



BIOTECHNOLOGY

**A Lesson Plan
developed for
Teachers of Agriculture**

This lesson plan is designed to assist teachers in guiding the learning process in students as they learn more about the area of biotechnology. As with any lesson materials that are not prepared by the teacher who uses them, this lesson plan serves only as a guide. Teachers must adapt, supplement, and/or alter this suggested plan according to their expertise and to the local needs, interests, and expected outcomes of the students who are in that classroom. Only in this way will the instruction given meet the needs of the students, school, community, and state in which the students live and the teacher works.

The development of this lesson plan was made possible by a grant to

the National Association of Agricultural Educators

by

**Cooperative State Research, Education, and
Extension Service
United States Department of Agriculture**

June 2004

BIOTECHNOLOGY

Lesson Title: The Future of Biotechnology

Terminal Objective: To determine the future impact that biotechnology might have on the field of agriscience and society at large

Enabling objectives: Given a lesson on biotechnology, students will be able to:

1. define terms that relate to biotechnology;
2. identify examples of biotechnology used in the past and today;
3. describe the value that biotechnology has provided to agriscience and society;
4. estimate the extent that genetically modified crops are grown in the U.S.;
5. determine how produce at the grocery store was grown;
6. identify the concerns/issues associated with the use of biotechnology;
7. discuss the reasoning behind the concerns/issues that have been associated with the development and use of biotechnology;
8. describe the responsibilities of the governmental agencies that regulate agricultural biotechnology activities, and
9. discuss the future of biotechnology in agriscience.

The teacher is encouraged to add his/her own enabling objectives that would take into account local situations or the need to add additional content information not provided within this lesson outline.

References, Equipment, Instructional Aids, and Selected Web Sites

NOTE: *Teachers should use professional judgment in the selection and use of web sites. Web sites change over time and thus, the relevancy and accuracy information contained on these sites will change as new information and technology are developed in the area of biotechnology.*

Samples of fruits and vegetables from the grocery store with small stick-on labels with numbers

Biotechnology for Plants, Animals, and the Environment, 2nd Edition CD, National Council for Agricultural Education, 2002

<http://www.usda.gov/wps/portal/!ut/p/ s.7 0 A/7 0 1OB?contentidonly=true&navid=AGRICULTURE&contentid=BiotechnologyFAQs.xml> – An overview of USDA and biotechnology

<http://www.biotech.ucdavis.edu> – Links to many web sites related to biotechnology

http://www.agbioworld.org/biotech_info/articles/usaid.html - USAID answers questions raised by other countries that are concerned about GMO products

<http://www.usda.gov/factbook/chapter1.htm> - Current topics and issues in American agriculture today

<http://www.topix.net/business/biotech> - A web site devoted to current developments in biotechnology as applied to agriculture.

<http://www.nal.usda.gov/bic/Newsletters/index.bac> - A USDA website devoted to the most up to date biotechnology news.

<http://www.aphis.usda.gov/> - USDA's **Animal and Plant Health Inspection Service (APHIS)**: Responsible for protecting American agriculture against pests and diseases

<http://www.fsis.usda.gov/> - USDA's **Food and Safety and Inspection Service (FSIS)**: Ensure the safety of meat and poultry consumed as food

<http://www.fda.gov/> - Department of Health and Human Service's **Food and Drug Administration (FDA)**: Governs the safety and labeling of drugs and the nation's food and feed supply, excluding meat and poultry

<http://www.epa.gov/> - **Environmental Protection Agency (EPA)**: Ensures the safety and safe use of pesticidal and herbicidal substances in the environment and for certain industrial uses of microbes in the environment

<http://www.nih.gov/> - Department of Health and Human Services **National Institute of Health** have developed guidelines for the laboratory use of genetically engineered organisms

<http://www.ers.usda.gov/briefing/biotechnology/chapter1.htm> - Contains facts on the extent that genetically grown crops are used in the U.S.

