PURPLE PLOW
Uncovering STEM Solutions

PUZZLERS

#1 Water Access

1 HOUR

PUZZLE: BUILD A PIPE PROTOTPYE THAT CAN TRANSPORT WATER ACROSS A 10-FT DISTANCE

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, NGSS.HS-ETSI-3

SUGGESTED MATERIALS: Water, straws, pipes, buckets

BACKGROUND: Water is critical to food production and human survival. In many developed countries, like the U.S. and Canada, they are fortunate enough to have access to clean water. However, not every person has the luxury of having clean, safe water nearby. In other parts of the world, women and girls are often responsible for collecting water with buckets, and can spend up to 6 hours every day collecting water.[i] There's an ongoing effort to build up the infrastructure to more easily transport water, but there is still much more work to be done.

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Research a different country and compare their water security to your home country.

[i] Water.org. (n.d.). *Water crisis - Learn about the global water crisis.* Retrieved from: https://water.org/our-impact/water-crisis/

PUZZLERS

#2 Mini Aquaponic System

2 HOURS

PUZZLE: ENGINEER A PROTOTYPE WHERE FISH AND PLANTS CAN GROW TOGETHER

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, NGSS.MS-LS2-5, NGSS.5-LS2-I, NGSS.HS-ETSI-2

SUGGESTED MATERIALS: Grow bed, tubing, PVC pipe, growing medium, pump, small plastic fish tank or plastic tote, tape/glue, razor, saw, waterproof tape, various plants, various animals, pH test strips

BACKGROUND: Aquaponics is a system of aquaculture in which the waste produced by farmed fish or other aquatic animals supplies nutrients for plants grown hydroponically, which in turn purify the water. Aquaponics uses no soil and requires less water than traditional agriculture. Maintaining the levels of nutrients is important to the health of both the fish and the plants being grown in the system. The pH of the system helps the organisms to grow strong and allows them to flourish.[i]

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2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Research how aquaponics systems are used across the country or throughout the world to better understand the importance of these systems in food production.

[i] Permaculture Research Institute. (2016, May 30). *What is aquaponics and how does it work?* Retrieved from https://permaculturenews.org/2016/05/30/what-is-aquaponics-and-how-does-it-work/

PURPLE PLOW Uncovering STEM Solutions

PUZZLERS

#3 Seed Sprout

1 HOUR

PUZZLE: SPROUT SEEDS WITHOUT USING SOIL

STANDARDS & CONNECTIONS: NGSS.3-5-ETS1, NGSS.MS-ETS1, NGSS.MS-LS2-5, NGSS.5-LS2-1, NGSS.HS-ESS3-4

SUGGESTED MATERIALS: Paper towels, napkins, water, variety of seeds, glass jars, plastic Ziplock bags

BACKGROUND: All fully developed seeds contain an embryo and, in most plant species, a store of food reserves, wrapped in a seed coat. Temperature, moisture, air, and light conditions must be correct for seeds to germinate. Aeration in the soil media allows for good gas exchange between the germinating embryo and the soil. Seeds need oxygen and produce carbon dioxide (CO_2). If the soil or media is not well aerated due to overwatering or compaction, the CO_2 will not dissipate and seeds can suffocate. Most seeds germinate best under dark conditions, however some seeds require sunlight. Most seeds germinate at around 70-90 ºF.[i] Can you sprout a seed without using soil?

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2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Once the seed has sprouted, have the students analyze whether their seeds are monocots or dicots! NOTE: It will take 1-2 weeks for the seeds to germinate.

[i] Pennsvylania State University Extension. (2012, August 28). *Seed and seedling biology.* Retrieved from https://extension.psu.edu/seed-and-seedling-biology

PUZZLERS

#4 Water Cycle

1 HOUR

PUZZLE: CREATE A MODEL THAT DEMONSTRATES THE WATER CYCLE

STANDARDS & CONNECTIONS: NGSS.3-5-ETS1, NGSS.MS-ETS1, NGSS.MS-ESS2-4, NGSS.5-ESS2-1, NGSS.HS-ESS2-5

SUGGESTED MATERIALS: Glass bowl, plastic food container with lid, warm or hot water, salt, plastic wrap, and ice

BACKGROUND: The water cycle is the continuous natural process of how water moves above, below, and on the Earth's surface. The four main phases of the water cycle are evaporation, condensation, precipitation, and collection. The sun heats surface water forcing some of it to evaporate into the atmosphere as vapor. Plants lose water through transpiration. As the vapor cools and condenses in the sky, it forms clouds. When the clouds are heavy with water, water falls or precipitates back to the Earth as rain, snow, or some combination of both. The water either collects in oceans, rivers, and lakes, freezes into glaciers or ice, or soaks into the ground as groundwater.[i] Water is needed to grow crops and raise healthy livestock.

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- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Students may need more guidance on the different stages of the water cycle before they start their project.

[i] U.S. Geological Society. (2016, December 15). *Summary of the water cycle.* Retrieved from: https://water.usgs.gov/edu/watercyclesummary.html

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PUZZLERS

#5 Aquarium Gravel Vacuum

1 HOUR

PUZZLE: BUILD A GRAVEL VACUUM THAT CAN CLEAN AN AQUARIUM

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Empty plastic soda bottles with tops, plastic tubing, scissors, bucket with water and small rocks (for testing)

BACKGROUND: Maintaining aquatic systems can be a difficult task. There are many factors to consider, such as water quality, the health of the plants and animals, and understanding the unique dynamics of the system. Aquatic organisms, both plants and animals, are susceptible to disease and this can pose a threat to the balance of the system they belong to. It is important to maintain healthy and quality organisms that can contribute to the system. A helpful piece of aquarium equipment is a gravel vac. They are useful for getting debris out of the bottom of a tank and helping drain a small aquarium to then replenish with clean water.

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3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have students take their vacuums home to use on their own aquariums!

