter Systems**<br>**Obtain information** | **Read to obtain information on how systems interact to create the driest desert in the world**<br>**There are many system interactions that effect the Atacama Desert. Convection in the ocean effects deserts. Energy from the sun drives changes in Earth’s systems.** | **What is the Rain Shadow Effect?**<br>**How does the ocean’s temperature effect the Atacama Desert?**<br>**Exit ticket: Relating convection cells to Atacama Desert**<br>**Student notebooks: review models giving feedback as needed (model of Ocean Temperature and Rain Shadow Effect)** |

| **5 Cause and Effect** | **Analyze and interpret data to begin developing a model to show how unequal heating of the Earth's systems causes patterns of atmospheric and oceanic circulation that determine regional climates.**<br>**Cold ocean currents effect the Atacama Desert. Elevation causes air to rise, cool and become less dense.**<br>**The Rain Shadow effect means that** | **How does all this evidence fit together to explain the cause of the dryness of the Atacama desert.**<br>**Student notebooks: review models giving feedback as needed (model of Ocean Temperature and Rain Shadow Effect)** |  |
| 6 | **Systems and Systems Models** | Develop a model to show how uneven heating of the Earth's systems causes patterns of atmospheric and oceanic patterns that determine deserts (Atacama desert) | Rain Shadow Effect (winds (atmosphere) carry moisture (hydrosphere-matter) toward mountains, then air loses energy (cools) and rains on the windward side of mountain; less water vapor in air (atmosphere) due to cooler ocean temperature (hydrosphere), and high elevation (geosphere) of the Atacama leads to dry air (atmosphere and hydrosphere). Bonus: The sun heats the ocean and the air over the ocean which causes the moisture to rise and move away from desert regions (convection). | What are some other weather patterns that cause different climates? | Student’s final model |

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### Student Science Performances

**Analyze and interpret data/ Ask questions**

<table>
<thead>
<tr>
<th>Topic: Global Climates and Deserts</th>
<th>Title: Why So Dry?</th>
</tr>
</thead>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:** Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

**Lesson Performance Expectations:** Analyze and interpret data about global climates and ask questions about patterns on map of global climate

#### Students Will... To Construct Meaning

**Part 1: Find Patterns on Maps**

1. Make observations about Map #1: Earth from Space in small groups. Students record observations in lab notebook.
2. Share out observations with group.
3. Record questions they have about data (map).
4. Make observations about World Climate Map #2. Use same format as above.
5. Share observations with other groups during class discussion.
6. Record patterns found both the maps.
7. Students compare both maps find patterns.
8. Students generate and record questions in lab notebook about patterns and world climate.
9. Students record 2-3 questions they have about world climates in lab notebook.

**Part 2: The Atacama Desert**

1. Record Phenomenon in lab notebook: The Atacama Desert is the driest desert in the world.
2. Give one reason why you think the Atacama Desert is the driest desert in the world.
3. Record 2-3 questions you have about the Atacama Desert.

**Management Strategies:** Plan for map activity by arranging students in group formation at beginning of class. Make groups of 2-4 students. Be sure to have color copies of maps for each group. Do not pass out both maps at once. Give one at a time and require students to record observations in notebook before moving on to next map. Use a timer to keep time urgent and moving. Give groups 2-3 minutes to make and record observations.

#### Teacher Will... To Support Students

**Part 1: Finding Patterns on Maps**

1. Hand out Map #1: Earth from Space. Have students work in small groups to analyze and interpret the data and note any patterns. Instruct students to record observations in lab notebook.
2. Listen to groups and circulate as students are analyzing data. Ensure that each student is recording something in lab notebook. Lead class discussion and clarify ideas as needed.
3. Hand out Map #2: Global Climates. Have students work in small groups to analyze and interpret the data and note any patterns. Instruct students to record observations in lab notebook.
4. Look for patterns on both maps and record in lab notebook.
5. Instruct students to find patterns on both maps and record in lab notebook.
6. Instruct students to record questions they now have about the patterns they see the cause of the patterns. You can name the patterns as the “effect” and explain how they need to figure out the “cause.”
7. **Students** ask and record that will lead into next episode and are relevant to what they need to know (what evidence they need to explain phenomenon).

