

4-H NATIONAL YOUTH SCIENCE DAY™

YOUTH WORKSHEETS

OCTOBER 7, 2009

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.

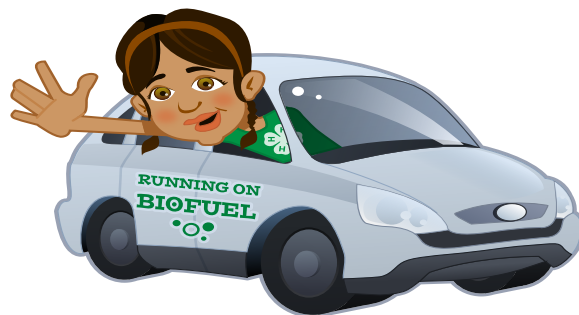
# introduction

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](http://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.



**Have you ever added yeast to bake bread? Yeast is actually a tiny organism—a fungus. Each individual yeast is a single cell, too small to see with the unaided eye. You can buy yeast packets at the grocery store, which have billions of dried-out, tiny yeast inside. Learn here what happens when yeast break down sugars!**

## **MATERIALS:**

- An empty and rinsed out 20 oz. plastic water or soft drink bottle with its cap (you can bring in one from your recycling bin)
- 8 packets or 3 tablespoons of white granulated sugar
- Warm tap water
- A packet of either active dry yeast or dry quick rise yeast (equal to 1 tablespoon if using a jar or bulk package)
- One 9" latex balloon (the typical party latex variety; if you are allergic to latex—use a substitute)
- Scissors
- String or construction paper (for bottle measurement)
- Small plastic funnel (you may also tape together a paper funnel)

## **TIME REQUIREMENT:**

- 10 minutes for preparation
- 10 minutes (or longer if desired) to observe your bottle

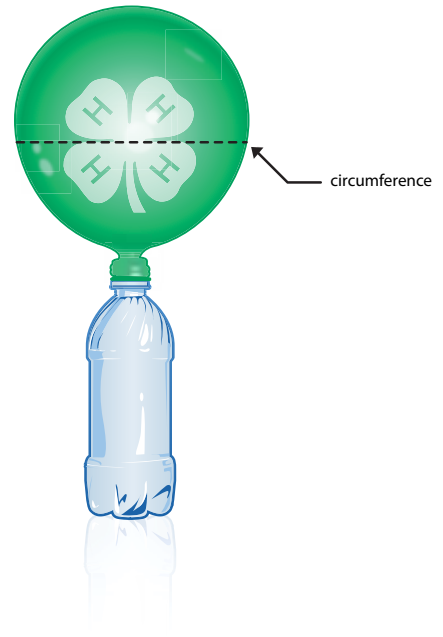
## **PROCEDURE:**

1. Add yeast and sugar to your bottle using a paper or plastic funnel, or a paper cup.
2. Fill your bottle half-full with warm tap water that is very warm to the touch, but not so hot that it is painful or scalding. Replace the cap and shake the bottle to mix in the yeast and sugar at the bottom of the bottle.
3. Place a balloon over the open top of the bottle and observe what happens. It will take a few minutes for the yeast to start eating the sugar.
4. Soon you will see the balloon is starting to inflate! Inside the balloon is a gas called carbon dioxide. It is the same gas that you exhale when breathing. As the yeast eat the sugar, they release waste products, one of which is carbon dioxide.

If you are using a plastic baggie instead of a bottle and balloon, add the yeast, sugar, and warm water (as described above) to the sandwich bag. Close the bag tightly, letting out as much air as possible, and mush/mix them together. See what happens to your bag over time! You might want to place the bag on its side and place paper or even a book on it. How high will the object rise? Try measuring how many inches the bag expanded and enter your data on [www.4-H.org](http://www.4-H.org). Share with us any other variations of the experiment you have tried!



5. You can measure the size of your balloon to compare which balloons have the most carbon dioxide in them. To do this, cut a long piece of string or a strip of construction paper. Wrap it around the largest part of the balloon and mark where the string begins and ends while wrapped around the balloon. This is called measuring the circumference. Compare the size of your balloon with those of others by placing all of the measurements side-by-side or hanging them on the wall!



6. Write down your results below and then go to [www.4-H.org/NYSD](http://www.4-H.org/NYSD) to share them with other kids in states across the country!

- How large is the circumference of your balloon after 10 minutes (in inches)?
- How large is it after one hour?
- Can you convert that size between inches and centimeters?
- For older students—can you calculate the approximate volume of the carbon dioxide inside the balloon and share it with everyone? [Hint: what is the volume of a sphere?]



