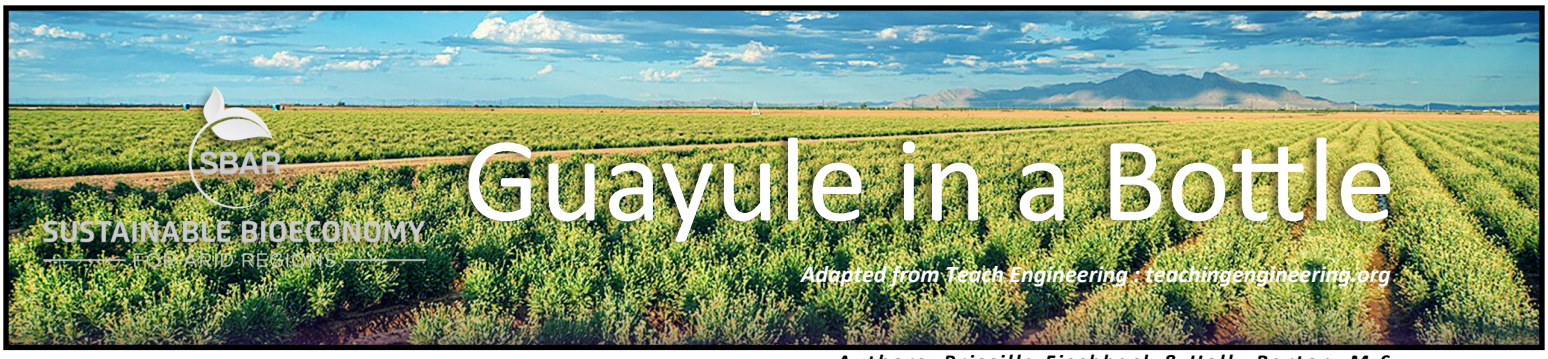

Guayule in a Bottle

Adapted from Teach Engineering : teachingengineering.org

Authors: Priscilla Fischback & Holly Barton, M.S.

Standards

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.

MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.

MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.

MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Materials/Resources

- PowerPoint 1: Guayule in a Bottle
- Handout 1: Observation Sheet (attached)
- Handout 2: Experiment Conclusion (attached)
- 2-3 plastic bottles
- 1 bottle cap
- Soil
- Cotton String
- Nail
- Scissors
- Duct Tape
- Seedlings—Guayule (or other low water plant), tomatoes, corn, brussel sprouts, lettuce, and/or other vegetable seedlings
- 1-2 heating lamps if the classroom does not have natural light available

Lesson Overview

In this lesson one to two week lesson, students will use the scientific process to conduct an experiment comparing a high water use seed/seedling and a low water/drought resistant plant (Guayule). The growing and observation process can last from 1-2 weeks, with daily observations—see the attached Handout 1 (Daily Observation Sheet). Final discussion questions and a conclusion report outline are included in the PowerPoint for this lesson and on the attached Handout 2.

Learning Objectives

- Students will learn about Guayule and other arid land crops.
- Students will be able to identify quantitative and qualitative changes in the bottle ecosystems.
- Students will increase their understanding of water usage and the implications to crops in arid regions.
- Students will be able to explain environmental characteristics that support or hamper the growth of particular plants.
- Students will implement data collection methods for monitoring and analyzing growth patterns.
- Students will be able to construct scientific arguments based on data collected and analyzed.

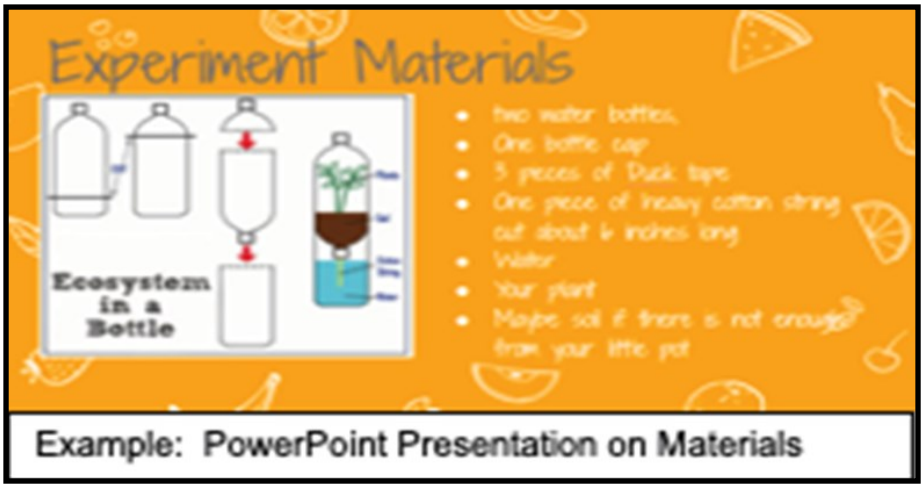

Diagram: Copyright, Geof Hill, ITL Program, College of Engineering, University of Colorado Boulder

