ACTIVITY 8

Science Is a Human Endeavor

VIDEO

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ACTIVITY SUMMARY

Students watch video segments on how scientific research may lead to possible solutions for water scarcity and improvements in water conservation. The contributions of individuals and teams from many nations and cultures to the field of science is highlighted. The concept of scientific optimism is formally introduced. Students begin to discuss the role of advances in science and technology in solving global problems.

ACTIVITY TYPE
VIDEO

NUMBER OF 40–50 MINUTE CLASS PERIODS
1

KEY CONCEPTS & PROCESS SKILLS

1 Scientific optimism enables scientists to solve difficult problems over long periods of time.

2 New scientific tools and techniques contribute to the advancement of science by providing new methods to gather and interpret data and can lead to new insights and questions. Technology can enhance the collection and analysis of data.

3 The development of scientific knowledge is iterative; it occurs through the continual reevaluation and revision of ideas that are informed by new evidence, improved methods of data collection and experimentation, collaboration with others, and trial and error.

4 hrough science, humans seek to improve their understanding and explanations of the natural world. Individuals and teams from many nations and cultures have contributed to the field of science.

CONCEPTUAL TOOLS


VOCABULARY DEVELOPMENT

scientific optimism
the belief that persistence and iteration on a scientific problem will eventually lead to insights

MATERIALS & ADVANCE PREPARATION

FOR THE TEACHER

- COMPUTER WITH INTERNET ACCESS AND PROJECTION

FOR EACH STUDENT

- STUDENT SHEET 8.1 "Video Notes"
- STUDENT SHEET 1.4 "Unit Concepts and Skills" (OPTIONAL)

Bookmark the video links and preview the video segments prior to showing them to the class. The focus of this activity is the use of science and technology to address water availability while highlighting the contributions of people (both individuals and teams) to this work. You may wish to show additional or alternative video segments; if so, look online and preview relevant videos. The two recommended video segments are:

PBS NewsHour's *How Scientists Are Harvesting Fog to Secure the World's Water Supply* (approximately 7 minutes)

RAZOR Science Show's *Water from Air: New Technologies to Combat Drought* (approximately 8 minutes)

Extension 1 provides an opportunity to investigate how traditional techniques are being rediscovered and implemented to address global water needs. The recommended video segment is:

Retro Report's *Fighting Drought with an Ancient Practice: Harvesting the Rain* (approximately 11 minutes)

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion** are highlighted in blue.

GETTING STARTED (10 MIN)

1 **Introduce the concept of scientific optimism.**

- As students explored so far in this unit, both professional scientists and others have continued to research the world scientifically, even when met with obstacles and errors. This approach of adopting a can-do attitude in light of challenges and believing that scientific problems are solvable are aspects of **scientific optimism**.
- For some student populations, you may find it helpful to introduce the idea of scientific optimism by first reviewing the idea of optimism—a positive attitude based on the belief that the future or a future outcome will happen as desired.
- Ask, What examples of scientific optimism have you observed in this unit so far? Create a list of student responses on the whiteboard. Student responses may include the work of Africa Flores, Julius Lucks and his team, and Marilou Sison-Mangus and her team. Students may point out the investigation of scientific ideas over time such as the canals on Mars, the development of the modern microscope, and the work of John Snow on cholera.

PROCEDURE SUPPORT (30-40 MIN)

2 **Students take notes while watching each video.**

- Explain that in these videos, students will learn about efforts to address global water needs.
- Depending on your student population and the time available, you may wish to show the video segments twice. Students can first watch a video in its entirety and then watch it a second time to take notes.
- Distribute Student Sheet 8.1, "Video Notes." Explain that the names on the student sheet are the individuals and/or team leaders for various efforts to address global water needs that are highlighted in the videos.

- As students watch each video, pause at the end of each group's work so students can record notes. The following table identifies where in the videos the focus on each team ends.