**Part 2: The Atacama Desert**

1. **Introduce the Phenomenon:** The Atacama Desert is the driest desert in the world.
2. Show students Pictures #1 and #2 and Map #3.
3. Point out the Atacama Desert is very close to the Amazon Rainforest.
4. Have students record questions they have
**ALSO** - The objective in Part 1 is to interpret the dataset presented in the map and then to ask questions about the patterns noted. Students record observations in their science journals. Examples of questions to spur student observation and discussion are below: What does your map represent? What do the colors represent on your map? What patterns do you observe? What questions do you have about the patterns you observe?

5. Instruct students to give one reason why they think that the Atacama Desert is the driest desert in the world.
6. Instruct students to record 2-3 questions they have about the Atacama Desert.
7. **Exit ticket:** As a group (the same group they worked with earlier) discuss the questions you have and write down the questions on a piece of paper. Each group will turn in a list of 5-8 questions that they have about the Atacama. Instruct them to write each question only once, so that no questions are repeated. This is a formative assessment for you to see what the students are thinking and wondering and what they will need to know to explain this phenomenon.

**Materials:**
Copies of Maps and Pictures - Sets for each small group.

**Assessment of Student Learning**

**Proficient:** The exit ticket is a formative assessment for you to see what the students are thinking and wondering and what they will need to know to explain this phenomenon. Sort through the questions and group and tally them yourself so that you can see where you will need to spend the most time during this storyline. Be sure to eliminate questions that will not generate evidence that explains the phenomenon: The Atacama Desert is the driest desert in the world.

**Map #1: Earth from Space**

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Map #2: Global Climates

Picture #1: The Atacama Desert
Picture #2: Location of Desert

Map #3: South America
# 6.3.3 Lesson Plan 2

## Student Science Performances

**Read to Obtain Information**

**Develop and model**

<table>
<thead>
<tr>
<th><strong>Topic:</strong> System of the Atacama: Atmosphere, hydrosphere, geosphere and biosphere.</th>
<th><strong>Title:</strong> What’s in a Desert System?</th>
</tr>
</thead>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:** Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

**Lesson Performance Expectations:** Read to obtain information and develop a model of the parts of the Atacama Desert system (atmosphere, hydrosphere, geosphere and biosphere)

## Students Will... To Construct Meaning

### Part 1: Reading- The Atacama Desert
1. Read the article *The Atacama Desert* as a class.
2. Pay attention to and underline the parts of the desert system.

### Part 2: Systems Model
1. Draw the “Systems Model” in lab notebook.
2. Label the center “Atacama Desert” and each of the four parts as instructed by teacher.
3. In small groups (2-4), discuss and record information found in the article and in the pictures that relates to each part of the larger desert system.

**Management Strategy:**

Always be thoughtful when assigning a reading in the science classroom. Some students have reading difficulties and need scaffolding such as reading with a partner and following along with a hi-lighter or summarizing at the end of the article. Be sure to check for understanding. You may also read as a class, but only ask volunteers to read.

## Teacher Will... To Support Students

### Part 1: Reading - The Atacama Desert
1. Make copies of the reading, *Atacama Desert*, one each student. (Cut and paste the article below onto one page).
2. Direct students to pay attention to (underline) the parts that make up the Atacama system. Remind them that most of these parts are non-living.
3. Direct a class discussion on what was discovered in the reading.

### Part 2: Systems Model
1. Put/draw the “Systems Model” on the board for the students to see and instruct each student to draw this in their lab notebook.
2. You can use the labels air, land, water, life, but also refer to atmosphere(air), geosphere(land), hydrosphere(water) and biosphere(life).
3. Check in with each group as they are working. Ask probing questions as needed.
4. Check “Systems Model” as a class to be sure all necessary information is recorded.
5. Tie back to the phenomenon: The Atacama Desert is the driest desert in the world.