## THINGS TO THINK ABOUT:

Below are some questions to think about. Try to answer them and keep notes about your own questions that come to mind, then login to [www.4-H.org/NYSD](http://www.4-H.org/NYSD) to join the discussion.

- Were there any differences in the size of your balloon compared to others? Why do you think this might be?
  
- Do you think that the yeast would eat other types of foods to make carbon dioxide?
  
- When you bake bread, you add yeast to make the bread rise. Now that you have seen what happens when yeast eats sugar, how do you think the yeast makes the bread rise?
  
- What do you think would happen if you added very hot water to the yeast?  
[Note: Do not attempt this without adult supervision. Hot water may cause injury]



In the “**Getting Started**” activity, you observed the process of *fermentation*. In this process, yeast breaks down sugars to get energy, just like when you eat sugars to give your body energy. In the process, the yeast releases two waste products: carbon dioxide (the same gas that you exhale) and ethanol (a liquid that can be used as a biofuel). Because the ethanol is mixed with water in the experiment, you can not see it directly.

Ethanol is a type of *biofuel*—a source of energy obtained from recently harvested plant materials. On the other hand, fossil fuels like coal or oil are sources of energy from plants and animals that died a very long time ago. The sugars inside of corn kernels can be broken down by yeast to make carbon dioxide and ethanol in the same process. In a chemical plant, the ethanol is removed from the mixture to make a fuel that is mixed with gasoline and sold at some gas stations. You may have noticed this at the gas pump, where the signs may say “E10”, which means 10% ethanol, 90% gasoline.

In the United States, most ethanol is made from corn. In this experiment, we are going to observe how yeast can break down processed corn sugars—like those found in corn syrup—through fermentation. We’ll also see if other plant products can be used by the yeast to make biofuels!

## MATERIALS PER GROUP:

- THREE empty and rinsed out 20 oz. plastic water or soft drink bottles with their caps (you can bring these in from your recycling bin)
- Warm tap water
- THREE packets of either active dry yeast or dry quick rise yeast (equal to 3 tablespoons if measuring from bulk)
- THREE 9” latex balloons (the typical party latex variety; if you are allergic to latex—use a substitute)
- Light-colored Corn Syrup
- Dried, ground-up leaves or wheat bran from the bulk foods section of your grocery store (see details in experiment instructions)
- Scissors
- String or construction paper (for balloon measurement)
- Small plastic funnel or paper cup for pouring
- Masking tape and markers (to label your bottles)

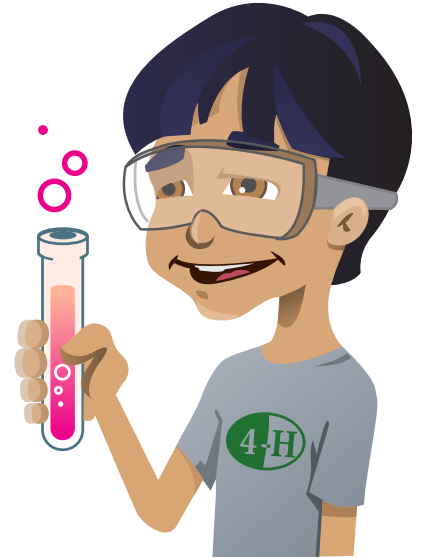
## TIME REQUIREMENT:

- 20 minutes for preparation
- 10 minutes (or longer if desired) to observe your bottles



## PROCEDURE:

1. Gather the three 20 oz. bottles and add one packet or one tablespoon of yeast to each bottle.
2. In the first bottle, you will not add any carbon source. In science, this is called the negative control—you will use it as a reference to see what happens when no food is added to the bottle.
3. In the second bottle, you will add 3-4 tablespoons of corn syrup—the sugars which are inside of corn. In the factory, the starches inside corn kernels are broken down into sugars to make corn syrup.
4. In the third bottle, you will add dried leaves. Dried leaves are made of cellulose, a material which a lot of sugars connected together. It is also an example of a polymer, which we learned about in last year's National Science Experiment.



Grind approximately 4 tablespoons of dried leaves and add them to the third bottle. [Note: do not use fresh leaves—only use brown ones. If you don't have a readily available source of dry leaves, a supermarket alternative is purchasing wheat bran from the bulk food bins. Bran is the outer layer of the wheat seed and contains a lot of cellulose.]

5. Scientists across the nation are studying how other parts of plants (and not just the corn syrup from corn kernels) might be used as sources of biofuels. If you would like, for the third bottle, you can use a source of dried plant material that is specific for your state.

Check out the map of the United States on the next page to see what crop material you might want to use. This map lists the types of crops that farmers could grow in different parts of the country for use in biofuel production.