PURPLE PLOW
Uncovering STEM Solutions

PUZZLERS

#6 Weather Station

1 HOUR

PUZZLE: BUILD A WEATHER STATION THAT CAN BE USED TO TRACK WEATHER

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, NGSS.MS-LS2-5, NGSS.5-LS2-I

SUGGESTED MATERIALS: Cardboard, paper, colored markers/pencils, glue, tape, streamers, empty plastic water bottle, ruler, skewer sticks

BACKGROUND: "Weather is the air temperature, cloud cover, precipitation, wind, moisture content, and air pressure at any particular time in any particular place."[i] Climate is the average weather pattern of a certain place over time. Meteorologists make observations and develop predictions on future weather called forecasts. Weather plays a critical role in agriculture. Farmers and ranchers check the weather daily to help guide their decisions. Good weather can dictate when farmers can plant, whether or not livestock get pneumonia, and many other implications.[ii]

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2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

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- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

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6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have students take their weather stations home to track and compare weather over time.

[i] National Oceanic and Atmospheric Administration. (n.d.). *Weather and climate basics.* Retrieved from https://oceanservice.noaa.gov/education/pd/oceans_weather_climate/weather_and_climate_basics.html

[ii] Center for Science Education. (n.d.). *Weather: The basics.* Retrieved from: https://scied.ucar.edu/shortcontent/weather

PUZZLERS

#7 Miniature Greenhouse

1 HOUR

PUZZLE: CREATE A MINIATURE GREENHOUSE

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, NGSS.MS-PS3-3

SUGGESTED MATERIALS: Plastic wrap, plastic water/soda bottle, plastic pipe, wire, wood pallet, cardboard

BACKGROUND: Greenhouses are used in agriculture because they stay warm inside, even during the cold months. They are typically made of glass or some type of translucent material. As the sun shines on the greenhouse, the temperature inside increases, but the heat is trapped so it can't escape.[i] As a result, greenhouses can prolong the growing season, making it possible to grow plants during the times of the year where the plant would otherwise freeze or die. Greenhouses are also used to grow young plants called seedlings because of the preferable environment.

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.[ii]

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

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6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Put a temperature gauge inside the greenhouse and place one outside. See if the temperature inside stays warmer than outside. Visit your local nursery to see what they use to maintain their greenhouses.

[i] NASA. (2018, April 23). *What is the greenhouse effect?* Retrieved from: https://climatekids.nasa.gov/greenhouse-effect/

[ii] University of Massachusetts Amherst. (2015). *Starting a greenhouse business.* Retrieved from: https://ag.umass.edu/greenhouse-floriculture/fact-sheets/starting-seeds-in-greenhouses

PUZZLERS

#8 Vertical Garden

2 HOURS

PUZZLE: BUILD A VERTICAL GARDEN

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Soil, wood pallets, containers, metal wire, pots, various seedlings, water, canvas, felt, wire mesh, nails, hammers

BACKGROUND: Vertical gardens save space because they grow up, instead of out, like most gardens. They can be utilized inside a home or office or used outside in a backyard or city square. Mexico City installed vertical gardens to combat the increasing pollution.[i] There are many different varieties of vertical gardens to choose from. One easy option is a container-style garden, which means potted plants are attached to a wall or displayed in rows, or planters are stacked. Another is a "pocket" garden, featuring plants tucked into pockets made from felt or canvas. Vertical gardens can also be grown using wood pallets. In wood pallets, landscaping fabric is stapled to the back, bottom, and sides of the pallet. The inside of the pallet is completely filled with soil, and plants are grown in the slat openings.[ii]

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2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

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4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Could your community use any beautification efforts? Vertical gardens are a great way to spruce up your town!

[i] Cave, D. (2012, April 9). *Lush walls rise to fight a blanket of pollution.* Retrieved from https://www.nytimes.com/2012/04/10/world/americas/vertical-gardens-in-mexico-a-symbol-of-progress.html

[ii] Yang, S. (2016, July 21). *How to grow a vertical garden.* Retrieved from: https://www.realsimple.com/home-organizing/gardening/how-to-make-

PUZZLERS

#9 Rain Garden

2 HOURS

PUZZLE: CREATE A RAIN GARDEN

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Soil, native plants, shovels, gloves, water

BACKGROUND: A rain garden is a garden planted with native shrubs, perennials, and flowers in a depressed area to encourage water collection. Rain gardens are most useful if they're situated downhill from rooftops and roads, as they are designed to collect runoff from those surfaces. Rain gardens are effective in removing up to 90% of nutrients and chemicals and up to 80% of sediments from the rainwater runoff. Compared to a conventional lawn, rain gardens allow for 30% more water to soak into the ground.[i]

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- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Encourage students to find a place at home where they can build their own rain garden.

[i] The Groundwater Foundation. (2018). *All about rain gardens.* Retrieved from https://www.groundwater.org/action/home/raingardens.html

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PUZZLERS

#10 Photosynthesis

1 HOUR

PUZZLE: FILM A 2-MINUTE VIDEO DEMONSTRATING THE PROCESS OF PHOTOSYNTHESIS

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, NGSS.HS-LSI-5, NGSS.HS-LS2-5

SUGGESTED MATERIALS: Access to the internet, cell phones, prop materials (paper, scissors, markers, etc.)

BACKGROUND: All plants, algae, and even some microorganisms use photosynthesis. Photosynthesis is the transfer of energy from the sun to a plant. The formula for photosynthesis is $6CO_2 + 6H_2O$ + Light energy –> $C_6H_{12}O_6$ (sugar) + $6O_2$. By taking in water (H_2O) through the roots, carbon dioxide (CO_2) from the air, and light energy from the sun, plants can perform photosynthesis to make glucose (sugars) and oxygen (O_2). After the sugar is produced, it is then broken down by the mitochondria into energy that can be used for growth and repair. The oxygen is released into the atmosphere through the leaves, providing oxygen to other life forms on earth that need it – like humans![i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

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4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

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6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Encourage students to be creative and to use props! Create a list of key vocabulary you'd like them to include in their video.

