As our nation grapples with important environmental issues such as global warming, sustainability and energy independence, “biofuels” are at the forefront of the discussion of alternative energy sources. For the second annual 4-H National Youth Science Day™, “Biofuel Blast” will help youth understand and engage in the important environmental issues our global community faces together, and the opportunities available for a greener tomorrow.
4-H is proud to introduce “Biofuel Blast,” the National Science Experiment which will introduce youth all around the nation to biofuels. Millions of young people will actively participate in a live demonstration of how organic materials can be converted to fuel to supply energy. The experiment, designed in conjunction with The University of Wisconsin-Madison Extension and Wisconsin 4-H, offers several activities to showcase how cellulose and sugars in plants can be used to create ethanol.

In addition to testing corn syrup, youth will test and discuss other alternative fuel options, including switchgrass, sawdust, sorghum and even algae. These fuel alternatives – researched by the 106 Land-Grant Universities and Colleges across the nation that oversee 4-H youth development programs in every state – differ by region throughout the U.S., providing an opportunity for youth to learn about their home region as well as others. Along the way, youth can join a national debate through www.4-H.org to discuss the “best” biofuel based on experiment outcomes. Young people will be able to see how their small creations are part of a major current nationwide discussion.

**OBJECTIVES AND OUTCOMES:**

- Youth across the nation will engage in an experiment that is simple enough for even the youngest to be successful, eye-catching enough to increase interest in science, and deep enough to allow for continued exploration by older participants.

- Participants will understand that yeast can break down sugars through a process called fermentation, releasing carbon dioxide gas and ethanol (which can be used as a “biofuel”).

- Participants will learn hands-on that the sugar in corn and other cellulose plants from fields across the nation can be converted into biofuels by yeast.

- Participants will engage in discussion about alternative energies and the need to develop new technologies that decrease our dependence on fossil fuels.

- Participants of all ages will get the chance to build their experimental design skills and understand how scientists test and compare.

- Older participants will get the chance to independently learn more about alternative energies and global climate change — important areas of knowledge for future generations.
In “Getting Started,” youth will learn what happens when yeast break down sugars to better understand how the concept of biofuels works. They’ll then move onto “Biofuel Blast” to explore how the concept is used with real biofuel materials. Use the tips below to help lead youth through the activity.

**NOTES FOR FACILITATORS:**

- Keep safety first. Remind youth to be cautious with scissors, and that nothing in this experiment should be consumed. Also, check into any existing latex allergies beforehand.

- Have youth bring clean, recyclable plastic 20 oz. water or soft drink bottles from their home recycling bin. Be sure to have a bin ready to collect the bottles when the experiment is complete.

- Options exist for younger children or large groups: You may want to use quart-sized storage bags instead of bottles and balloons.

- The temperature of the water will affect the experiment, but as long as you use warm water, the experiment will be successful. Cold water will not work well and scalding water will kill the yeast. In both cases, the balloons will not inflate. The optimum temperature for yeast to ferment sugars is between 80-100°F (27-38°C). Consider having an older youth fill the pitcher just as the session begins. If you have some kid-safe thermometers on hand, they can try measuring the temperature of the water they add.
• Don’t worry about spilling sugar and yeast; as long as most of the ingredients make it into the bottle, the experiment will work. Using funnels whenever possible will help make pouring into the bottles easier.

• If you have a balloon that’s not inflating, check for a problem with the seal of the balloon on the top of the bottle or for a hole in the balloon itself. Differences in the amount of sugar and yeast in the bottle can affect the time it takes to inflate the balloon, so be patient if it takes a few extra minutes for some of the balloons to inflate. If the participants forget to use warm water, you can heat the bottle by placing it in a tub of warm water.

• Participants can take the bottles home to continue to monitor the inflation of the balloon. Overnight they may see some additional inflation but may also see some leakage of air from the balloon. The greatest expansion of the balloon can be seen between the first 10 minutes and the next day!

• To calculate the volume of the air in the balloon with older groups, use the following formula:

\[
\text{Volume} = \frac{\text{Circumference} \times \text{Circumference} \times \text{Circumference}}{59.2}
\]

The units are based on whatever units you start with—i.e., if you measure the circumference in inches, the volume will be in cubic inches. Older students can use their math skills or look online to convert cubic inches into units like cubic centimeters or liters.

• Yeast makes bread rise by eating the sugars in the bread as it is heated in the oven, releasing bubbles of carbon dioxide gas as waste and forming air pockets in the bread. Eventually, as the oven makes the bread super hot, the yeast will die, but the air pockets will remain.

• For a picture of what the yeast cells that make up a package of store-bought yeast look like under the microscope, visit the resources page under “The Experiment” at www.4-H.org/NYSD.
In “Getting Started,” youth observed the process of fermentation. Now, they’ll expand to work directly with biofuel materials in “Biofuel Blast.” Use the tips below to help lead youth through the activity.

