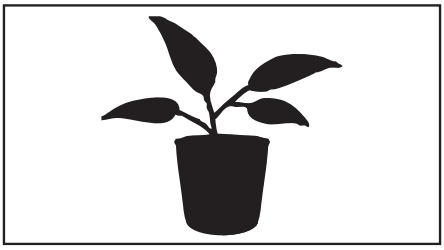
Hands-On Science



Introduction to Biotechnology

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WALCH EDUCATION®

Contents

To the Teacher

Humans were using biotechnology long before the word existed to describe what they were doing. Selective breeding was used on plants or animals with desirable traits to increase the frequency of the appearance of those traits. Recognizing that certain natural processes could be adopted, early people used fermentation, often promoted by microorganisms, to produce items such as beer, wine, cheese, yogurt, bread, sauerkraut, and kimchi. Early people also discovered that parts of many plants and animals could be used to treat illness, as naturally occurring antibiotics, and to promote healthy crop growth as fertilizers and insecticides. People using willow bark tea to treat headaches, fever, and even inflammation were unknowingly experimenting with biotechnology when they produced medicines.

All of these "classic" uses of biotechnology are still used by modern humans, but we have also added the field of modern biotechnology. This is a catchall phrase that refers to the use of living cells and organisms and their molecules, such as DNA, that we can extract or manipulate. This field encompasses work done in several diverse areas, such as bioremediation, gene therapy, genetic testing, cloning, biofuel production, waste treatment, crop production, biodegradable plastics, bioleaching, biological weapons, pharmaceutical production, the Human Genome Project, and many, many others.

The goal of this book is to address concepts and issues across many parts of biotechnological history. Students need to be aware that making cheese and extracting DNA from an onion are both forms of biotechnology. To that end, the activities are a mix of old and new. From making yogurt to performing electrophoresis, a wide swath of biotech activities will hopefully engage students' curiosity about where this field can take them in the future. As they finish each activity, you may find it helpful to have a class discussion about information that students discover, whether the activity expressly recommends it or not. The more students talk about biotechnology, the more motivated they will hopefully become.

These activities are designed to stand alone as supplements to your instruction. While the activities can be performed in any order according to your teaching plans, please note that some activities are similar in concept to others. For example, it will reinforce student understanding and save you time and effort to perform Activity 11: Running a Gel following Activity 9: Gel Electrophoresis. Also, both Activity 4: GMO Pro, GMO Con and Activity 14: The Community and Genetically Modified Foods focus on community attitudes toward and knowledge of genetically modified foods.

1. Making Yogurt

TEACHER RESOURCE PAGE

Instructional Objectives

Students will be able to:

- identify lactose fermentation as a tool of biotechnology
- produce yogurt at home

National Science Education Standards Correlations

Grades 5–8

Content standard	Bullet number	Content description	Bullet number(s)
A	1	Abilities necessary to do scientific inquiry	3, 4, 7
A	2	Understandings about scientific inquiry	1, 4
C	1	Structure and function in living systems	1, 2

Grades 9–12

Content standard	Bullet number	Content description	Bullet number(s)
A	1	Abilities necessary to do scientific inquiry	1–6
A	2	Understandings about scientific inquiry	1, 3, 6
B	3	Chemical reactions	1
E	1	Abilities of technological design	1–5
E	2	Understandings about science and technology	1–3
G	3	Historical perspectives	3

Vocabulary

- **bacteria:** single-celled microorganisms
- **biotechnology:** the use or modification of organisms for human purposes
- **yogurt:** a dairy product that is made from milk though lactic acid fermentation

Materials

- masking tape
- marker
- 600 ml milk
- spoons
- incubator
- hot plate or stove
- goggles
- two glass jars with covers (each able to hold at least 300 ml of milk)
- large saucepan
- food-grade thermometer
- unflavored, plain yogurt
- lab aprons
- gloves

= Safety icon

1. Making Yogurt

TEACHER RESOURCE PAGE

HELPFUL HINTS AND DISCUSSION

Time frame: one class period
Structure: individuals/partners/groups
Location: classroom

Making yogurt from scratch is not impossible, but it is relatively expensive. Starter kits with the correct kind of bacteria can be purchased from a health food store, but generally it is easier and less expensive to use commercial yogurt as a starter. If you should purchase yogurt starter, you should follow the directions with extreme care. In all aspects of the lab, cleanliness is important. Food-grade materials should be used in the yogurt production, as students will be tasting and smelling the yogurt they produce.

Safety note: You should have the final say as to whether or not the yogurt is safe to consume before students do so. Students should not eat the material in the control jar. Students should be encouraged to be extremely careful with the hot materials and equipment used in the activity.