**Materials:**

*Copy of Atacama Desert for each student.*
*Slide or copy of Systems Model*

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Assessment of Student Learning

**Proficient:** Students will include at least 2 of the following for each category:

Hydrosphere: very little water to no, less than 1 mm rain/year, few oases
Atmosphere: dry air, few clouds, 0-25 degrees Celsius average temperature (32-77 degrees F)
Geosphere: near Pacific Ocean, long piece of land, 600 miles, sand dunes, mud cracks, high altitude
Biosphere: hard for plants, animals and humans to live there, small plants/grasses

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**THE ATACAMA DESERT**

The Atacama is the driest desert in the world. The desert typically gets less than 1 mm of rain a year and some places haven’t ever recorded rain. It is extremely hard for people and plants and animals to live here. Life is concentrated around oases (waterholes) and mining towns.

Deserts are places where rain is scarce, but there is only one area on this earth - the central portion of Chile's Atacama Desert - where it has never ever rained - at least since humans started keeping a record - about 400 years ago! The most amazing part is, that this 600-mile stretch of land lies right alongside Chile's coast, next to the biggest body of water on Earth - The Pacific Ocean. Though drier than all other deserts, the temperature in the Atacama Desert is quite cool, ranging from 0-25 degrees Celsius (32-77 degrees Fahrenheit), thanks to its high altitude.

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Atacama FACTS

Size: 40,600 square miles (105,000 square kilometers)
Countries: Chile, Peru
Continent: South America

Edited from: https://wiki.kidzsearch.com/wiki/Atacama_Desert

Figure 3: Mud cracks on the desert floor.

Systems Model:
6.3.3 Lesson Plan 3

Student Science Performances
Carry out an investigation
Analyze and Interpret Data

| Topic: Convection Cells in the Atmosphere | Title: The Convection Connection |

Overarching Performance Expectations (Standard) from State Standards or NGSS: Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

Lesson Performance Expectations: Carry out an investigation to test a prediction on how energy effects the movement of matter in two of Earth’s systems- the atmosphere (air) and in the hydrosphere (ocean). Analyze and Interpret data to find patterns in energy flow and matter cycling between Earth’s systems (hydrosphere, atmosphere, geosphere).

