SBAR
SUSTAINABLE BIOECONOMY
FOR ARID REGIONS

What and Why of Deserts

Authors: Traci Klein and Matthew Katterman

Standards

Arizona

> **7.E1U1.5:** Construct a model that shows the cycling of matter and flow of energy in the atmosphere, hydrosphere, and geosphere.

NGSS

> **MS-LS2-3:** Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.

> **MS-ESS2-5:** Collect data to provide evidence for how the motions and complex interactions of air masses result in changes in weather conditions.

Materials

> **PowerPoint 1:**
Deserts: Definition and Causes
> **PowerPoint 2:**
Hot vs. Cold Air: Density
> **Student notebooks, pencils**
> **For teacher demonstration:**
Bucket of water
Sponge
Rock of similar size to sponge
> **For each set of students:**
empty water bottle (500 mL)
balloon
hot water (500 mL)
2 beakers (1 L)

Resources

Video: Rain shadow effect
(4min : 26s)
https://www.youtube.com/watch?v=DoKTTHd-XEQ

Video: Why does earth have deserts?
(2min : 18s)
https://www.youtube.com/watch?v=T6Us1sPXBfA

Sustainable Bioeconomies for Arid Regions Center of Excellence
https://sbar.arizona.edu

Overview

This lesson explains what a desert is and describes contributors to the creation of deserts, such as Hadley Cells and the rain shadow effect. It includes an experiment to demonstrate how temperature affects density and the flow of the atmosphere.

Grade Level: 6–8

Goals

• Students will be able to explain what a desert is and what causes deserts to form in particular places on Earth.

Learning Objectives

• Students will be able to accurately describe a desert and discuss the issues that arise from living in a desert.

• Students will be able to accurately explain how deserts form with contributions from the rain shadow effect and Hadley cells.

• Students will be able to accurately record, analyze data and draw conclusions about hot and cold air and density.

Vocabulary

• **Desert:** (noun) A region so arid (dry) because of little rainfall that it supports only sparse and widely spaced vegetation or no vegetation at all.

• **Sustainable:** (adjective) Able to be maintained or kept going, as an action or process.

• **Density:** (noun) The amount of mass in a given volume, or how much stuff fits in a given space. Synonyms: heaviness, consistency, thickness.

• **Hadley Cells:** (noun) The low-latitude overturning circulations that have air rising at the equator and air sinking at roughly 30° latitude. Hadley cells are responsible for the trade winds in the Tropics and control low-latitude weather patterns.

• **Rain Shadow:** (noun) A region having little rainfall because it is sheltered from prevailing rain-bearing winds by a range of hills.

Set Up

This lesson plan takes place over three class periods (150 minutes). Day 1 & 2 activities include: class discussion, drawing diagrams in notes, and access to the internet to show a YouTube video (may need a projector). Day 3 involves a short experiment which requires materials for each set of students, as listed on the left.

Lesson Procedure: Day 1 (50 minutes)

Lesson at a Glance

1. Present the PowerPoint "Deserts: Definition and Causes" through slide #15.
2. Initiate discussion. Students should:
    a. Discuss or write about their prior knowledge of deserts.
    b. State or write their definition of a desert.
    c. Discuss issues that arise from living in a desert.
    d. Argue from evidence why humans should conserve water when they live in the desert.

Activities and lesson materials are found in the PowerPoint presentation "Deserts: Definition and Causes."

Detailed Lesson Plan

1. (6 minutes) Have students individually free write in science notebooks.

    Ask the driving question to the class: What are some things that make it difficult to live in deserts both for humans and other species?

2. (5 minutes) Conduct a Think Pair Share

    Possible question prompts:

    b. What is a desert?
    c. What are deserts like?
    d. How much rain do deserts get?
    e. What is the weather like in a desert?
    f. How many plants are there in the desert?

3. (5 minutes) Provide a definition of a desert that includes amount of rainfall: "a region so arid because of little rainfall that it supports only sparse and widely spaced vegetation, or no vegetation at all." Have students record in their notebooks.
4. (5 minutes) Have students discuss amongst themselves what are the names of some deserts they know of and then share these to the class afterwards. Teacher can post on board.

    Optional: Have students write names of deserts they know on post-it notes. Display on board.