[i] Smithsonian Science Education Center. (2018, April 12). *Whar is photosynthesis?* Retrieved from https://ssec.si.edu/stemvisions-blog/what-photosynthesis

PUZZLERS

#11 Roots Rule

1 HOUR

PUZZLE: BUILD A ROOT SYSTEM THAT CAN HOLD A PENCIL IN PLACE

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Pencils, tape, pipe cleaners, scissors

BACKGROUND: Roots anchor the plant and are responsibile for the uptake of water. They promote soil health by preventing erosion and creating beneficial microbila communities. Shallow roots can access bands of fertilizer like Nitrogen and Phosphorus. Deep roots can forage for water during times of drought and channels made through the soil by roots allow water to infiltrate deep down. Vertical roots, like taproots, can punch through hardpans that limit growth.[i]

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ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Experiment trying to "root" heavier items. Have a competiton to see who can support the heaviest item!

[i] York, L. (2018, June 1). *Why roots matter to soil, plants and you.* Retrieved from https://www.noble.org/news/publications/ag-news-and-views/2018/june/why-roots-matter-to-soil-plants-and-you

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PUZZLERS

#12 Worm Farm

1 HOUR

PUZZLE: CREATE A WORM FARM

STANDARDS & CONNECTIONS: NGSS.3-5-ETS1, NGSS.MS-ETS1, NGSS.MS-LS2-5, NGSS.5-LS2-1, NGSS.HS-ESS2-7

SUGGESTED MATERIALS: Soil, cardboard box with lid, water, food scraps

BACKGROUND: An earthworm has no arms, legs or eyes, but is responsible for helping make our soil healthy so we can grow food. As worms move through soil, they create space for water, roots, and air. This helps make the soil less compact, making it easier for plants to grow. Worms also break down organic matter, like leaves and grass, which are important for soil health. As they break down organic matter, they create waste, or castings, which are a natural fertilizer for plants.[i] In one acre of land, there could be one million earthworms that can create 100 tons of castings.[ii] Earthworms are an invaluable helper to the agriculture industry.

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

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Punch holes in the lid and keep the box in a shaded place to keep the soil moist. Occasionally put scraps in the box for the worms to eat. Do not put in meat, onions or peppers and limit citrus and starchy food.

[i] University of Illinois Extension. (n.d.). *Can't live without me.* Retrieved from http://extension.illinois.edu/worms/live/

[ii] University of Illinois Extension. (n.d.). *Worm facts.* Retrieved from http://extension.illinois.edu/worms/facts/

PUZZLERS

#13 Soil Erosion

1.5 HOURS

PUZZLE: CREATE A PROTOTYPE THAT PREVENTS SOIL EROSION

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-LS2-5, NGSS.HS-ESS2-2

SUGGESTED MATERIALS: Water, different types of soil, potted plants, mesh netting, screens

BACKGROUND: Soil erosion is the removal of soil from the earth's surface from either wind or water. Soil erosion is bad for agriculture because it reduces the amount of farmable land available. The wind and water carry away the topsoil, which is often the soil with the most nutrients, making it difficult for plants to grow well. Water quality can also be poorly affected as the soil runs into streams and waterways. Soil erosion is a problem across the globe that must be addressed to in order to produce enough food.[i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Research what your local community is doing to prevent soil erosion.

[i] Al-Kaisi, M. (2000, July 24). Soil erosion: *An agricultural production challenge.* Retrieved from: https:// crops.extension.iastate.edu/soil-erosion-agricultural-production-challeng

PUZZLERS

#14 Edible Soil Profile

1 HOUR

PUZZLE: CREATE AN EDIBLE SOIL HORIZONS PROFILE

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, NGSS.HS-ESS2-7

SUGGESTED MATERIALS: Clear plastic cups, plastic spoons, green sprinkles and gummy worms (O), chocolate pudding (A), vanilla pudding (B), hard candies (C), graham crackers (whole - R; crushed - E), variety of other sweets for them to make their own versions

BACKGROUND: All soils have different types of layers and those layers give us insight into the fertility of the soil. Dig down deep into any soil, and you'll see that it is made of layers, or horizons (O, A, E, B, C, R). Together, the horizons form a soil profile. The O horizon is made of loose and partly decayed organic matter or humus. The A horizon is mineral matter mixed with some humus, also known as topsoil. The E horizon is light-colored mineral particles and is the zone if eluviation (signigicant loss of minerals) and leaching. The B horizon is the accumulation of clay transported from above, known as the subsoil. The C horizon is partially altered parent material. Lastly, the R horizon is unweathered parent material called bedrock and is not considered soil.[i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

If you'd like to take this activity one step further, follow it up with Puzzler #15 Soil Sample and use Playdough instead of edible materials.

[i] University of Hawai'i. (2018). *Soil profile.* Retrieved from https://www.ctahr.hawaii.edu/mauisoil/a_profile.aspx

PUZZLERS

#15 Soil Sample

1 HOUR

PUZZLE: DEMONSTRATE HOW TO TAKE "SOIL" CORE SAMPLES TO DETERMINE SOIL FERTILITY

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Playdough (soil), straws (soil probes), paper boat food trays, three different colors of nonpareil sprinkles (NPK nutrients)

BACKGROUND: Soil is a major source of nutrients needed by plants for growth. The three main nutrients found in healthy soil are nitrogen (N), phosphorus (P) and potassium (K). Nitrogen is a key element in plant growth. It is found in all plant cells, in plant proteins and hormones, and in chlorophyll. Phosphorus is a major component in plant DNA and RNA. Phosphorus is also critical in root development, crop maturity and seed production. The role of potassium in the plant is indirect, meaning that it does not make up any plant part. Potassium is associated with the movement of water, nutrients and carbohydrates in plant tissue. It's involved with enzyme activation within the plant, which affects protein, starch and adenosine triphosphate (ATP) production.[i] Farmers and ranchers will collect soil samples and send them in to a University laboratory to be analyzed for their nutrients and fertility levels.

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Assign N, P, and K a sprinkle color. Students can take "soil" core samples, squeeze them out, and determine the the ratio of NPK in their soil by counting the sprinkles.

