Lesson Plan Information

Name: Yeast Feast and Landfill-in-a-Bottle

Grades: 3-12

Topic: Decomposition and Fermentation

Students will learn how food waste decomposes in landfills, generating air pollution but also generating gases that can be used as an energy source. They will also learn how microorganisms (yeast) digest sugar into carbon dioxide through fermentation. Students will assemble a set of "landfills in bottles" and apply the scientific method to observe decomposition processes and draw evidence-based conclusions.

Time: One hour to conduct Yeast Feast and assemble Landfill-in-a-Bottle experiment; three to five days to track decomposition.

Introduction:

Have you ever noticed how old food starts to smell after it's been in the trash for a while? Or how apples turn brown after you cut them, bread grows mold and milk turn into cheese? These are all examples of organic decomposition, which happens when microscopic organisms (like mold, bacteria and yeast) consume food products and change them into something else.

Bacteria turn milk into cheese or yogurt, cucumbers into pickles and cabbage into sauerkraut. While breaking down these food items, they release gases that contain an

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energy source called **biogas**. Engineers have developed ways to capture this biogas, purify it, and use it as a fuel source for vehicles and power plants.

Another term for food scraps that come from plants or animals is **organic matter**, which means it was once alive and is made up of many elements including carbon. Carbon is one of the most important and abundant elements on Earth and is energy-rich. We eat it in the form of carbohydrates (sugars and starches) and burn it to make electricity (coal, oil and natural gas). You may have learned about the carbon cycle, Earth's natural recycling system for carbon. Because carbon is so useful to life, and because there is so much of it in the food we eat, it is vital to understand how it behaves and how we can capture it from our food scraps and use it as a renewable energy source.

Organic Matter Breaks Down in Two Ways

Organic matter breaks down in nature in one of two ways: **aerobic** and **anaerobic digestion**.

- Aerobic digestion – meaning "with oxygen" – happens when matter decomposes out in the open. Think of a pile of leaves, a sliced apple on your kitchen counter or a compost pile in the backyard. Bacteria in the air break down this matter and produce two things: Carbon dioxide gas and nutrient-rich soil (**digestate**).
- Anaerobic digestion, on the other hand, occurs in a sealed environment without oxygen. Think of a cow's stomach, or deep under a landfill. The bacteria that live

in that environment also break down the matter, but they produce a different gas: **biogas**, which is primarily made of methane – alongside the digestate. This biogas is extremely energy rich and can be used as a **renewable energy source**.

Why is it important to capture methane and use it as a fuel source? Methane gas is the main ingredient in the natural gas we use to cook food, heat homes and generate electricity. Huge amounts of it are generated from the breakdown of organic matter. It's usually either trapped in pockets deep underground or released into the atmosphere where it forms a potent **greenhouse gas**. By capturing methane generated by the breakdown of the food we grow, eat and throw away, we can turn this greenhouse gas into something useful to our community while also preventing the release of harmful greenhouse gases into our atmosphere.