5. (15 minutes) Show slides of common deserts, mentioning facts about some of the deserts.
    a. *Sahara*: One of the largest deserts, known for sand dunes and temperature extremes.
    b. *Gobi*: Known for being cold. Unique plant life is highly adapted to the arid conditions.
    c. *Namib*: Known for red sand dunes.
    d. *Mojave*: Where Death Valley is located. Death Valley is known for having the hottest air temperature and surface temperature ever recorded on Earth. Its flora includes creosote, Joshua trees, and the Mormon tea plant.
    e. *Chihuahuan*: A large desert that spans Arizona, New Mexico, and Texas in the United States. Spans Chihua-

Any opinions, findings, conclusions or recommendations expressed in this publication/work are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.
Grant #: 2017-68005-26867

Lesson Procedure: Day 1 (50 minutes)

hua, Coahuila, Durango, Zacatecas, and Nuevo León in Mexico.

f. *Sonoran*: The type of desert in Tucson. Only place on Earth where the saguaro cactus grows. The lands of the Tohono O'odham Nation are located in the Sonoran desert. The O'odham word for saguaro is ha:sañ.

6. (5 minutes) Conduct a Think Pair Share.
    a. Question prompt: What issues do we face living in a desert?
    b. Possible answers:
        i. being able to grow enough food
        ii. hard to grow plants because of water and weather
        iii. venomous animals such as scorpions, snakes, etc.
        iv. very hot and bright here
        v. being able to stay cool enough
        vi. dust storms
7. (9 minutes) Ask the driving question to the class: What do we most need to be concerned about to make sure we are living sustainably in the desert?
    a. Remind students of the definition of *sustainable*.
    b. Collect student responses on post-it notes or record answers on the board.

Important takeaway: In the desert, we need to make sure we have enough water to sustain life.

Any opinions, findings, conclusions or recommendations expressed in this publication/work are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.
Grant #: 2017-68005-26867

Lesson Procedure: Day 2 (50 minutes)

Lesson at a Glance

1. Continue presenting the PowerPoint "Deserts: Definition and Causes" beginning at day 2 PowerPoint, slide #17.
2. Students will watch two videos, one on rain shadows and one on Hadley cells.

   The focus will be on Hadley cells and the role of density in generating the circulation of air.
3. Present discussion questions that are designed to walk students through precipitation cycles step by step.
4. Students should understand that the relationship between temperature and density creates air and precipitation cycles.

Videos:

Rain shadow effect: 2 minute Geology (4 min : 26 s) - https://www.youtube.com/watch?v=DoKTTHd-XEQ

Why does earth have deserts? (2 min : 18 s) - https://www.youtube.com/watch?v=T6Us1sPXBfA

Detailed Lesson Plan

1. (5-10 minutes) Conduct a Think Pair Share.

   Possible question prompts:

   a. What causes a desert? Some possible answers that could guide student sharing include mentioning that not enough water or rainfall in the area may cause a desert. A desert may contain a high air pressure area and high-pressure areas are associated with dry, warm and settled weather conditions. This is because sinking air does not result in precipitation.

   b. Why are some places on the planet wet and others are dry? The teacher could encourage the students to come up with answers that include one or a combination of factors that include wind, ocean currents and high and low air pressure areas that determine where rainfall occurs. The idea that the terrain is different in some areas such as high mountains, plains, etc., makes it easier for certain locations to get rain.
2. (15 minutes) Conduct activities exploring rain shadows as a cause of desert formation.

   a. Definition of **Rain Shadow** – A region having little rainfall because it is sheltered from prevailing rain-bearing winds by a range of hills.

   b. Watch the 4–5 minute video on rain shadows called ***Rain Shadow Effect: 2 minute Geology***. https://www.youtube.com/watch?v=DoKTTHd-XEQ

   c. Demonstration: Using a sponge, a bucket of water, and a model for a mountain, plunge the sponge in a filled bucket of water or in a sink. Comment that the sponge is a cloud and as it rises it gets denser until it cannot hold the water and then it rains. Squeeze the sponge. As the cloud goes up and over the "mountain," all the

Any opinions, findings, conclusions or recommendations expressed in this publication/work are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.
Grant #: 2017-68005-26867

Lesson Procedure: Day 2 (50 minutes)

moisture is removed from it so it is dry and no longer rains on the other side.

d. Have students draw (copy) the diagram of a mountain and land on both sides. Go through the steps of the clouds raining and then disappearing when going over the mountain. Have them draw the diagram at each step as seen on the screen (from shots in the video).

3. (5 minutes) Learning about Hadley cells.

   a. Define Hadley cell: A pattern of atmospheric circulation in which warm air rises near the equator, cools as it travels poleward at high altitude, sinks as cold air and warms as it travels towards the equator again.

   b. Play a 3-minute video on Hadley cells called ***Why does earth have deserts?*** https://www.youtube.com/watch?v=T6Us1sPXBfA

      i. The video may be confusing but further exploration will clarify concepts.

      ii. Play video at 1.5x using YouTube settings to allow for better retention of video.