[i] Ball, J. (2007, January 3). *Back to basics: The roles of n, p, k and their sources.* Retrieved from https://www.noble.org/news/publications/ag-news-and-views/2007/january/back-to-basics-the-roles-of-n-p-k-and-their-sources/

PUZZLERS

#16 Stop the Rot

1 HOUR

PUZZLE: CREATE A PROTOTYPE THAT CAN DELAY AND SPEED UP THE RIPENING PROCESS OF FRUIT

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Bags, plastic wrap, fruit, boxes

BACKGROUND: Fruits naturally produce the gas ethylene that causes fruit to ripen. Climacteric fruits continue to ripen after they are picked, and non-climacteric fruits will slowly start to rot after they are separated from their host plant.[i] Grocery stores will buy climacteric fruit and store it in a temperature-controlled warehouse until they are ready to send the product to stores. Then they'll release ethylene gas into the room and the fruit will start to ripen again. This practice allows consumers to have ripe produce and reduces potential food waste.[ii]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have students take their prototype home to test!

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[i] Abell, C. (2017, April 6). *Ripening 101: Climacteric vs. non-climacteric fruits.* Retrieved from https://foodandnutrition.org/blogs/student-scoop/ripening-101-climacteric-vs-non-climacteric-fruits/

[ii] International Service for the Aquisition of Agri-Biotech Applications. (2017, August). *Pocket k no. 12: Delayed ripening technology.* Retrieved from http://www.isaaa.org/resources/publications/pocketk/12/default.asp

PUZZLERS

#17 Seasonal Produce Display

1 HOUR

PUZZLE: CREATE AN INFORMATIONAL DISPLAY FOR GROCERY STORES THAT INFORMS CONSUMERS ON SEASONAL PRODUCE

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, CCSS.ELA-LITERACY.SL.9-10.4

SUGGESTED MATERIALS: Colored markers/pencils, poster paper, cardboard, tape, glue

BACKGROUND: Seasonal produce is fresh fruits and vegetables that are harvested and eaten during the time of year they grow best. What's in season will vary depending on where we live and what the climate is like. The United States Department of Agriculture (USDA) recommends that half of our plate be fruits and vegetables, whether they are canned, frozen, dried or fresh. However, eating fresh produce in season likely tastes more fresh and may be more nutritionally dense.[i] To find out what's in season in your area visit your local farmers' market and check out the USDA Seasonal Produce Guide: https://snaped.fns.usda.gov/seasonal-produce-guide.

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Ask your local grocery stores and farmers' market if they'll put up the best displays.

[i] U.S. Department of Agriculture. (2018, January 26). *MyPlate.* Retrieved from https://www.choosemyplate.gov/MyPlate

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PUZZLERS

#18 Community Food Map

2 HOURS

PUZZLE: CREATE A COMMUNITY FOOD MAP

STANDARDS & CONNECTIONS: NGSS.3-5-ETS1, NGSS.MS-ETS1, CCSS.ELA-LITERACY.SL.9-10.4

SUGGESTED MATERIALS: Access to the internet, poster paper, colored markers/pens, glue, scissors

BACKGROUND: The United States Department of Agriculture (USDA) estimates that 40 million people live in neighborhoods without easy access to fresh, affordable, and nutritious food options. Accessing healthy food can mean multiple bus rides while carting groceries and children, or scrambling to find someone with a car who is willing to drive to the nearest market. This problem affects residents in both urban and rural parts of the US. It is estimated that 4.6 million people live in rural areas without access to a full service grocery store. These areas are greatly in need of reliable transportation, in addition to the jobs and economic activity that grocery stores and healthy food retail can provide.[i] Community food mapping involves finding out where people can buy, grow and eat food in a local area. The information might be displayed on a physical map, a digital version or some other visual representation of the area.[ii]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have students research a policy that could be changed or enacted to improve food access in their communities.

[i] Sustain. (n.d.). *Food mapping.* Retrieved from https://www.sustainweb.org/foodcoopstoolkit/foodmapping

[ii] Healthy Food Access Portal. (2018). *Making the case.* Retrieved from http/www.healthyfoodaccess.org/access-101/making-the-case

PUZZLERS #19 Food Budget

1 HOUR

PUZZLE: DEVELOP A MONTHLY FOOD BUDGET & GROCERY PLAN FOR A FOUR-PERSON FAMILY HOUSEHOLD

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, CCSS.ELA-LITERACY.SL.9-10.4

SUGGESTED MATERIALS: Access to the internet, calculator, Excel

BACKGROUND: Disposable income is the total amount of money available for an individual or population to spend or save after taxes have been paid. U.S. consumers spend about 10% of their disposable personal income on food, while those in other countries spend much more.[i] Mexico spends 23% of their disposable income and Nigeria spends 57% of their disposable income on food.[ii] A budget is a plan for how you plan to spend money. Creating this spending plan allows you to determine in advance whether you will have enough money to do the things you need to do, like eat and pay bills, or would like to do, such as go to the movies.

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have students choose different countries and compare their budgets and grocery plans.

[i] USDA. (2018, October 24). *Americans budget share for total food changed little during the last 20 years.* Retrieved from https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=76967

[ii] American Farm Bureau Foundation for Agriculture. (2017). *Food and farm facts.* Pg 5.

PUZZLERS #20 Food Drive Action Plan

1 HOUR

PUZZLE: BUILD AN ACTION PLAN FOR A COMMUNITY FOOD DRIVE

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, CCSS.ELA-LITERACY.SL.9-10.4

SUGGESTED MATERIALS: Access to the internet, paper, colored markers

BACKGROUND: Forty million people struggle with hunger in the United States, including more than 12 million children.[i] About 795 million people in the world do not have enough food to lead a healthy active life. That's about one in nine people on Earth.[ii] Many households who visit charitable food programs make difficult choices in order to meet basic needs. Specifically, households served by the Feeding America network report choosing between food or medical care, housing, transportation, and utilties. Food insecurity can be an extremely stressful situation for a person or household. When people don't know where their next meal will come from, their central focus becomes securing that next meal and it can be difficult to focus on other important things like school and work.[iii]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Take a field trip to tour around and volunteer at your local Food Bank.