Here are some suggestions:

- The West— Wood chips or sawdust, including poplar or eucalyptus
- The Southwest—Dried corn husks
- The Great Plains—Dried grasses, like switchgrass
- The Midwest, Northeast and Southeast— Dried grasses like switchgrass, wood chips or sawdust from trees like hybrid poplar or silver maple.



6. Add the same amount of very warm water to each bottle as you did before, so that each bottle is about half full of water. Replace the cap and shake to mix contents.

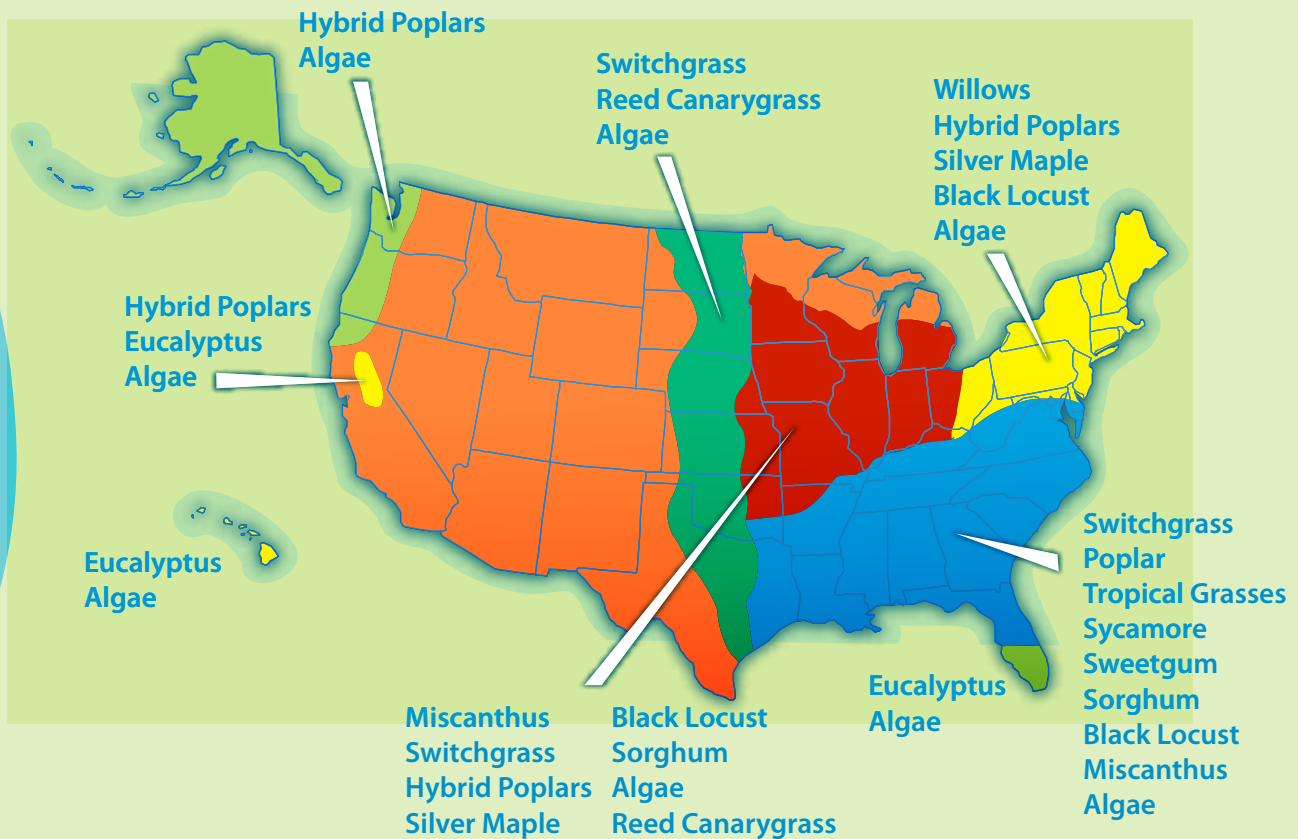


Image concept provided by the U.S. Department of Energy Genome Programs: <http://genomics.energy.gov>

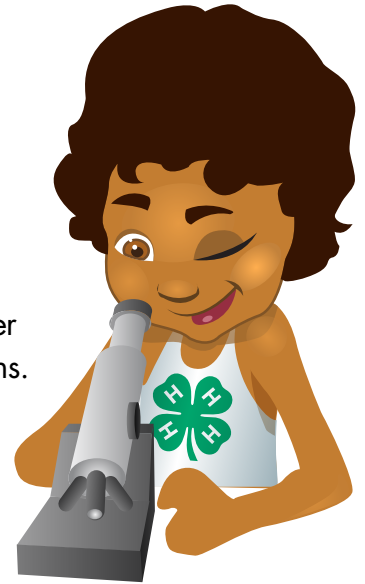
7. Remove the cap and place a balloon over the mouth of each bottle and see what happens! Measure the size of each balloon with string or paper as you did in the first activity.