<table>
<thead>
<tr>
<th>Students Will . . . To Construct Meaning</th>
<th>Teacher Will . . . To Support Students</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part 1: Predicting Energy with Maps</strong></td>
<td><strong>Materials alert: BLUE ice cubes needed! Must make a day ahead!! Fill 8 plastic shoe boxes half full of water a day ahead.</strong></td>
</tr>
<tr>
<td>1. Glue two small maps of world into lab notebook. Title one “Hydrosphere” and the other “Atmosphere.”</td>
<td><strong>Part 1: Predicting Energy with Maps</strong></td>
</tr>
<tr>
<td>2. Discuss with your small group your prediction on where the surface of the ocean is the warmest (more energy) and where the surface of the ocean is the coldest (less energy) in this system.</td>
<td>1. Arrange students into small groups (2-4).</td>
</tr>
<tr>
<td>3. Use a blue pencil to represent cold. Use a red pencil to represent warm. Draw on your “Hydrosphere” map where these areas (warm and cold) are located. Use arrows, words, coloring in, etc.</td>
<td>2. Make 3 copies of the world maps for each student.</td>
</tr>
<tr>
<td>4. Now, discuss with your group where you think warm and cold air is in the Earth’s atmosphere (system). Also think of how the air is moving- which direction and what might be causing this.</td>
<td>3. Instruct students to glue 2 maps in lab notebook and title one “Hydrosphere” and the other “Atmosphere.”</td>
</tr>
<tr>
<td>5. Watch your teacher set up this model of a system. It is very important to follow all instructions precisely for desired results.</td>
<td>4. Tell students to discus in a small group their prediction on where the surface of the ocean is the warmest (more energy) and where the surface of the ocean is the coldest (less energy) in this system</td>
</tr>
<tr>
<td>6. Set up model with smallgroup.</td>
<td>5. Direct students to use a blue pencil to represent cold and a red pencil to represent warm. Instruct them to draw on ”Hydrosphere” map where these areas (warm and cold) are located. Use arrows, words, coloring in, etc.</td>
</tr>
<tr>
<td>7. Record your data (draw a picture) in your lab notebook using your red and blue pencils of what you observe. Be sure to use arrows to show which way the water (matter) is moving in your model. Identify what the energy source is in your model.</td>
<td>6. Walk around and listen to what students are saying and what their predictions are. This will help to guide the questions you ask in the next section.</td>
</tr>
<tr>
<td>8. Clean up area and return materials to teacher.</td>
<td><strong>Part 2: Convection in a Fluid Model</strong></td>
</tr>
<tr>
<td><strong>Part 2: Convection in a Fluid Model</strong></td>
<td>7. One method in geoscience is using a model for understanding a process or event. Your students will create a model to help them understand convection in fluids (liquids and gases- ie the ocean and atmosphere). This is not an investigation with a controlled variable, but rather an investigation into understanding a process. Thus, you must model HOW to set the model up.</td>
</tr>
<tr>
<td>5. One method in geoscience is using a model for understanding a process or event. Your students will create a model to help them understand convection in fluids (liquids and gases- ie the ocean and atmosphere). This is not an investigation with a controlled variable, but rather an investigation into understanding a process. Thus, you must model HOW to set the model up.</td>
<td></td>
</tr>
</tbody>
</table>
9. Make a table in lab notebook listing the components of your systems model (container of water, hot red water, blue cold water).
10. Indicate in your table what each component of the model represents for the atmosphere and then for the hydrosphere. (Note: don’t give answers! Let students think and connect).

11. Example:

<table>
<thead>
<tr>
<th>Model we used</th>
<th>Atmosphere</th>
<th>Hydrosphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot red water</td>
<td>Hot, rising air</td>
<td>Warm, rising water</td>
</tr>
<tr>
<td>Cold blue water</td>
<td>Cold, sinking air</td>
<td>Cold, sinking water</td>
</tr>
<tr>
<td>Container of water</td>
<td>An air mass in the atmosphere</td>
<td>Water in the ocean</td>
</tr>
</tbody>
</table>

12. Write a sentence about how energy effects matter in the atmosphere. Label this as convection.
13. Write a sentence about how energy effects matter in the hydrosphere(ocean). Label this as convection.
14. Answer these questions: What is the source of energy (heat) in the atmosphere? What is the source of energy (heat) in the ocean?

Part 4: Revisiting Predictions
15. Glue the last map (3rd) into lab notebook.
16. Follow teacher’s directions on where to draw actual currents with red and blue pencils.
17. Discuss meaning of currents and source of energy.
19. Discuss two questions with your group: What is the source of energy (heat) in the atmosphere? What is the source of energy (heat) in the ocean?
20. Write a statement for each in your lab notebook.
21. Exit Ticket- Clearest Point, Muddiest Point assessment (described in teacher notes).

Management Strategies:
1. Make 3 copies of the world maps for each student. Copy and paste four maps onto one page and then copy and cut apart on a paper cutter. The maps do not need to be large.
2. It is very tempting to want to do the investigation only as a demo, but DON’T! Let students do their own investigation.