POSSIBLE STOPPING LOCATIONS IN THE VIDEO AFTER MINUTES:SECONDS	EXPERTS
How Scientists Are Harvesting Fog to Secure the World's Water Supply	
1:40	Dar si Hmad (Director, Jamila Bargach) and the German Water Foundation
4:38	MIT Professor Kripa Varanasi and team
6:25	Virginia Tech University Professor Brook Kennedy and team
Water from Air: New Technologies to Combat Drought	
3:55	MIT Professor Evelyn Wang and team
6:55	University of Texas at Austin Professor Guihua Yu and team

- If appropriate, have students briefly compare notes in pairs or groups before resuming a video. Alternatively, project a copy of Student Sheet 8.1 and have students contribute to collective classroom notes.
- Have students complete Student Sheet 8.1 by describing how each person exhibited scientific optimism by being persistent and continuing to iterate on the problem they were addressing.
- Discuss students' thinking about how these individuals and teams represent scientific optimism. In general, these examples demonstrate a commitment to work on a global problem with the goal of eventually contributing significantly to a solution.

3 Students brainstorm ideas for improving the availability of safe drinking water.

- After students have watched some recent innovations and research intended to address water availability, they work in groups to brainstorm their own ideas for solving global water needs. This is intended to help prepare students for Activity 10, Procedure Part A, when they will again brainstorm ideas and reflect more deeply on their proposed solutions and compare them to current global solutions. Following is one sample student idea:

Sample Student Response, Procedure Step 4

I would like to make something that could turn shower water into drinking water or water for plants. It is a waste for shower water to just go down the drain. It would need to be filtered to get all the soap and dirt out first.

- If time allows, encourage students to explore this idea creatively and consider how students might describe their solutions (e.g., with drawings, slides, skits, photos).

- Have students share their ideas with the class. Some students may have lots of proposed solutions, while other students may find that their thinking is sparked by listening to others' ideas.
- In Procedure Step 5, construct a class list of student ideas. Students are asked to refer to this list in Activity 10, so each student should record the list in their science notebook. Students can use this list as a springboard for ideas they will propose in Activity 10.

SYNTHESIS OF IDEAS (10 MIN)

4 Lead a class discussion to highlight the role of scientific optimism and scientific advancement.

- As described in Procedure Step 6, have a class discussion to connect the work of the people in the videos with the concepts of scientific optimism and scientific advancement. Use the following questions and discussion points:

How did the researchers featured in the videos contribute to scientific knowledge about water collection?

In the PBS NewsHour video, Virginia Tech University professor Brook Kennedy and his team investigated ways to improve fog-collecting technology by experimenting with different mesh designs (fog harp), and MIT professor Kripa Varanasi and his team explored the use of electric fields to improve efficiency of water collection from fog.

In the RAZOR Science Show video, MIT Professor Evelyn Wang and her team developed a new technology to capture water from the air in dry climates, while University of Texas at Austin professor Guihua Yu and his team developed a hydrogel soil that can absorb water and slowly release it when heated by sunlight.

How does the work of scientific researchers build on prior scientific knowledge in the PBS NewsHour video?

Fog collectors are based on a water collection approach developed in traditional communities from the Middle East and South America. The researchers used technology that already existed (mesh) and relied on other aspects of science (measurement, experimental design) to construct their collectors and improve its efficiency.

What role did scientific optimism play in the work of the people highlighted in the videos?

Each of the people in the videos was optimistic about finding solutions through science to address issues of water availability. Scientific optimism underlies the work that is being done because people believe that there are solutions to global needs, such as water accessibility, and are finding ways to test their ideas.

In what other areas have you observed the effects of scientific optimism?

Scientific optimism is improving applications of new technology, such as increasing the efficiency and use of fuels in cars by moving from gas-powered to electric and making innovations more widely available, such as the use of cellphones around the world or the availability of solar panels for home energy use rather than only for industrial applications.