MEETING THE NEEDS OF DIVERSE LEARNERS

Students who need extra challenges should complete the Follow-Up Activity and the Extension Option. These students should also be encouraged to help struggling students with the use of equipment and monitoring safety concerns. Students who need extra help should be encouraged to define the vocabulary words and to keep them in a word bank for later use. They should also be allowed to work with a partner if necessary.

SCORING RUBRIC

Students meet the standard for this activity by:

- making clear observations using scientific language
- answering Concluding Questions accurately
- correctly sterilizing equipment
- properly following lab safety procedures

RECOMMENDED INTERNET SITES

- **Suite101.com—Making Yogurt at Home**
  http://healthycooking.suite101.com/article.cfm/making_yogurt_at_home
- **Tempeh info—Lactic Acid Fermentation**
  www.tempeh.info/fermentation/lactic-acid-fermentation.php

1. Making Yogurt

TEACHER RESOURCE PAGE

ANSWER KEY

1. If done correctly, there should be yogurt in jar Y, and the material in jar C should not look anything like yogurt.
2. Sterilization of the jars helps ensure that the only bacteria that grows in the jar is that from the store-bought yogurt.
3. The process of making yogurt breaks down lactose, which is the material that lactose-intolerant people cannot digest.
4. The yogurt is experiencing bacterial growth while in the incubator.

Name _____ Date _____

1. Making Yogurt

STUDENT ACTIVITY PAGE

OBJECTIVE

To make yogurt through the fermentation of lactose

BEFORE YOU BEGIN

Yogurt has been made in one form or another by humans for well over 1,000 years. It is one of the many early applications of **biotechnology** in which humans found an organism in nature (**bacteria** in this case) and used it to produce materials for humans to consume. Modern yogurt producers use a wide variety of bacteria, and some of them even consider the kind that they use to be a trade secret. One way yogurt is made is by turning the lactose in milk into lactic acid, which causes the curd of the yogurt to form. This formula shows the very simplified reaction of lactose to lactic acid:

$$C_{12}H_{22}O_{11} + H_2O \rightarrow 4\ C_3H_6O_3$$

(Lactose plus water produces lactic acid.)

Living organisms actually use many steps to produce this reaction. However, the end result is that lactic acid forms, and that is key to the process of yogurt making.

MATERIALS

- masking tape
- marker
- 600 ml milk
- spoons
- incubator
- hot plate or stove
- goggles
- tablespoon
- two glass jars with covers (each able to hold at least 300 ml of milk)
- large saucepan
- food-grade thermometer
- unflavored, plain yogurt
- lab apron
- gloves

= Safety icon

PROCEDURE

Safety note: Use extreme caution while working with boiling water. DO NOT eat anything in the lab without the express permission of your teacher. Be sure to wear your goggles, gloves, and lab apron.

1. Put enough water in the saucepan to cover the two jars and their covers. Be sure the covers are OFF the jars so that all parts of the jars and covers are submerged and in contact with the water.
2. Bring the water to a boil.

Name _____ Date _____

1. Making Yogurt

STUDENT ACTIVITY PAGE

3. Boil the jars and covers for 5 minutes to sterilize them.
4. Let the water cool and then remove the jars and covers to dry on clean paper towels. Do not touch the inside of the jars or covers.
5. Using a strip of masking tape and the marker, label one jar "Y" for *yogurt* and the other jar "C" for *control.*
6. Warm the milk in a saucepan to about 45°C.
7. Put half of the milk in jar Y and half in jar C.
8. Add a tablespoon of the plain yogurt to jar Y and stir well. This jar now contains the starter culture. DO NOT add yogurt to jar C.
9. Record your observations about the materials in the two jars in the "Before incubation" column of the table in the Data Collection and Analysis section.
10. Put the covers on the jars and leave them overnight in an incubator with the temperature around 45°C.
11. Remove the jars from the incubator. Record your observations in the "After incubation" column of the data table.

EXTENSION OPTION

You may *sample* some of the yogurt from jar Y, but you should not eat the material from jar C. For best results, keep the original yogurt that was used as the starter culture and refrigerate the yogurt you prepared so that they are both the same temperature. How do the tastes/smells/textures of the two yogurts compare?

DATA COLLECTION AND ANALYSIS

Jar	Before incubation	After incubation
Y		
C		

Name _____ Date _____

1. Making Yogurt

STUDENT ACTIVITY PAGE

CONCLUDING QUESTIONS

1. What differences did you see between the material in jar Y and the material in jar C after incubation?

2. Why did you have to sterilize the jars?

3. Why are people who are lactose intolerant sometimes able to eat yogurt without any significant digestive problems?

4. What is happening to the yogurt while it sits in the incubator overnight?

FOLLOW-UP ACTIVITY

Repeat the lab, but use a wide variety of brands of plain yogurt as your starter culture. When each kind is finished, compare the taste/smell/texture of the yogurt you made with that of the starter yogurts you purchased. Record your data in a table similar to that used for this lab, with a row for each brand of yogurt you use.