8. Write down your results below and then go to [www.4-H.org/NYSD](http://www.4-H.org/NYSD) to share these results with other kids in states across the country!

- What kind of dried plant material did you use in the third bottle?
- Record the size (circumference) of each of your balloons on the 4-H site after 10 minutes and after 60 minutes, if possible. For older students, try to calculate the volume of air that is inside your balloons.



- Do you see any evidence of carbon dioxide inside the bottles (in addition to the fact that the balloons get inflated)?
- What do you think could have caused some of variation in results between different groups?

9. Let the experiment sit overnight, if possible. The next day, note changes in the size of the balloon, if any at all. Remove your balloons from the top of each bottle and compare the smell from each bottle. You might be able to smell a difference between the negative control (bottle #1) and the corn syrup bottle (bottle #2). In the corn syrup bottle, the yeast is breaking down sugars to make ethanol, which has an odor.

10. When you have completed your experiment, empty the contents of your bottles and rinse for your next experiment or place them in your recycling bin!



# join the discussion

[Youth Worksheet]

Write down some of your notes or go right to [4-H.org/NYSD](http://4-H.org/NYSD) to discuss what you think with others:

- Can the yeast use the sugars inside corn syrup as food? How can you tell from your experiment? Do you think you made biofuel from the corn syrup?
  
- Can the yeast use the sugars inside the cellulose in the dried leaves (or other plant material) for food? How can you tell from your experiment? Do you think you made biofuel from this plant material?
  
- Although there are a lot of sugars inside of the dried leaves and wood chips, the yeast cannot digest the leaves and wood directly to get energy and release carbon dioxide and biofuels. The cellulose first needs to be broken down into tinier parts before the yeast is able to eat it. However, unlike the process in which the starches inside of corn kernels are made into corn syrup, it is currently much harder and more expensive to break up the cellulose in crops like wood chips or dried grass. Scientists are working on ways to make it easier to break up the cellulose so that all the other crops you saw on the U.S. map can be used to make biofuels for our cars.



Here are some ways you can explore this experiment further:

- What are some of the factors (variables) that affect fermentation by yeast? For example, how does the temperature of the yeast bottle affect the amount of carbon dioxide that is produced? Can other sweeteners (brown sugar, artificial sugar, molasses) be broken down by the yeast? Select one question to test and design an experiment to test your question.
  
- Where are corn and other biofuel materials produced? Look at the biofuel map that shows where biofuel crops grow. If you live in a state where biofuel crops are grown, ask to interview a farmer or an ethanol producer to learn more about this process.

As an example, to make corn syrup, producers must take the starch that is inside the corn kernels and break it apart into its individual sugars. Read more about this process by visiting the resources page under "The Experiment" at [www.4-H.org/NYSD](http://www.4-H.org/NYSD).



# join the discussion

[Youth Worksheet]

- Global warming occurs when carbon dioxide (and other greenhouse gases) from the fuels we burn accumulates in the atmosphere.
  - What do you think the impact of biofuels on global warming would be?
  - What are some of the advantages and disadvantages of using biofuels?
  - What are some other alternative energy technologies, and how do they compare?
  - What types of sources of alternative energy do you think would be best suited to your state?
- How do biofuels and bioenergy affect your life? Check out [www.4-H.org/NYSD](http://www.4-H.org/NYSD) the website below to find out how you might be using bioenergy in your daily life.
- Biofuels and alternative energy are big topics in the news right now. Do something that takes what you've learned in this experiment and share it with others. Create a poster for your school about biofuels, share this experiment with your class at school or a community group, or write an article about biofuels in your school newspaper. You may want to find some newspaper or Web news articles that talk about biofuels. If you are working on the *4-H Power of the Wind project*, you could set up an "Alternative Energies Day" to combine your expertise on wind power with your new knowledge about biofuels!

Visit [4-H.org/NYSD](http://4-H.org/NYSD) for fun resources to see just how much you learned and to discuss more with others.

To learn more or for a full FAQ sheet, visit [www.4-H.org/NYSD](http://www.4-H.org/NYSD) and click on "The Experiment."



# **glossary of terms**

## **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.

## 4-H PLEDGE

I pledge my **Head** to clearer thinking,  
my **Heart** to greater loyalty,  
my **Hands** to larger service,  
and my **Health** to better living,  
for my club, my community, my country and my world.

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™.



**UW**  
*Extension*



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