- Build Understanding item 2 ties the concept of scientific optimism back to other examples that students have seen in this unit. You can use this item to formatively or summatively assess students' understanding of scientific optimism.
- You may wish to have students revisit optional Student Sheet 1.4, "Unit Concepts and Skills," and add the concepts of scientific optimism and science as a human endeavor.
- Connections to Everyday Life item 6 provides an opportunity for metacognitive thinking. Point out this opportunity for student self-reflection.
- Complete the activity by evaluating if your students are able to identify the essential ideas of the activity related to the key concepts and process skills by asking the Guiding Question, *What role does scientific optimism play in the development of scientific solutions?*

EXTENSION (10 MIN)

5 Use the Extensions as an opportunity for advanced learning.

- In Extension 1, students watch a video about how traditional techniques are helping address local water needs in different regions. The video describes how the following individuals and their communities took action to improve water availability in their area:
  - Dr. Rajendra Singh of India helped revive the use of *johads*, small earthen dams that collect rainwater and provide groundwater recharge.
  - Zephaniah Phiri Maseko of Zimbabwe used contour ridges and other low-cost methods to collect and redirect water.
  - Brad Lancaster of Tucson, Arizona, was inspired by Singh and Maseko to raise his neighborhood pathways and create curb cuts to change rainwater flow, as well as to redirect water from his household drains and roof.
  - Tucson, Arizona's Community Sustainability Organization Flowers and Bullets teamed with Silvia Valdillez, Rachel Frank, and Jesus Romero to install water harvesting tanks and other local sustainable techniques.
  - City of Tucson stormwater programs (described by Blue Baldwin of Tucson Water) and Manzo Elementary School's rainwater garden incorporate water harvesting.

- Discuss the question in Extension 1: In what ways do traditional techniques contribute to scientific advancement? The use of traditional techniques has led to innovative ways to address water needs while utilizing relatively low-tech solutions, such as johads. The scientific knowledge and processes of water conservation have advanced through the rediscovery of these traditional techniques. These techniques are also the basis of new approaches to water use, such as curb cuts to provide rainwater for growing plants in a neighborhood.
- In Extension 2, students do online research to investigate whether scientific optimism has driven a recent innovation in science and technology. They select one recent innovation and identify the team(s) responsible, as well as their motivations. Students can share their findings with a family member and ask about a scientific or technological innovation that occurred during the family member's lifetime. Together, they can research who was responsible for that breakthrough and what motivated them.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

1. **The development of scientific knowledge occurs through continual reevaluation and iteration of ideas that are informed by:**

   - **new evidence**
   - **improved methods of data collection and experimentation**
   - **collaboration with others**
   - **trial and error**

   Which methods did the individuals featured in the video use? Explain how each person used one or more of these methods.

   All these methods were probably used. The scientist studying water condensation by using a solar absorber was collecting new evidence to address issues related to dew points in arid climates. The scientists collecting fog were using improved materials and experimental methods to evaluate fog catching. All the individuals probably had to collaborate with others and try out their ideas before they were able to conduct successful trials.

2. **Look back at the work you have done so far in this unit.**

   a. **What other examples of scientific optimism have you encountered? List as many as you can think of.**

   The work of Julius Lucks, Africa Flores, and Marilou Sison-Mangus and their teams are all modern examples of scientific optimism. Other examples include John Snow; the individuals who contributed to the study of Mars; and the individuals who developed, refined, and used microscopes.

   b. **Choose one example and explain exactly how it represents scientific optimism.**

   Africa Flores was interested in addressing environmental issues in Guatemala. Even though she did not initially have the data she needed, she persisted and tried to gather it on foot. She then found satellite data and was able to use it to make iterations of her model. This helped her better understand the spread of the algal bloom.

3. **What role does creativity play in scientific optimism? Support your answer with examples.**

   Creativity can help people persist in looking for solutions or scientific ideas because they may think of something new or find solutions in unexpected places. For example, applying the fog-catching traditions from other countries to research using modern materials is a creative approach. Creativity can also lead people to keep improving new innovations, such as the use of a soil gel to absorb and release water for plants.