Part 3: Connecting your Model to Earth’s Systems
14. Instruct students make a table in lab notebook listing the components of the systems model. See example to left.
15. Emphasize how energy causes matter to rise (more energy-heat) and sink (less energy-cold). This is a BIG idea here! Warm air rises, cool air sinks. Warm water rises, cool water sinks. This creates currents in the air (atmosphere) and the ocean (hydrosphere). This is a connection to Strand 6.2. The new piece here is to tie this to fluids- liquids and gases- and then label the liquid hydrosphere and the gas atmosphere.
16. Give students the two questions: What is the source of energy (heat) in the atmosphere? What is the source of energy (heat) in the ocean? To discuss with their groups.
17. Be sure to check understanding that the sun is the source of energy that heats both the atmosphere and the ocean.
18. Tie this to the phenomenon-
the students try out it out and investigate. Even if not all groups get a strong, visible convection cell, someone in the class will get it to work and everyone can use that as a model.

http://www.srh.noaa.gov/srh/jetstream/ocean/circulation.html

20. Here is information about atmospheric circulation: http://www.srh.noaa.gov/jetstream/global/circ.html. Your students do NOT need to know the names of the three circulation cells—just that there are large convection cells that transport energy around the Earth. It IS important for them to connect that more energy from the sun at the equator means that warm, moist air is rising. Connect this to the convection cell model.

21. Have students glue the third map in lab notebook. Label Actual Oceanic Circulation.

22. Show the map of oceanic circulation.

23. Instruct students to draw the correct arrows on the map using Basic Ocean Currents as a guide.

24. Discuss the source of energy (the sun) and point out how warm currents are moving away from the equator, while cold currents are moving away from the poles. Connect to the convection cell model.

25. Now, show the map of Global Atmospheric Circulation.

26. Instruct students to draw a circle on their paper to represent the Earth. It is NOT necessary to draw any continents. Label Global Circulation.

27. DO include the equator. This is a BIG deal (most incoming solar radiation).

28. Instruct students to use red and blue pencils, again, to show convection currents in the atmosphere.

29. Exit ticket: Clearest Point and Muddiest Point—Put up two big pieces of chart paper or draw to very large squares on the board. Label one Clearest Point and the other Muddiest Point. Give each student 2 post-it notes. Instruct them to write down one thing from today’s lesson that they got and one thing that still seems unclear. Have them place their notes as they leave/end class.

30. Materials:
Two small copies of map for each student
Glue sticks (one per student)
Colored pencils
Post-it notes
Plastic shoe boxes (one per group) half full of water
Blue food coloring
Ice cube tray
12 blue ice cubes
Red food coloring
Microwave or hot pot (electric kettle)
Small bottles or containers for hot red water (one per group)
Pipettes (1 per lab group)

**Assessment of Student Learning** - After class, group the notes in each category (Clearest and Muddiest) so that you can see what is clear and what (and who) still needs more attention.

**Map of World**

**Global Atmospheric Circulation**

**Basic Ocean Currents**
### 6.3.3 Lesson Plan 4

<table>
<thead>
<tr>
<th>Student Science Performances</th>
<th>Overarching Performance Expectations (Standard) from State Standards or NGSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop and model</td>
<td>Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Topic: Interactions of systems of the Atacama: Atmosphere, hydrosphere, geosphere and biosphere.</th>
<th>Title: It’s All About the Interactions</th>
</tr>
</thead>
</table>

#### Lesson Performance Expectations:
Read to obtain information on how systems interact to create the driest desert in the world

### Students Will... To Construct Meaning

#### Part 1: Reading - The Atacama Desert
1. Review System Model for the Atacama Desert prepared in previous lesson
2. Read the article *The Atacama Desert, Chile: The Driest Desert on Earth* as a class.
3. Record system interactions in lab notebook by adding them to your four-box model from Episode 2.

#### Part 2: Asking
1. In small groups (2-4), discuss how this information relates to the phenomenon of the Atacama Desert being so dry.
2. Pay attention to and write down questions you still have about the systems interactions. Record them in lab notebook.

#### Part 3: Connecting Systems Model Convection Model
1. Refer to convection model from previous lesson.
2. **Exit ticket**: How does the convection model relate to what you learned today about the Atacama Deserts’ systems? Make as many connections as you can.