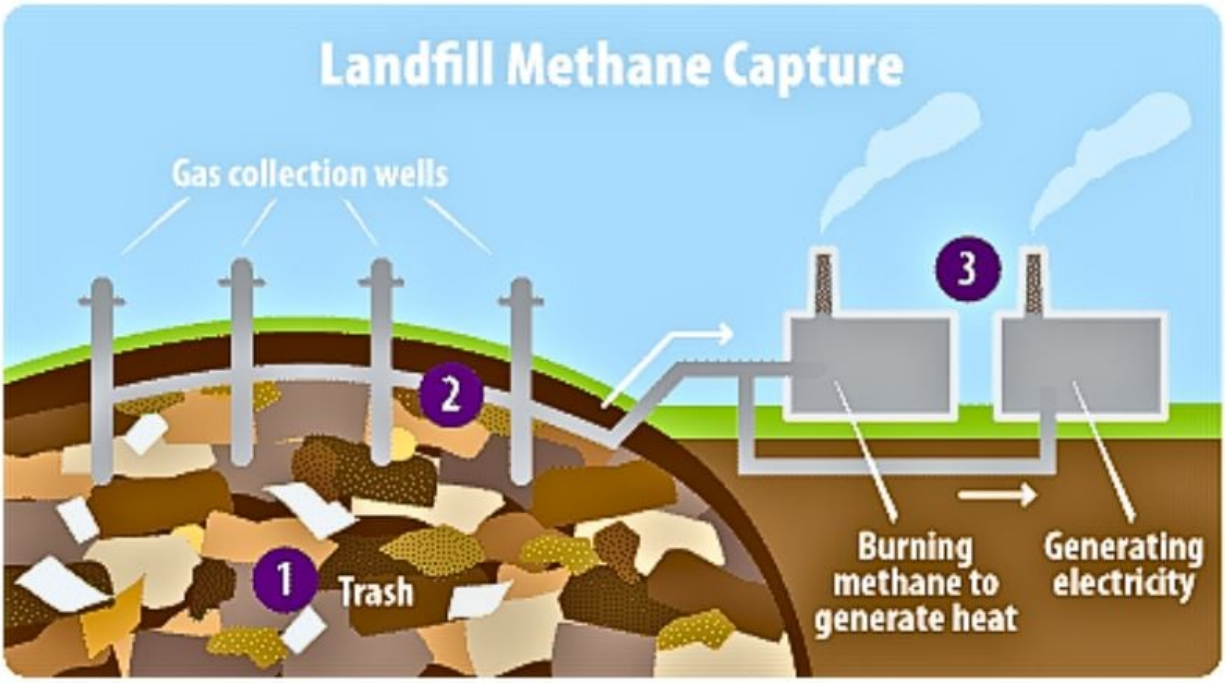

Image courtesy of the U.S. Environmental Protection Agency, 2023.

DFW Airport has a fleet of nearly 200 that buses that operate 24/7. They drive enough miles to circle the Earth once every 20 hours, which means they need a lot of fuel. For more than 20 years, 100% of DFW's buses have been powered by natural gas – a much cleaner fuel than diesel or gasoline. Since 2025, 100% of that natural gas has come from renewable sources, such as landfill biogas. This allows DFW to keep its buses running, while capturing large amounts of biogas from Texas landfills and putting it to good use.

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The experiments you are about to try will show you in real time how organic matter breaks down into gases that are either released into our atmosphere or captured and used as an energy source. Good luck!

Key Terms:

Aerobic Digestion – Breakdown of organic material, such as food waste, by bacteria in the presence of oxygen. This process typically occurs out in the open and generates carbon dioxide gas and digestate.

Anaerobic Digestion – Breakdown of organic material, such as food waste, by bacteria in the absence of oxygen. This process can occur underground or in a sealed container and generates biogas and digestate as byproducts.

Biodegradable – Ability of a substance to be broken down naturally by bacteria and air.

Biogas – Renewable gas produced by anaerobic digestion of organic matter, such as food scraps, sewage and animal manure. It is a mixture of gases, mainly methane (CH_4) and carbon dioxide (CO_2). The methane portion can be purified, bottled and burned as a fuel source in power plants, furnaces and vehicle engines.

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Composting – Controlled decomposition of organic waste into nutrient-rich material called digestate, or compost. Composting is performed through either aerobic or anaerobic digestion and generates biogas and digestate.

Digestate – Nutrient-rich material left over after the composting process, which is used as a soil additive in farming, gardening and potted plants. It can be a solid, liquid or a mixture of both.

Fermentation – Process where microorganisms (bacteria, yeast or mold) break down carbohydrates in a container without oxygen. This produces compounds such as acids, alcohol and mixed gases. Products made through fermentation include pickles, bread, wine and ethanol fuel.