[i] Feeding America. (2018). *Facts about poverty and hunger in America.* Retrieved from https://www.feedingamerica.org/hunger-in-america/facts

[ii] World Food Programme. (2015 September 30). *10 facts about hunger.* Retrieved from https://www.wfp.org/stories/10-facts-about-hunger

[iii] Feeding America. (2018). *What are the connections between food insecurity and health?* Retrieved from ttps://hungerandhealth.feedingamerica.org/understand-food-insecurity/hunger-health-101

PUZZLERS

#21 My Cafeteria Menu

2 HOURS

PUZZLE: DESIGN A SCHOOL CAFETERIA MENU (BREAKFAST & LUNCH) FOR ONE MONTH USING MYPLATE GUIDELINES

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Paper, colored markers/pens, MyPlate reference information, food magazines, glue

BACKGROUND: Farmers and ranchers are committed to growing and raising healthy, safe food for consumers. They do their part in following state and federal regulations, as well as their own set of protocols for producing healthy food on the farm. As consumers, we have to do our part in caring for and protecting our bodies. Our bodies need the proper fuel to function. This includes a balanced diet of vegetables, fruits, grains, protein and dairy as shown here within the MyPlate guidelines: https://www.choosemyplate.gov/.

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Ask your school's food service employees to come share their career and how they build the menus.

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PUZZLERS #22 Supply & Demand Board Game

2 HOURS

PUZZLE: CREATE A BOARD GAME ABOUT THE LAW OF SUPPLY AND DEMAND

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Dice, paper, colored markers, scissors, cardboard, access to the internet or economic books

BACKGROUND: The basic economic principles of supply and demand often determine the price of food in the grocery store. Supply is the amount of a product that a seller is willing and able to sell. Demand is a consumer's willingness and ability to buy a product. There are a variety of factors, or determinants, that determine supply and demand. If the supply is low, and demand is high, the price will rise. If the supply is high, and the demand is low, the price will fall. This concept is the Law of Supply and Demand.[i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have students research supply and demand before creating their game if they are unfamiliar with the concept. Keep the best games in your classroom for students to play during their free time.

[i] North Dakota State University. (2013, September 26). *Demand & supply.* Retrieved from https://www.ag.nd-su.edu/aglawandmanagement/agmgmt/coursematerials/demandsupply

PUZZLERS

#23 No-Bake Granola Bar

1 HOUR

PUZZLE: CREATE A NO-BAKE HEALTHY GRANOLA BAR

STANDARDS & CONNECTIONS: NSFACS:4.4.4, NSFACS:8.5.10

SUGGESTED MATERIALS: Wax paper, quick oats, honey, nut butter, seeds, dried fruit, nuts, spices

BACKGROUND: Oats are considered a whole grain because they still have their entire grain kernel – the bran, germ, and endosperm.[i] Horses eat oats whole, but most oats you buy at the grocery store have been steamed and flattened to make them easier to for people to eat. Oats are used in a variety of goods including cereals and granola bars. Eating oats and oatmeal can lower our "bad" cholesterol and may help lower our risk of heart disease.[ii]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have a taste test! See which students made the tastiest granola bars. Be sure to check if any of the students have allergies before starting this Puzzler.

[i] U.S. Department of Agriculture. (2018, April 6). *All about the grains group.* Retrieved from https://www. choosemyplate.gov/grains

[ii] Whole Grains Council. (n.d.). *Oats - January grain of the month.* Retrieved from https://wholegrainscouncil. org/whole-grains-101/easy-ways-enjoy-whole-grains/grain-month-calendar/oats-%E2%80%93-january-grain-month

PUZZLERS #24 Careers in Agriculture

1.5 HOURS

PUZZLE: CREATE A "GO FISH" CARD GAME USING CAREERS FROM THE NINE AG CAREER FOCUS AREAS

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, CCSS.ELA-LITERACY.SL.9-10.4

SUGGESTED MATERIALS: Computer with Internet access, paper, colored markers/pens, scissors

BACKGROUND: There is a broad range of careers within the industry of agriculture. Agriculture has a variety and abundance of careers that fit within nine exciting career focus areas. Careers may have you using advanced equipment, creating new hybrid seeds, raising animals, managing people or designing new products and packaging. These nine areas include agribusiness systems, animal systems, biotechnology systems, environmental services systems, food products and processing systems, natural resources systems, plant systems, power, structural and technical systems, and agricultural education.[i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Students can find a local citizen with a career in agriculture and job-shadow them for an afternoon!

[i] Ag Explorer. (2018). *Ag Explorer.* Retrieved from https://www.agexplorer.com/

PUZZLERS

#25 Egg Carrier

1 HOUR

PUZZLE: BUILD A HANDS-FREE EGG CARRIER TO HELP COLLECT EGGS

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Egg cartons, ribbon, string, tape, rubber bands, wide popsicle sticks, flat foam pieces

BACKGROUND: There are eight steps to get eggs from the farm to your table: laying, collecting, washing, candling, storing and packing, shipping, selling and storing, and enjoying. Female chickens, hens, lay their eggs in either a hen house or outside. Larger chicken farms can have thousands of eggs to collect in a day, so they rely on automated gathering belts which help them collect eggs. Some smaller farms still gather eggs by hand.[i] It's important to collect eggs in a timely manner to lower the risk of them getting broken. If the eggs are cracked or broken, they can't be sold.

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Put eggs or rocks outside on a lawn. Time students to see how well and efficient their egg-carriers work.

[i] American Egg Board. (2018). *On the farm.* Retrieved from: https://www.incredibleegg.org/where-eggs-come-from/

PUZZLERS

#26 Cardboard Tractor

1 HOUR

PUZZLE: BUILD A CARDBOARD TRACTOR THAT CAN ROLL DOWN A RAMP

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Cardboard, glue, tape, colored markers/pens, rubber bands, straws, scissors

BACKGROUND: Just like many of us, farmers have looked to technology to make their jobs easier. In the 18th century, farmers used horses and oxen to pull wooden plows. In 1837, John Deere started producing steel plows and in 1868 steam tractors were invented that no longer needed horses or oxen. Then, John Froelich invented the first successful gas-powered tractor in 1892. Today tractors are used when planting, fertilizing, harvesting, and moving items around the farm. Over 120 years later and tractors are still helping farmers and ranchers perform many agricultural tasks.[i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Take a tour to a local farm supply store to see a real-life tractor.