4. (10 minutes) Learning about density.

   a. Define density as presented in day 2 PowerPoint, slide #19. Students should copy the scientific definition: The amount of mass in a given volume, or how much stuff fits in a given space.

      Note: It may be helpful to keep a copy of the definition on display.

   b. Go over some examples of objects that are dense and ones that are not as dense. As in the PowerPoint slide discuss a rock, oil and water separation, and a helium balloon.

   c. Introduce the relationship between density and temperature.

      i. **Note:** It is helpful to move your hands in opposite directions when explaining that one goes up while the other goes down.

      ii. Show the pictures of how far apart and how many molecules are in cold or hot air as shown in day 2 PowerPoint, slide #22. This gives the students a better idea of the relationship between temperature and density.

5. (15 minutes) Drawing a Hadley cell.

Students should draw the steps of a Hadley cell using time points from the video. Continue asking: *Why does earth have deserts?* During each step, a discussion will ensue with the students regarding the mechanisms of air movement and weather.

   a. Video 1:19: Have the students draw what is shown on the screen. A picture of the sun, a semicircle with equator line, cold air with arrows going towards the equator, hot air rising straight above.

      Ask: What heats the air at the equator? Does it become more or less dense? Which direction does it move?

Any opinions, findings, conclusions or recommendations expressed in this publication/work are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.
Grant #: 2017-68005-26867

Lesson Procedure: Day 2 (50 minutes)

b. Video 1:33: Have the students draw clouds above with rain coming down and perhaps a forest with some trees at the equator.

   Ask: Why does the air cool as it goes up? As it cools, does it get more or less dense? What happens to the space between air molecules? What does this do to the water between the air molecules? Remind the students of the sponge squeezing out water from the rain shadow as an example to help answer the questions.

c. Video 1:43: Have the students draw a ceiling at the 17 km mark as a dotted line and then air flow separating at the top going both south and north as shown by arrows and wind lines.

   Ask: Why does the air stop going up? Where does it go?

d. Video 1:53: Have the students draw the air sinking down and going towards the earth again with the wind lines and arrows, perhaps drawing the deserts below it.

   Ask: What happens to the temperature of the air as it moves sideways at high altitude? Is cold air more or less dense? What happens to dense air? Does this cold air have much water in it?

e. Complete the drawing by having the air move back to the equator from both the north and south deserts with the appropriate wind lines and arrows. Tell them this wind pattern cycle is the Hadley cell, which helps form the deserts and rain forests of the world.

Any opinions, findings, conclusions or recommendations expressed in this publication/work are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.
Grant #: 2017-68005-26867

Lesson Procedure: Day 3 (50 minutes)

Lesson at a Glance

1. Present the PowerPoint "Hot vs Cold Air: Density"
2. Students will perform an experiment demonstrating density.
3. Students will record data in their personal science notebooks that provide evidence to answer the questions:
    a. What happened to the balloon in hot water?
    b. What happened to the balloon in cold water?
    c. Why do you think the balloon inflated in hot water?
3. **Assessment.** Students will write a conclusion answering these questions:
    a. What happens to air when you heat it up?

        Important takeaway: When you heat up air, it expands and becomes less dense. Molecules are farther apart from each other when it is hot.

    b. What was your hypothesis and were you correct?

        Ideal hypothesis: When you heat the bottle in the hot water the balloon should expand out from the bottle. When you put the balloon in ice water it should shrink to the point that the balloon goes into the bottle.

    c. What evidence supports or does not support your hypothesis?
    d. What does this imply about air at the equator? How does our experiment relate to air at the equator?

        Important takeaway: Air at the equator rises because the sun is heating the equator more directly than other areas of the earth. As it rises it starts to cool off again and can't hold in all its moisture because it gets denser, therefore it rains a lot near the equator.

Detailed Lesson Plan

1. (5 minutes). Ask the class for an observation and a question to gauge understanding of the topic. Have you seen hot air balloons? What happens to air when you heat it up?
2. (7 minutes). Talk about background research with the class in four segments.
    a. Discuss what is in air. Tell them it is made of small pieces of matter called molecules. Mention the specific kinds of molecules in it such as oxygen, nitrogen and water vapor.
    b. Discuss what density is. Give a brief definition (how heavy an object is for a given volume). Present an example of which object is more dense, a rock or a sponge. Tell them the rock is heavier. The sponge is lighter because of the many holes in it.