### Teacher Will... To Support Students

#### Part 1: Reading - The Atacama Desert
1. Make copies of the reading, *Atacama Desert, Chile: The Driest Desert on Earth* one each student. (Cut and paste the article below onto one page).
2. Review the Systems Model students prepared in previous lesson.
3. Direct students to pay attention to (underline) the interactions of the systems in the Atacama system.
4. During reading, stop and check for understating by asking questions. Also, stop and Figure 1. Instruct students to draw Figure 1 in lab notebooks. (This is an important piece of evidence.)
5. Model how to add and label an interaction between the systems by drawing arrows on the outside of the box from one system to another and labeling the interaction. For example, cold ocean water (hydrosphere) prevents moisture that could turn into clouds and rain (atmosphere). The arrow going from hydrosphere to atmosphere could say “prevents moisture that could be rain”. Instruct each student to draw this in their lab notebook.
6. Continue reading as a class and adding information on systems interactions to the model.
7. Also point out how energy and matter are

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a difficult time doing this on the spot in front of the students. You will discover were something is unclear and then will be able to help students as they read and make sense of the information.

8. Check “Systems Model” as a class to be sure all necessary information is recorded.
9. Tie back to the phenomenon: The Atacama Desert is the driest desert in the world.
10. Direct a class discussion on what was discovered in the reading.

**Part 2: Asking Questions**
11. Instruct students to discuss in small groups how this information relates to the Atacama Desert being so dry.
12. Have students record questions in lab notebooks.
13. Move around the classroom and read the questions. Make note of what information the students still need. This is a formative assessment for you to know what to spend time on next.

**Part 3: Connecting Systems Model Convection Model**
14. Have students review convection model on own.
15. Assign exit ticket: How does the convection model relate to what you learned today about the Atacama Deserts' systems? Make as many connections as you can.
16. Collect exit tickets and review feedback to guide next lesson.

**Materials:**
Copy of *Atacama Desert, Chile: The Driest Desert on Earth* for each student.
Slide or copy of *Systems Model*

**Assessment of Student Learning**

**Proficient:** Exit Ticket
Students will make two or more of the following connections:
Heat energy from the sun causes hot air to rise and move moisture away from the desert.
Hot air can prevent precipitation
Due to high elevation, mountains cause air to rise, cool and drop moisture
A cold ocean current causes on inversion that prevents moisture from rising that would lead to rain
Mountains prevent rain from moving over to the other side (rain shadow effect)

**Systems Model:**
C. Penrod
THE ATACAMA DESERT, CHILE: THE DRIEST DESERT ON EARTH

A desert is a hot area of land that gets very little rain, and where temperatures during the daytime can get as high as 55°C (131°F). At night, deserts cool down, sometimes even below 0°C. Most deserts lie between 15° and 35° north and south of the equator. The desert climate is due in part to air that rises over the equator and comes down over the Tropic of Cancer and the Tropic of Capricorn. All over the world, around 20% of the deserts lie in these regions.

How does this happen? (See figure 1)
1. Land over the equator becomes very hot because the sun’s rays hit the equator at a direct angle between 23°N and 23°S latitude. The hot and wet air rises and it rains a lot in these areas.

2. The air cools down and moves north and southwards as it gets drier.

3. The cool, dry air sinks to the ground over the Tropic of Cancer in the north, and the Tropic of Capricorn in the south, causing high pressure (“sunny weather”).

4. And then again, warm air near the surface moves back to the equator causing the air to rise. These moving air masses are called trade winds. As the rising air cools, clouds and rain develop. The resulting bands of cloudy and rainy weather near the equator create tropical conditions. **But… what makes the Atacama Desert in Chile drier than other deserts?**

A cold ocean current flows northward along the Chilean coast (see figure 2). The cold, humid air produced by the sea stays down along the coastline due to hot air masses rising from the continent (an inversion layer). This reduces the moisture in the air and, also, results in nearly 350 days of clear skies inland.