[i] Ag In the Classroom. (2014). *Historical timeline - farm machinery & technology.* Retrieved from: https://www.agclassroom.org/gan/timeline/farm_tech.htm

PUZZLERS #27 Grassland Biome

2 HOURS

PUZZLE: BUILD A MODEL OF A GRASSLAND BIOME

STANDARDS & CONNECTIONS: NGSS.5-LS2-1, NGSS.MS-LS2-3

SUGGESTED MATERIALS: Access to internet, cardboard boxes, pizza boxes, colored paper, colored markers, scissors, glue, tape, other creative materials

BACKGROUND: The world's arid wild lands are also called rangelands. There are five main biome categories: grassland, shrubland, woodland and savana, tundra and alpine, and barren lands. Rangelands provide a vast array of resources, products and values, including forage for livestock, habitat for wildlife, clean water, renewable energy, recreational opportunities, open space, and magnificent vistas.[i] Grasslands are comprised of at least 25% herb cover (usually a grass) and less than 25% shurbs and trees.[ii] Many farmers' and ranchers' livelihoods depend on stewarding the natural resources available on grasslands.

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Build models for the other biomes: Shrubland, woodland and savana, tundra and alpine, and barren land.

[i] Wrangle. (2018). *Rangeland biomes.* Retrieved from https://wrangle.org/

[ii] Wrangle. (2018). *Grassland.* Retrieved from https://wrangle.org/biome/grassland

PUZZLERS #28 Bud Box

1 HOUR

PUZZLE: BUILD A LOW-STRESS "BUD BOX"

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, CCSS.ELA-LITERACY.SL.9-10.4

SUGGESTED MATERIALS: Access to the internet, popsicle sticks, glue, cardboard

BACKGROUND: Cattle ranchers design and use their facilities with intention and purpose so that both the cattle and the operators have a pleasant experience. A "Bud Box" is a simple system design aimed at reducing stress on cattle as they are being worked through processing facilities.The term Bud Box is named after the creator Bud Williams. A Bud Box uses cattle's natural instincts to move the cattle throughout the pen and into a cattle chute where they are often weighed, given vaccinations, or checked to see if they are pregnant. The "box" layout has open slates, often metal corral panels, and the trained stockman are in the pens either on foot or on horseback operating a gate.[i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have the students build a Sweep Tub next and compare the two!

[i] Mayo, D. (2015, August 7). *The "Bud Box" and the double alley design for cattle pens.* Retrieved from http://nwdistrict.ifas.ufl.edu/phag/2015/08/07/the-bud-box-and-double-alley-design-for-cattle-pens/

PUZZLERS #29 Ruminant Digestion

1 HOUR

PUZZLE: DEMONSTRATE THE FLOW OF FOOD IN A RUMINANT DIGESTIVE SYSTEM

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Computer with Internet access, text/print resources, paper, coloring supplies, string, thick fishing line, tape, scissors, colored water

BACKGROUND: Monogastric animals, such as pigs, poultry and humans, only have a single-chambered stomach. Ruminants, such as cattle, sheep, and goats, are hoofed mammals that have a unique four-chambered digestive system that allows them to more easily eat roughages like grass and hay. Ruminant stomachs have four compartments: the rumen, the reticulum, the omasum and the abomasum. Rumen microbes ferment feed and produce volatile fatty acids, which is the cow's main energy source. Food travels through different parts of the stomach for rumination, back up to the mouth (as a cud) for further chewing, and then back again so that the grass or grain can be broken down enough for nutrients to be available when the food travels to the intestines. By better understanding how the digestive system of the ruminant works, livestock producers can better understand how to care for and feed ruminant animals.[i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Students may need more guidance on the digestive system before they start their project.

[i] Mississippi State University Extension. (2018). *Understanding the ruminant animal digestive system.* Retrieved from http://extension.msstate.edu/publications/publications/understanding-the-ruminant-animal-digestive-system

PUZZLERS #30 Carbon Cycle

1.5 HOURS

PUZZLE: CREATE A MODEL THAT DEMONSTRATES THE CARBON CYCLE

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-LSI-7, NGSS.HS-LS2-5

SUGGESTED MATERIALS: Variety of paper, scissors, glue, colored markers, access to the internet

BACKGROUND: Carbon is a critical element that serves as the backbone to life on Earth. Most of the carbon on Earth is stored in sediment and rocks, while the rest of it resides in the atmosphere, ocean and living organisms, like humans! Carbon is constantly being stored and exchanged throughout these various reservoirs through a process called the carbon cycle.[i] Carbon moves from the atmosphere to plants through photosynthesis and from plants to animals when animals eat plants. When animals and plants die and decay, the carbon stored in them breaks down into the soil. Some carbon will become fossil fuels after being in the ground for millions of years and then humans will burn it for energy and the carbon will be released into the atmosphere. Oceans and other bodies of water absorb carbon from the atmosphere as well.[ii]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Students may need more guidance on the different stages of the carbon cycle before they start their project.

[i] National Oceanic and Atmospheric Administration. (2011). *Carbon cycle*. Retrieved from https://www.noaa.gov/resource-collections/carbon-cycle

[ii] The National Center for Atmospheric Research. (2007). *The carbon cycle*. Retrieved from https://scied.ucar.edu/carbon-cycle

PUZZLERS

#31 Mason Bee Hotel

1.5 HOURS

PUZZLE: BUILD A HOME FOR MASON BEES

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI

SUGGESTED MATERIALS: Small wood pieces, newspaper, carboard, string, pine cones, sticks

BACKGROUND: Bees have a big job in agriculture because they help pollinate plants. Pollination is the transfer of pollen from the male parts (stamen) of the flower to the female parts (pistil). The result of pollination is a fertilized plant that can now produce the many crops that we enjoy such as almonds, watermelon, and apples. Bees fly flower to flower collecting nectar and gathering pollen on their body and legs. As they travel, they end up brushing the pollen onto the stigma.[i] One type of bee is the Mason bee. They are solitary bees, meaning they don't live in hives with other bees. Instead, they find crevices in trees or rocks to live by themselves and build nests.[ii]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have students take their bee hotels home and hang or place them somewhere conducive for Mason bees.