Greenhouse Gases – Gases in the Earth's atmosphere that trap heat. They let sunlight pass through the atmosphere, but they prevent that same heat from leaving the atmosphere. Thus, causing a Greenhouse Effect and warming the planet's surface.

Landfill – Site for the disposal of waste materials, typically involving burial of waste under soil.

Natural Gas – Low-pollution fossil fuel formed from tiny dead plants and animals deep underground over millions of years. It's used to power vehicles, heat homes and make electricity and mostly comprised of methane.

Organic Waste – Biodegradable waste from plants or animals, such as food scraps, animal manure and yard trimmings.

Renewable Energy – Energy that is made from sources that can be regenerated. Sources include solar, wind, geothermal, biomass/biogas and hydropower from dams and tides.

Renewable Natural Gas – Purified methane captured from decomposing organic waste (like landfills, sewers, and farms) and used in place of regular natural gas. This fuel allows us to keep using natural gas systems (vehicles, stoves, power plants, etc.), but to collect the gas from sustainable organic sources – making it a renewable and cleaner fuel for our needs.

Sanitary Landfill – Special type of landfill designed to minimize environmental impacts by burying waste in layers.

Zero Waste – Philosophy that aims to design and manage resources to eliminate waste sent to landfills.

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Materials:

Kit will include:

- Four balloons per group (plus a few spares)
- One yeast packet per group
- Three sugar packets per group
- One paper funnel per group
- Two rolls of electrical tape – to be shared among groups
- One pouch of compost per group – carries microorganisms essential to anaerobic digestion
- One Yeast Feast Worksheet per group
- One Landfill-in-a-Bottle Worksheet per student

Not included in the kit:

- Four bottles per group – any size will do, as long as each group's four bottles are the same size
- Fruit and vegetable scraps from home – berries, onion scraps, banana peels, etc.
- Ruler
- Tap water

Experiment Procedures:

1. Divide the students into six small groups and number the groups
2. Ensure each group has a copy of the printed Yeast Feast Worksheet
3. Ensure each student has a copy of the printed Landfill-in-a-Bottle Worksheet
4. Have each group prepare the materials they brought from home
    a. Yeast Feast bottle
    b. Three empty bottles removing any labeling
    c. Ruler
    d. Three different fruits or vegetables, cut into small pieces
5. Provide each group with remaining materials from the kit to conduct both experiments
    a. Balloons (four per group)
    b. Compost pouch (one per group)
    c. Yeast pouch (one per group)
    d. Sugar packets (four per group)
    e. Paper funnel (one per group)
    f. Electrical tape (two rolls per classroom)
    g. Bottle labels (three per group; one for each unmarked bottle)
    h. Access to tap or bottled water

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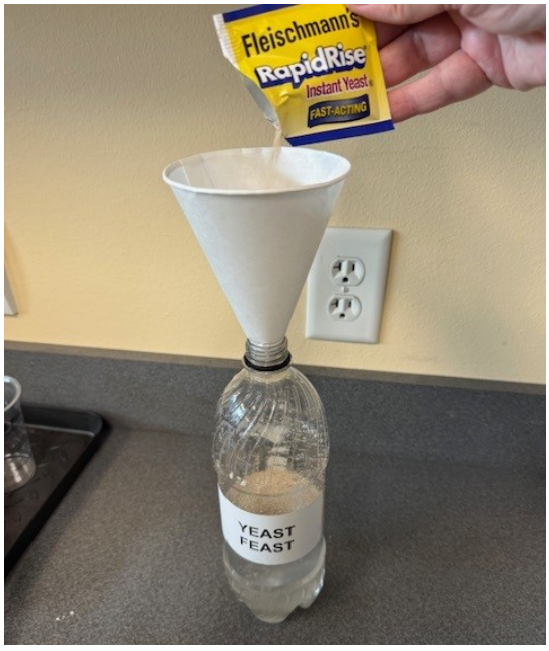
YEAST FEAST