It must also be considered that the Atacama Desert is located over **high altitudes**, above 8,200 feet (2,500 meters) above sea level. This fact contributes to low, drying temperatures and very low humidity in the air (about 10%).

Another important reason is that two mountain ranges, the Chilean Coastal Range and the Andes Range, run along the west and east sides of the Atacama Desert acting as natural barriers of moisture (the rain shadow effect). A rain shadow is a dry region of land on the side of a mountain that is protected from the prevailing winds (winds that occur most of the time in a particular location on the Earth), also called the leeward or down-wind side of the mountain.

Prevailing winds carry air toward the mountain range. As the air rises, it cools, and water vapor condenses to form clouds over the windward side of the mountain. Here, precipitation falls in the form of rain or snow. The windward
side of a mountain range is moist and lush because of this precipitation. Once the air passes over the mountain range, it moves down the other side, warms, and dries out. This dry air produces a rain shadow. Land in a rain shadow is typically very dry and receives much less precipitation and cloud, creating desert conditions on the leeward side of the range cover. Nowhere else on Earth do these climatic features come together as they do in Atacama!  

MODIFIED FROM CARMEN ABUHADBA'S ORIGINAL ARTICLE PUBLISHED ON 9/4/2013
# Student Science Performances

**Develop a model**

<table>
<thead>
<tr>
<th>Topic: Annual Precipitation, Ocean Temperatures, and Rain Shadow Effect</th>
<th>Title: Defining the Cause</th>
</tr>
</thead>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:** Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

**Lesson Performance Expectations:** Analyze and interpret data to begin developing a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

### Students Will... To Construct Meaning

#### Part 1: Developing A Model

1. Move into small groups (2-4 people).
3. Write down three observations you make from the patterns on this map.
4. As a group, discuss and record evidence and its cause from this map that would support the phenomenon.

#### Part 2: Rain Shadow and Ocean Currents

5. Teacher will assign group one piece of evidence (B or C).
6. As a group, work together to develop a model of either Ocean Temperatures or the Rain Shadow Effect. Draw pictures, label parts and write descriptions. Also, refer to the article *The Atacama Desert, Chile: The Driest Desert on Earth*. Focus on how this provides evidence that supports WHY or the cause of the Atacama Desert being so dry.

#### Part 3: Refining and Recording the Models

7. Record the model your group created in your lab notebook.
8. Hang up posters. Go visit and study the other models that are the same topic as your own. Add things to your model that you may have missed.
9. Return to your seat.
10. As a group, fix anything you want on your model.
11. Now, record the other model that you do not have that is presented in class by another group.

### Teacher Will... To Support Students

#### Part 1: Developing A Model

1. Prepare group sets of Evidence A- C. Print in color.
2. Instruct your students that they will begin constructing their model to explain the phenomenon: The Atacama Desert is the Driest desert in the world.
3. Give each group a copy of the Evidence Card A: South America: Annual Precipitation (1976-2009). Instruct students to record evidence from the patterns on this map that would provide evidence of WHY the Atacama is so dry.

#### Part 2: Rain Shadow and Ocean Currents

4. Distribute Evidence Card B: Ocean Temperatures to half the groups and Evidence Card C: Rain Shadow Effect to the other half. The object here is for each group to become experts on one of the pieces of evidence and then share with the class.
5. Hand out a piece of chart paper and markers to each group. Instruct students that each group is to make a poster to share that will explain this piece of evidence. Students must include pictures, label parts and written descriptions/explanations on the model and connect to the Atacama being so dry. Students should also refer to previous article: *The Atacama Desert, Chile: The Driest Desert on Earth*
6. Move around and listen to groups while they are preparing posters.

#### Part 3: Refining and Recording the Models

C. Penrod
Management Strategies:

1. Make color copies of the Evidence Cards are essential to today's lessons. Students need to see the colors to effectively analyze the data on each card.

2. It is essential to clear up and correct any wrong information about Rain Shadow Effect and Ocean Temperatures BEFORE it is presented as a final model to the class. Take the time you need to be sure posters are accurate.