[i] Michigan State University. (n.d.). *Pollination*. Retrieved from: https://www.canr.msu.edu/nativeplants/pollination/

[ii] Penn State Extension. (2015, August 12). *So what is a mason bee?* Retrieved from: https://extension.psu.edu/programs/master-gardener/counties/luzerne/news/2015/so-what-is-a-mason-bee

PUZZLERS #32 Monarch Migration

2 HOURS

PUZZLE: CREATE A MAP OF MONARCH BUTTERFLY MIRGRATION PATTERNS

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, CCSS.ELA-LITERACY.SL.9-10.4

SUGGESTED MATERIALS: Variety of paper, colored markers/pens, access to the internet, glue

BACKGROUND: The annual migration of North America's monarch butterfly is a unique and amazing phenomenon. The monarch is the only butterfly known to make a two-way migration as birds do. Unlike other butterflies that can overwinter as larvae, pupae, or even as adults in some species, monarchs cannot survive the cold winters of northern climates. Using environmental cues, the monarchs know when it is time to travel south for the winter. Monarchs use a combination of air currents and thermals to travel long distances. Some fly as far as 3,000 miles to reach their winter home! Monarchs can travel between 50-100 miles a day; it can take up to two months to complete their journey. The farthest ranging monarch butterfly recorded traveled 265 miles in one day. Monarchs in Eastern North America have a second home in the Sierra Madre Mountains of Mexico. Monarchs in Western North America overwinter in California.[i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Do you live near a migration pathway? Take a trip to visit a monarch butterfly reserve near you!

[i] USDA Forest Service. (n.d.). *Migration and overwintering.* Retrieved from https://www.fs.fed.us/wildflowers/pollinators/Monarch_Butterfly/migration/index.shtml

PUZZLERS #33 Pollinator Poetry

2 HOURS

PUZZLE: WRITE A POEM ABOUT POLLINATORS

STANDARDS & CONNECTIONS: CCSS.ELA-LITERACY.CCRA.L.5, CCSS.ELA-LITERACY.W.5-12.2, CCSS.ELA-LITERACY.SL.9-10.4

SUGGESTED MATERIALS: Access to the internet, paper, pen/pencil, Word, colored markers/pencils

BACKGROUND: Pollinators are critical to ecosystems. The work of pollinators help ensure that we have food to harvest and contribute to overall plant health. In the U.S., it's estimated that pollination produces $20 billion worth of products annually. Most pollinators (about 200,000 species) are beneficial insects such as flies, beetles, wasps, ants, butterflies, moths, and bees. The health of pollinator populations depends on citizens around the world doing their part to provide habitat, minimize pollution, and remain educated on how to improve their well-being.[i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have your students group up and turn their poems into songs!

[i] The Pollinator Partnership. (2011). *Pollination fast facts.* Retrieved from https://pollinator.org/PDFs/NPW/Pollination%20Fast%20Facts%20(3).pdf

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PUZZLERS

#34 Bee-ing in the Kitchen

1.5 HOURS

PUZZLE: BAKE A TREAT USING HONEY

STANDARDS & CONNECTIONS: NSFACS:8.5.10

SUGGESTED MATERIALS: Access to the internet (for recipes), honey, other ingredients for recipe, oven, baking pans, oven mitts

BACKGROUND: Honey is a natural product made from bees. As bees fly around from flower to flower they collect nectar. When they return back to the hive the nectar gets broken down into simple sugars which are stored inside the honeycomb. The most common form of honey is as a liquid in a bottle or jar, but it can also be enjoyed as a comb, crystallized, and whipped. The nectar of the flowers that the bees gather determines the color, aroma, and flavor. Honey has a handful of uses. It's used as a sweetener in baked goods and provides natural energy. Honey has been used for centuries to supress coughs and soothe sore throats too.[ii]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Host a teacher appreciation luncheon and serve your honey treats to the attendees.

[i] National Honey Board. (2018) *Honey benefits.* Retrieved from https://www.honey.com/about-honey/honey-benefits

[ii] National Honey Board. (2018) *Honey varietals.* Retrieved from https://www.honey.com/about-honey/honey-varietals

PUZZLERS #35 Honeycomb Home

1 HOUR

PUZZLE: BUILD A HONEYCOMB STRUCTURE THAT CAN HOLD 5 LBS

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, HS-ETSI-2

SUGGESTED MATERIALS: Newspaper, cardboard, tape, variety of paper, toothpicks, popsicle sticks, hot glue

BACKGROUND: The most noticeable contents of a beehive, besides the bees themselves, is the honeycomb attached to the walls and interior frames of the hive. Bees construct each cell of the honeycomb to provide a home for raising young and storing honey. For raising young, the queen bee lays her eggs in each cell, the pupa is cared for by worker bees until it hatches. Honeycomb can also be used to store honey. Beekeepers collect honey by removing frames from the hives, and then extracting honey from the honeycomb before returning the frames to the hive.[i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Keep increasing the weight to see who has the strongest honeycomb structure!

[i] National Honey Board. (2018). *How honey is made.* Retrieved from https://www.honey.com/about-honey/how-honey-is-made

PUZZLERS

#36 Solar Oven

1 HOUR

PUZZLE: CREATE A SOLAR OVEN

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, NGSS.HS-PS3-3

SUGGESTED MATERIALS: Pizza box (or similar item), aluminum foil, glue, scissors, black paper, plastic wrap, food for cooking (s'more supplies, tortillas, etc)

BACKGROUND: From campfires to microwaves and modern-day ovens, we have learned there are multiple methods to preparing a hot meal, including using solar energy. Solar energy is the light and heat emitted from the sun.[i] It is the most abundant energy resource on earth. That energy can be used to power farms, cars, and even cook food! Solar ovens work by absorbing direct energy from the sun and reflected sunlight from the oven.[ii]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have a cookout! Keep your solar ovens and have students bring food from home to cook in class. Caution: Please supervise as solar ovens can get very hot. Do not cook raw meat with solar ovens.