6. Fill the Yeast Feast bottle about two-thirds full of room-temperature water. The water can be warm to the touch, but not hot. The yeast has to survive inside it
7. Using the funnel, pour the yeast and sugar packets into the bottle



8. Put the cap on the bottle and gently swirl it to mix the contents

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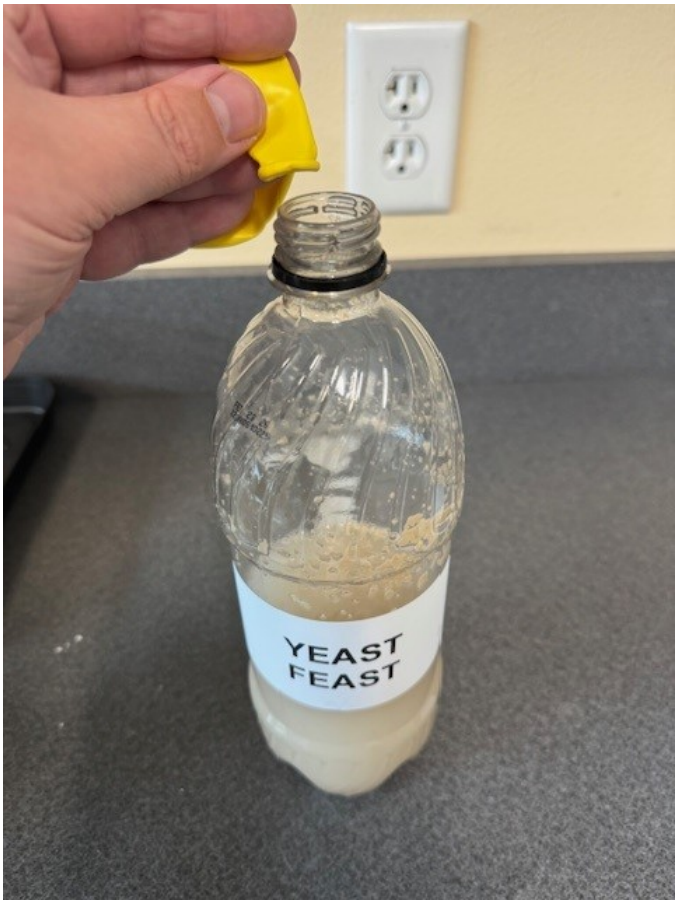
9. Remove the lid and wrap a balloon over the opening of the bottle



10. Wrap electrical tape around the edge of the balloon to make an airtight seal
11. Have students set the Yeast Feast bottle aside while they work on the Landfill-in-a-Bottle. Experiment but have them check on the Yeast Feast balloon every ten minutes or so. If the mixture inside the bottle starts to settle at the bottom, give the bottle a gentle swirl to mix it up again
12. Set the Yeast Feast bottles aside for now – but keep them with their groups. They will inflate after about an hour and the next phase of the kit will be complete by then

START THE LANDFILL-IN-A-BOTTLE EXPERIMENT HERE

LANDFILL-IN-A-BOTTLE

13. Gather each group's materials for the Landfill-in-a-Bottle Experiment
    a. Empty bottles (three)
    b. Balloons (three)
    c. Paper funnel (one)
    d. Electrical tape (two rolls per classroom)

e. Bottle labels (three per group; one for each unmarked bottle)
f. Ruler (one per group) – borrow from classroom/student supplies
g. Three different fruits or vegetables, cut into small pieces – have students bring from home
h. Access to tap or bottled water

14. Each group should have at least three food products – fruits, vegetables, etc. – chopped into small pieces or mashed by hand
15. Have each group pick three different food items – one for each bottle
16. Have each group write their group number and the food item of choice (“material”) on the three labels provided

17. Groups should affix one completed label to each empty bottle

SEE NEXT PAGE FOR LANDFILL-IN-A-BOTTLE WORKSHEET

Landfill-in-a-Bottle Worksheet

Allow each group to decide for themselves how much water and compost to put into the bottles – it should be the same amount in all three bottles, but the exact amount is up to each group.