NOTES FOR FACILITATORS:

- Follow the same recommendations from the “Getting Started” activity.

- If you are conducting this portion of the experiment in a club or larger group, you may want to have youth work in small groups to set up the bottles together (one set of bottles per group).

- For younger participants, pour the syrup into a small paper cup and then pour the syrup into the bottle. Or you can use storage bags as an alternative.

- The corn syrup has sugars that the yeast will break down. Corn syrup is made by taking the starch out of corn kernels and converting it into sugars. The most widely found brand of Karo syrup is a high-fructose corn syrup, meaning that some of the glucose in the cornstarch has been converted to fructose. [Note: Karo also offers Karo Corn Syrup Lite, which has no fructose, only glucose. This differs from Karo Corn Syrup Light, which refers to the light color and is recommended for purposes of this experiment.]

- Yeast cells cannot ferment plant cellulose as they can small sugars like glucose, sucrose, or fructose. Therefore, you will not see the balloon expanding much on the bottle with the dead plant leaves (or other biomass).
  - It is important to use dried plant leaves because fresh plant leaves will be able to take in and release carbon dioxide through the processes of photosynthesis and cellular respiration, thus complicating the experiment.
  - Unlike the process of breaking down the cornstarch in kernels into corn syrup, it is currently too inefficient and expensive to effectively break down cellulose into its component sugars for large-scale biofuel production. Scientists are working to engineer microbes that will be able to do this efficiently. Then, the sugars released by breaking down the cellulose can be converted by yeast into ethanol.
“Biofuel Blast” is a great way to help youth talk to others in the group as well as peers online nationwide to learn more. Use the tips below to help youth expand beyond the previous activities and to “Join the Discussion.”

NOTES FOR FACILITATORS:

Encourage youth to use the activity to spark the discussion:

- Use the questions to help youth discuss with each other.
- Ask youth to pay attention to the news leading up to 4-H National Youth Science Day and encourage them to bring in an article they found related to biofuels and share with your club or class.

Ideas for variables to test in a yeast experiment:

- Changing the water temperature
- Changing the sugar source, including the use of sugar substitutes or fruit juices
- Adding cornstarch, corn meal, powdered cellulose, etc. as potential carbon sources
- Something that might kill the yeast, like lemon juice, a cleaning product, or alcohol
- Changing the source of yeast (different brands, instant vs. active dry)
- Changing the amount of sugar added
- Changing the amount of water
**BIOFUEL**
A fuel (or material that can be burned as a source of energy) that comes from recently harvested material, like corn kernels, as opposed to fossil fuels like oil and gas, which come from material that died a long, long time ago.

**CARBON DIOXIDE**
A gas that is released when you exhale; is a product of fermentation of sugars by yeast in this experiment; and is implicated in global warming when present in high levels in our atmosphere.

**CELLULOSE**
A major component of plant material; it is not digestible by humans and is part of dietary fiber. It is the most common organic compound on Earth!

**CIRCUMFERENCE**
A measure of the distance around a circle

**ETHANOL**
A liquid produced by the fermentation of sugars by yeast; it can be mixed in a refinery with gasoline to use as a fuel in car engines.

**FERMENTATION**
Generally, the process by which organisms like yeast break down substances for energy without using oxygen. In our experiment, the fermentation of sugars by yeast produces energy for the yeast and releases carbon dioxide and ethanol as waste products.

**FOSSIL FUELS**
Sources of energy, like coal and oil, which come from plants and animals that died a very long time ago.

**NEGATIVE CONTROL**
A part of a scientific experiment that is expected to have no result; used here as a test to make sure that the balloon did not inflate without the addition of sugars.

**RENEWABLE ENERGY**
Energy from sources like the sun or wind that can be replenished.

**VARIABLE**
Something that can vary, or differ, in a scientific experiment.

**YEAST**
A type of fungus that is made up of only one cell per organism (as opposed to a mushroom, for example, which is a fungus that is made up of lots of cells per organism).
For over 100 years, 4-H has been at the forefront of teaching youth about science, engineering and technology. 4-H National Youth Science Day™ is an important annual part of 4-H’s One Million New Scientists. One Million New Ideas™ campaign, with a bold goal of attracting one million new youth to science, engineering and technology programs by the year 2013.

This experiment is a joint project of the University of Wisconsin-Madison Extension Service, Wisconsin 4-H, The Great Lakes Bioenergy Research Center, National 4-H Council, National 4-H Headquarters at USDA, and the National 4-H Science, Engineering and Technology Leadership Team. Special thanks to Cathy Vrentas, Ph.D., Biotechnology Outreach Specialist, UW-Madison Biotechnology Center and UW-Extension for her vision in bringing biofuel education to youth across the nation for this year’s 4-H National Youth Science Day™.

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