[i] Science Buddies. (2014, July 31). Sunny science: Build a pizza box solar oven. *Scientific American.* Retrieved from: https://www.scientificamerican.com/article/sunny-science-build-a-pizza-box-solar-oven/

[ii] U.S. Department of Energy. (2016, June 6). *Top 6 things you didn't know about solar energy.* Retrieved from: https://www.energy.gov/articles/

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PUZZLERS #37

Paper Windmill

1 HOUR

PUZZLE: BUILD A PAPER WINDMILL

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, NGSS.HS-PS3-3

SUGGESTED MATERIALS: Paper, pencils with eraser tops, push pins, scissors

BACKGROUND: Agriculture includes food, feed, fiber and energy. Energy powers our cities, farms, and rural communities. The most common energy sources are the fossil fuels coal, oil, and natural gas. A growing industry is renewable or clean energy, which includes energy sources like solar, wind and water.[i] We have been using wind energy for a long time – Egyptians used wind energy to power boats and American colonists used windmills to grind grain and pump water. Today we use windmills – tall towers with blades – that catch wind and convert it into energy.[ii]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Place the windmills outside in your school garden.

[i] U.S. Department of Energy. (n.d.). *Clean energy.* Retrieved from https://www.energy.gov/science-innovation/clean-energy

[ii] U.S. Department of Energy. (2014, June 20). *How a wind turbine works.* Retrieved from https://www.energy.gov/articles/how-wind-turbine-work

PUZZLERS #38 Waterwheel

2 HOURS

PUZZLE: ENGINEER A WATERWHEEL

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, NGSS.HS-PS3-3

SUGGESTED MATERIALS: Cardboard or foam board, push pins, string, scissors, box cutter, wood skewers, rulers, rubber bands, metal washers

BACKGROUND: Early attempts to make use of the energy of the natural world was to direct water being pulled by gravity, such as a waterfall or simply a flowing stream, by the use of a waterwheel. These tools involve a wheel with various attachment designs that interact with water and cause the wheel to turn. Early versions of waterwheels were used in milling grain for flour, grinding wood for papermaking, and pounding fiber for clothing. As engineers and waterwheel operators have experimented with new designs, waterwheels improved in efficiency and power. Turbines are the model descendent of waterwheels, and are part of many energy systems, from providing electricity to cities to powering jet airplanes.[i]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

How big can you make your waterwheel? See who can make the largest functioning waterwheel!

[i] University of Alaska. (2010). *The physics of a water wheel.* Retrieved from http://ffden-2.phys.uaf.edu/211_fall2010.web.dir/Brooks/index.html

PUZZLERS **#39** Rube Goldberg Machine

1.5 HOURS

PUZZLE: USE A RUBE GOLDBERG MACHINE TO DEMONSTATE ENERGY TRANSFER

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, NGSS.HS-PS3-3

SUGGESTED MATERIALS: Construction paper, marbles, small paper cups, paper towel tubes, string, jumbo paper clips, rubber bands, hot glue, tape, dominos, balloons, pins, scissors

BACKGROUND: Energy is defined as the ability to do work. There are two main types of energy: potential and kinetic. Potential energy is energy an object has as a result of its position. Kinetic energy is energy in motion or movement. The Conservation of Energy principle states that "the amount of energy remains constant and energy is neither created nor destroyed. Energy can be converted from one form to another (potential energy can be converted to kinetic energy) but the total energy within the domain remains fixed."[i] Rube Goldberg was an inventor and cartoonist known for his drawings depicting elaborate contraptions that solved a simple task.[ii]

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

Have students identify where the kinetic and potential energy is in their Rube Goldberg machines. You can specify the "simple task" that the machine does – Pop a balloon, staple a piece of paper, close a door, etc.

[i] NASA. (2015). *Conservation of energy.* Retrieved from https://www.grc.nasa.gov/www/k-12/airplane/thermo1f.html

[ii] Rube Goldberg. (2018). *Who was rube goldberg?* Retrieved from https://www.rubegoldberg.com/rube-the-artist/

Purple Plow Uncovering STEM Solutions

PUZZLERS #40 Energy PSA

2 HOURS

PUZZLE: FILM A PUBLIC SERVICE ANNOUNCEMENT ABOUT CONSERVING ENERGY

STANDARDS & CONNECTIONS: NGSS.3-5-ETSI, NGSS.MS-ETSI, NGSS.HS-LS2-7, CCSS.ELA-LITERACY.SL.11-12.5

SUGGESTED MATERIALS: Cell phone, video editing software, access to the internet, paper, colored markers

BACKGROUND: "A PSA (Public Service Announcement) is a short informational clip that is meant to raise the audience's awareness about an important issue. PSAs may include interviews, dramatizations, animations and many other types of video and audio content."[i] We use energy every day and everywhere - in our homes, in our businesses, when we travel, etc. Energy sources include solar, wind, water, geothermal, biomass, nuclear, coal, oil, natural gas, electricity, stored energy, and hydrogen.[ii] There are benefits and drawbacks to every type of energy source.

1. IDENTIFY: Share the background information with the students, then share the puzzle to be solved. Determine constraints (e.g., time alotted, space, materials provided, etc.) and divide students into small groups.

2. IMAGINE: Ask a series of questions to help students brainstorm solutions to the puzzle. Encourage students to list all ideas – don't hold back! Before moving on, make sure each group selects a solution that fits within the contraints.

- Ask: *How can you can solve this puzzle? Which of your ideas can you build a prototype for given the constraints?*

3. DESIGN: Students diagram the prototype, identify the materials needed to build the prototype, and write out the steps to take. Students describe the expected outcomes.

- Ask: *What steps will you take to create your solution? What do you expect your solution to look like and be able to do?*

4. CREATE: Students follow their design plan and build their prototypes. Monitor their progress and remind them about how much time they have.

5. TEST & IMPROVE: Students evaluate their creation and compare it with the expected outcomes. Students seek areas of improvement and make changes where needed.

6. SHARE: Students share their solution to the puzzle and communicate lessons learned.

- Ask: *What was your biggest takeaway? What would you do differently?*

ADDITIONAL RESOURCES: For more background information on this topic, please visit www.purpleplow.org.

See if you can team up with your school's computer and video class to create a PSA together.

[i] The Pennsylvania State University. (2018). Public service announcement. Retrieved from https://mediacommons.psu.edu/2017/02/14/public-service-announcement/

[ii] The Pennsylvania State University. (2018). Public service announcement. Retrieved from https://mediacommons.psu.edu/2017/02/14/public-service-announcement/