④ **Imagine you are a scientist working on water issues in Skipton. What questions would you like to investigate? How could these questions help address water quality and water availability in Skipton? Describe the research that you would do and how it might address Skipton's water problems.**

I would like to find more information about the water quality and availability in the area over time. I would search the published literature and reach out to other investigators. I could find out if the water quality and water availability had decreased, increased, or stayed the same. I could use this information to decide what additional research to do and to determine if there was a viable long-term clean-water source in the Skipton area.

CONNECTIONS TO EVERYDAY LIFE

⑤ **How do you use optimism in your own life? Describe a situation in which you persist toward your own goals even when you encounter challenges.**

I try again and use different approaches when my first way doesn't work. For example, if I don't do well in math, I don't give up on that subject. Instead, I try studying differently.

⑥ **Different food crops require different amounts of water, as shown in Table 8.1. What role do you think science can play in reducing the amount of water needed for agriculture?**

TABLE 8.1: GLOBAL AVERAGE WATER FOOTPRINT (PER TON OF CROP)

FOOD CROP CATEGORIES	WATER USAGE (CUBIC METERS PER TON)
Sugar (sugar cane, sugar beet, etc.)	200
Vegetables	300
Roots and tubers (potatoes, yams, etc.)	400
Fruits	1000
Cereals (corn, wheat, rice, etc.)	1600
Oils (sunflower, canola, peanut, etc.)	2400
Pulses (lentils, peas, dried beans, etc.)	4000

Science may come up with new crop varieties that require less water; find new ways to improve water efficiency in agriculture; develop new methods of water conservation; and, perhaps, one day create techniques to increase precipitation in areas with low rainfall.

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INDIVIDUALS AND TEAMS	NOTES ABOUT THEIR WORK	HOW IS THIS AN EXAMPLE OF SCIENTIFIC OPTIMISM?
How Scientists Are Harvesting Fog to Secure the World's Water Supply		
Dar si Hmad (Director, Jamila Bargach) and the German Water Foundation		
MIT Professor Kripa Varanasi and team		
Virginia Tech University Professor Brook Kennedy and team		
Water from Air: New Technologies to Combat Drought		
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How Scientists Are Harvesting Fog to Secure the World's Water Supply		
Dar si Hmad (Director, Jamila Bargach) and the German Water Foundation	• *fog collectors utilize natural wind patterns that bring fog inland* • *19,000 square feet of "cloud fishers" in Morocco's mountains where there is only 5 inches of rain per year* • *water collects on mesh and drips into pipes* • *pipes provide water to 1,000 people per day; previously had to walk 1–2 hours to collect water*	*People are using scientific technology based on traditional techniques to address local water needs.*
MIT Professor Kripa Varanasi and team	• *an electric field pulls water droplets from fog onto mesh* • *technology can be used in power plant cooling towers, which use 40% of freshwater in the U.S.* • *increases efficiency of water collection to almost 100%*	*Researchers iterate by designing investigations and gather data to identify ways to increase efficiency of water collection from fog.*
Virginia Tech University Professor Brook Kennedy and team	• *developing a fog collector known as a "fog harp" with vertical wires; no horizontal wires prevents water getting stuck* • *inspired by redwood trees* • *3 times more efficient at collecting water*	*Researchers iterate on the design of fog collectors to increase efficiency of water collection.*
Water from Air: New Technologies to Combat Drought		
MIT Professor Evelyn Wang and team	• *solar absorber on lid and absorbent material underneath, which collects water from the air* • *when box is closed, sunlight heats top of box and water droplets form on condenser, which cools and drips onto a collector* • *goal is to collect enough water needed by a single person for a day*	*Researchers persist in developing a tool for dry climates where historically atmospheric water would be difficult to condense.*
University of Texas at Austin Professor Guihua Yu and team	• *developing a super moisture-absorbent gel (SMAG) to mix with soil* • *moisture-absorbing polymer absorbs water from the air and thermal-releasing polymer releases water under natural sunlight* • *can reduce amount of water needed for agriculture and increase areas available for farming*	*Researchers persist in developing a material to increase water availability for crops and are investigating feasibility of widespread use in the natural environment.*