Any opinions, findings, conclusions or recommendations expressed in this publication/work are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.
Grant #: 2017-68005-26867

Lesson Procedure: Day 3 (50 minutes)

c. Mention briefly that a rock sinks in water because it has higher density.

d. Talk about the difference between cold and hot air. Mention that the cold air sinks and shrinks while the hot air expands and spreads out, like the stuff in a sponge.

3. (3 minutes). Create hypotheses. Read out loud (and potentially have the students copy in their notebooks) the few sentences that describe the hypothesis in the given day 3 PowerPoint, Hot vs Cold Air: Density, slide #7, (whether the balloon will inflate or deflate if put into a hot beaker of water).

4. (5 minutes). Discuss the materials, procedure and safety issues of the upcoming experiment with the class.

   a. List the materials they will use as is shown in the slide (empty water bottle, balloon, hot plate, ice, water, beaker).

   b. Explain the procedure to the class. Briefly explain all of the steps listed on the slide given for the procedure.

   c. Discuss safety for experiment. Engage students in creating a safe environment.

      i. Hair ties

      ii. Goggles

      iii. Common sense safety: do not touch hot beakers or hot plates.

5. (5 minutes). Go over data collection for experiment.

   Students should draw what is happening to the balloon at the beginning, what it looks like in hot water, and what it looks like in ice water. They should draw out three boxes in their lab notebook for each of the drawing steps.

6. (15 minutes). Perform the experiment. Have the students follow the procedure presented to them.

   Note: Have the procedure available for students to review.

7. (10 minutes). Data analysis and conclusion.

   a. Ask: What did the balloon do in hot water? What did it do in cold water? Why do you think the balloon inflated in hot water?

   b. Students should write sentences in their lab notebooks answering the following questions:

      i. What happens to air when you heat it up?

      ii. What was your hypothesis? Were you correct?

      iii. What evidence supports or does not support your hypothesis?

      iv. How does our experiment relate to air at the equator?

Any opinions, findings, conclusions or recommendations expressed in this publication/work are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.
Grant #: 2017-68005-26867

What and Why of Deserts

Further Exploration:

Lesson Plan: 'What is a desert?' – http://desertusa.com/desert.html

Lesson Plan: Unit 1: World Deserts – http://coreknowledge.org/free-resource/ckhg-unit-1-world-deserts/

Lesson Plan: 'Farming the desert – The science behind desertification' – PBS Learning Media: http://az.pbslearningmedia.org/

Learning Media: 'Air density, convection and the movement of air molecules' – http://education.com/science-fair/article/convection-air-motion/

H. Reich (April 2013). Why does the earth have deserts? (2 min : 18 s) https://www.youtube.com/watch?v=T6Us1sPXBfA

N. Zentner & T. Foster (Mar 2015). Rain Shadow Effect : 2 minute Geology. (4 min : 26 s) https://www.youtube.com/watch?v=DoKTTHd-XEQ

M. Arthur, D. Saffer, P. Balmond. Atmospheric conditions : Hadley cells. InTeGrate – Penn State & Utah State Universities. http:/e-education.psu.edu/earth111/node/752

Author Bios:

Matthew Katterman is a PHD graduate student at the University of Arizona studying Biosystems Engineering. He is interested in irrigation engineering along with computer modeling of the guayule production system. He also has an intense interest in bioproducts and biofuels production. Matthew is a native of Tucson, Arizona, and received his Bachelor's in Chemistry in 1997 as well as his Masters in Agricultural and Biosystems Engineering in 2004.

Traci Klein grew up mostly in Massachusetts, then came west to go to Brigham Young University. She graduated with a BA in Comparative Literature in 1993. After a stint in Salt Lake City while her first husband went to medical school and their two boys were born, they moved to Tucson. Traci decided to switch fields and did graduate work in Plant Sciences at the University of Arizona and worked as a lab researcher for several years. After taking time at home to raise her sons, and after a divorce, she decided to dip her toes into education and began working as a long term substitute in the Baboquivari School District on the Tohono O'odham nation while taking online education classes. She received her teaching certificate and has been teaching 7th grade science at Valencia Middle School for 6 years. She has also been the MESA (Math Engineering Science Achievement) Club Advisor for 5 years. Currently, she is enrolled in the Masters in Educational Leadership program at Northern Arizona University and hopes to go into education administration.

Any opinions, findings, conclusions or recommendations expressed in this publication/work are those of the author(s) and do not necessarily reflect the view of the U.S. Department of Agriculture.
Grant #: 2017-68005-26867