Vocabulary

- **Guayule** - an evergreen shrub native to the Southwest U.S.
- **Ecosystem** - a community of living and nonliving organisms
- **Variable** - any factor, trait, or condition that can exist in differing amounts or types
- **Hydrologist** - a scientist who studies how water interacts with Earth
- **Soil Infiltration** - a process by which water on the grounds surface enters the soil
- **Niche** - a specific environmental condition that fits the preference a species
- **Producers** - organisms that produce their own food
- **Habitat** - the natural home or environment of a species
- **Decomposers** - organisms that break down dead or decaying organisms

Notes

- Students should have a basic understanding of ecosystems and plant needs (e.g., water, soil, and sunlight)
- To introduce Guayule, here is a YouTube video about the plant, pronunciation, uses, and historic/cultural significance. https://www.youtube.com/watch?

Experiment Procedure

Students will, in groups of four, construct an ecosystem using 2 plastic bottles

- Cut the top off of bottle (a) at the shoulder to create a base. Keep the top and discard the cap. Cut the bottom of bottle (b) an inch from the bottom to create a cover and discard the bottom. Feel free to label the cover and base.
- Create a small hole in Bottle A's cap and put the cotton string through, then tie a knot with an excess 1-2 inches. Then close cap with string inside Bottle A.
- Fill Bottle B with soil up to an inch then place the seedling and cover with soil. Fill Bottle A with water up to 2 inches and mark the water level with a date.
- Situate Bottle B upside down with the cap facing the base, inside Bottle A. Then tape the bottles together.
- Save the top of Bottle A and tape it on top of Bottle B. Keeping the cap on Bottle B would create a closed system and the water will be recycled thus affecting the experiment outcome. Then place the experiment in an area with natural light or under a heating light.
- Students will create charts to record water changes (water level will be marked with another color marker each day) and visual changes with plant
- Each day, the students will work on the Daily Observation handout on their plant. They can measure the water level changes and record any qualitative changes of the plant and experiment.
- During the research period, students can learn about the water cycle or ecosystem services.
- At the end of the observation period, have the students graph the information they have obtained through observations. At this time, they should write hypotheses to explain some of the things they observed.
- Pose questions to the students about their project designs such as, Why did we include the string and does it matter how long it is? What ways do you think you can keep your plant alive? What are some of the differences in between the different plants?"
- Outcome/Assessment: In a desert region, why would we care about plants and their water usage? If we only planted guayule or corn, how would that affect our community? Can we use one crop of plant for everything? How did your plant fare against other plants (e.g., graphs on water usage) and did your hypothesis prove correct?

For Further Exploration

- Teach Engineering: STEM Curriculum for k-12, teachengineering.org
- University of Arizona, SBAR Project (Sustainable Bioeconomy for Arid Regions Project https://sbar.arizona.edu/research
- YouTube Video: Guayule at Red Rock Energy Farm https://www.youtube.com/watch?v=jwEgHpInBR4
- Website: US Arid Land Agricultural Research Center: https://www.ars.usda.gov/pacific-west-area/maricopa-arizona/us-arid-land-agricultural-research-center/
- "Traditional Arid Lands Agriculture: Understanding the Past," *edited* by Scott E. Ingram and Robert C. Hunt https://muse.jhu.edu/book/38237

Authors & Reviewers

Priscilla Fischback & Holly Barton, M.S. | Ms. Fischback is a high school science teacher in Tucson Arizona. Ms. Barton is a graduate of the Masters program in Planning from the University of Arizona and an Associate Planner in Washington State. Reviewers include Torran Anderson, Cara Duncan, and Corey Knox

SBAR SUSTAINABLE BIOECONOMY FOR ARID REGIONS
USDA NIFA United States Department of Agriculture National Institute of Food and Agriculture
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
Cooperative Extension · ARIZONA · NM STATE UNIVERSITY · NM College of ACES/CES · COLORADO SCHOOL OF MINES · BRIDGESTONE · Colorado State University · USDA ARS Agricultural Research Service

Student Handout 1: DAILY OBSERVATION

HYPOTHESIS: Does Guayule use (high or low) amounts of water compared to other plants (Brussel sprouts, corn, and tomato)? What kind of plants are best suited for the desert?

Date	Observation (increase, decrease, the same? Use your senses)	Measurement

1. What did you observe about the guayule plant?

2. What did you observe about the vegetable plant?

3. Which plant used the most water?

4. If a plant uses a lot of water, why is this a problem here in Arizona?

Student Handout 2: CONCLUSION

Group Name and Plant	Observation (Water usage, plant condition, and other observations)	How would you improve this experiment?

Experiment Conclusion

1. Why did we conduct this experiment?

2. State your findings, what happened?

3. Restate your hypothesis.

4. Does your experiment confirm your hypothesis? Why?

5. Discuss errors and ideas for improving your experiment design?

6. What are your ideas for future experiments?

Whole Group Discussion

1. Which plants used the most water?

2. Which plants used the least amount of water?

3. Why is the amount of water a plant needs a concern in Arizona or other arid regions?