Gas production is a function of four main ingredients inside the bottle: Organic matter, water, compost/bacteria and air. Changing the amount of one or more of these factors will influence how much gas is produced for the balloon.

1. Form a hypothesis and write it down below about which material will make the most gas in its balloon.

   Hypothesis: _____

   _____

2. Write the three materials for your group along the top row of the table below:

3. Using your hands and a paper funnel, put one type of food/material into each bottle. You should aim to put an equal amount of food into each bottle, so they fill to roughly the same height.

4. Using your hands or a paper funnel, add an equal amount of compost to each bottle on top of the food/material.

5. Fill each bottle to an amount that your group decides. If it helps, you can mark the bottles with a fill line.

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6. Place a balloon over each bottle opening, adding electrical tap to make an airtight seal.

7. Note the current time and write it below as the measurement time in the upper left corner. Every day, for the duration of the experiment, you should try to take your measurements at the same time every day to promote consistency.

8. Make sure your group's bottles are clearly labeled with your group number and the material inside the bottle and that the tape seals are intact.

9. Set all bottles aside in a safe space where they won't be bumped or cause a distraction.

10. At the measurement time that you indicated in the seventh step, measure your three bottles' balloons by gently placing a ruler at the widest point of the balloon.

    a. Record the diameter within the table listed in the second step.
    b. The ballons may not inflate for the first few days – maybe start the experiment on a Monday as "day one" on the worksheets.

18. The Yeast Feast balloon should start to inflate after an hour. Have students measure the balloon at its widest point every five minutes, recording the diameter on the Yeast Feast worksheet

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19. The Yeast Feast balloon should peak in size after about two hours. Have the students take final measurements and record their observations then have them gently remove the balloons – DO NOT POP THE BALLOONS! – and empty the bottles into a sink. Empty bottles can be recycled or reused (for the same experiment) after rinsing.
20. After the Yeast Feast bottles have been cleaned up and each team's Yeast Feast worksheet is complete, you may conclude with a class discussion. Ask students to explain what happened and spark a discussion about the concept of Fermentation. Review the groups' worksheets and results. Did anyone have a particularly large or small balloon? Did anyone's yeast mixture inside the bottle behave strangely? Did anyone shake their bottle more than expected? How did these factors influence the results? Since yeasts need sugar and warm water to produce gas, what factors might a chemist or baker have to consider if they wanted to ferment a substance more quickly or slowly? Would the yeast eat more slowly if they were fed something besides sugar?

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21. After three to five days, or at the teacher's discretion, conclude the experiment. Make sure all students' individual worksheets are filled out with all measurements for their group's balloons

22. Have each student write whether their original hypothesis was correct or incorrect and fill in the blanks on the worksheet
23. Gently remove the balloons – DO NOT POP BALLOONS! – and pour out the bottles. Empty bottles can be recycled but messy bottles should be discarded as trash.
24. After cleanup is complete, lead a class discussion about what everyone learned. What was the most exotic fruit or vegetable they tried? Which food made the most or least gas? Who tried a mixture of more water and less compost or more compost and less water? What did those changes do to the final result? What else happened to the food floating in the water after so many days? If an energy engineer wanted to turn food scraps into bus fuel, what food products would make the most gas in the least amount of time? Whose hypotheses were correct and why? If one bottle in one week could make this much gas, try to imagine how much all the food scraps from a place as big as Dallas-Fort Worth could make in a day or a year. It's enough to make a lot of fuel.

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Key Takeaways:

After completing this activity, students will:

- Learn about fermentation and how microscopic organisms can produce gas and chemical change by eating and digesting things
- Learn about landfills, including the different waste products decompose to generate various outputs – heat, odors and harmful air pollution
- Learn how biogas and biomass – the twin products of anaerobic digestion – are beneficial to the planet and our community
- Apply the scientific method of Observation, Hypothesis, Experiment, Analysis and Reporting

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