3. To quickly check all student notebooks, walk around giving immediate feedback on needed corrections and then stamp correct models when satisfactory.

4. Have students hang models up. Spend a few minutes examining each model. Have students take notes on how to improve their model. Look at and study models during this time so that *you can correct* anything that is wrong in a by asking probing questions to rethinking.

5. Direct students to return to tables and fix models.

6. Chose most accurate model for each topic (Ocean Temperatures and Rain Shadow Effect). Have students from these groups present their model to class. Students record models in lab notebooks.

7. The objective here is for students to end up with a correct model for Rain Shadow Effect and Ocean Temperature in their own notebook. Make use of a class discussion to clarify and refine anything that needs attention.

8. Check all student notebooks and review models giving feedback as needed. **Correct models are essential to the success of the final lesson (the performance expectation).**

Materials:

Group sets of Evidence Cards A-C
Poster paper
Markers

Assessment of Student Learning

Proficient:
Each student will have a correct model of Ocean Temperature and Rain Shadow Effect and explain the *cause* for each. Consult Evidence Cards B and C for details.
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.

Key: Sea Surface Temperature in Degrees Celsius

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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.
### 6.3.3 Lesson Plan 6

#### Student Science Performances

<table>
<thead>
<tr>
<th>Topic: Evidence for Dryness</th>
<th>Title: Now I Know Why... the Atacama is so Dry!</th>
</tr>
</thead>
</table>

**Overarching Performance Expectations (Standard) from State Standards or NGSS:** Develop and use a model to show how unequal heating of the Earth’s systems causes patterns of atmospheric and oceanic circulation that determine regional climates.

**Lesson Performance Expectations:** Develop a model to show how uneven heating of the Earth’s systems causes patterns of atmospheric and oceanic patterns that determine deserts (Atacama Desert)

#### Students Will... To Construct Meaning

**Putting it All Together**

1. In your lab notebook, create a final model that explains WHY (the causes), using evidence gathered, the Atacama Desert is the driest desert in the world.
2. Use all the resources available, including the Systems Model made earlier in the storyline.
3. Include text (explanations) and drawings/illustrations of concepts presented, including. It should identify the parts of the system (atmosphere, hydrosphere, and geosphere) and how matter and energy interact to create this system. Focus thinking on causes and explaining each one.

**Management Strategy:**

1. Remember the model is being used to explain WHY the Atacama Desert is so dry. This is not a model of the Atacama Desert. Also, this is a conceptual model so it is complex. This may take some time for your students to put all the evidence together. Be sure to refer students back to the Systems Model and the interactions. This is where the answer lies- in the interactions!
2. Develop your own conceptual model BEFORE you give students this task. You will know where students may need support and will also better understand the phenomenon yourself.

#### Teacher Will... To Support Students

**Putting It All Together**

1. Make all maps and articles used in the storyline available for students.
2. Prompt students to create a final model for explain WHY (cause) the Atacama Desert is the driest desert in the world.
3. Instruct them to use the evidence they have gathered in creating the model.
4. Also, encourage students to use any resources they need. Remind them that they have all the parts recorded in their lab notebook, they just need to pull it all together.
5. The model should focus on the causes and include text (explanations) and drawings/illustrations of concepts presented, including: the parts of the system (atmosphere, hydrosphere, and geosphere) and how matter and energy interact to create this system.

**Materials:**

All maps and articles used in storyline

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**Assessment of Student Learning**

**Proficient:** Rain Shadow Effect (winds (atmosphere) carry moisture (hydrosphere-matter) toward mountains, then air loses energy (cools) and rains on the windward side of mountain; less water vapor in air (atmosphere) due to cooler ocean temperature (hydrosphere), and high elevation (geosphere) of the Atacama leads to dry air (atmosphere and hydrosphere). Bonus: The sun heats the ocean and the air over the ocean which causes the moisture to rise and move away from desert regions (convection).