<http://www.ers.usda.gov/Briefing/Biotechnology/> - Reports the economic impact of the use of biotechnology

<http://www.accessexcellence.org> –Links to issues and uses of biotechnology

http://www.biotech.iastate.edu/biotech_info_series - Contains biotechnology definitions and related information on biotechnology

<http://www.geo-pie.cornell.edu/gmo.html> – Issues on biotechnology from Cornell Extension

<http://www.cfsan.fda.gov/~lrd/biotechm.html> - Biotechnology link on the Center for Food Safety and Applied Nutrition web site

<http://www.plucodes.com/> - Web sit for the International Federation for Produce Coding of fruits and vegetables sold in stores

Lesson Plan Color Code

GREEN – Suggestions to the teacher of teaching approaches, teaching techniques, instructional aids, or other ideas that the teacher might find helpful in teaching this lesson. Space is also adequate for teacher notes.

BLUE – Web sites that provide information, knowledge, or background that relate to the Enabling Objectives for the lesson. In some cases, the teacher can use the web sites to prepare for the lesson, in other cases; the students can go to the web sites for basic information or further reading.

RED – Questions a teacher can pose to the students or they can be used to guide the teaching process. Question numbers relate back to the numbered Enabling Objectives found at the beginning of the lesson.

Introduction: The following ideas are possible suggestions for introducing this lesson topic.

1. Ask students to visit a local supermarket, read the food labels, see if they can find any foods that have been genetically altered, and if any were found, what did the label say? What does it mean if the label says “Naturally Grown,” “Made only from Natural Products,” or “Organically Grown?”
2. Ask students what they have heard about genetically altered foods and/or what do they think about them? Summarize their thoughts on the chalkboard,
3. Ask students to stand and ask them why they think they are different in heights, in hair color, and in eye color?
4. Ask why at the first frost, corn is killed, but alfalfa still lives; marigolds die, but pansies still live? Why do some cattle have horns and some do not?
5. If a company is in the community that focuses on biotechnology products, invite a company spokesperson to class to talk with the students on the impact that biotechnology might have with that company.
6. Ask students If they could improve something(make it better) e.g. dairy cow, beef cow, rose, chicken, corn, white pine, wheat, holly, trout, or cucumber, what would they do?

As a transition into the unit content, the teacher may wish to post on the board or in a handout to the students a list of web site(s) and ask them to review these sites for possible background reading on biotechnology.

NOTE: *In the review of literature and web sites, a wide variation was found in the depth that biotechnology was covered and explained. Some materials were highly scientific, very technical, and went to great depth on how living organisms were being changed or were being researched. The teacher is encouraged to gage the depth of instruction desired with this unit based on the interest, intellectual ability, and previous instruction students have received in biology based subjects. While some teachers may feel the following content is too basic, most of the references and web sites listed offer ample information and content for teachers to take students as far as they would like to go in biotechnology content once students have mastered the foundational material in this unit.*

TEACHING OUTLINE

Methods/hints/aids
Teacher notes

Technical/subject matter content

1a. What is biotechnology?

<http://www.usda.gov/wps/portal/!ut/p/ s.7 0 A/7 0 10B?contentidonly=true&navid=AGRICULTURE&contentid=BiotechnologyFAQs.xml>

Biotechnology for Plants, Animals, and the Environment, CD

Student look in dictionary

BIO – refers to life, of living things

Student look in dictionary

TECHNOLOGY – refers to applying scientific knowledge for practical use

SIMPLE DEFINITION OF BIOTECHNOLOGY
Using modern technology to change existing or create new living organisms

A BETTER DEFINITION

Using modern technology to change or modify the biological structure of living organisms or to create new organisms for specific uses

A MORE COMPLETE DEFINITION

Using modern technology to change or modify, with the goal of improving, the biological structure of living organisms or to create new organisms, for specific positive uses and/or to provide beneficial processes, products, or services to consumers/businesses/society

Have students compare the three definitions

1b. What new words were added for each definition?

Discussion

1c. Could living organisms also be changed or created to the detriment of consumers/businesses/society?

Yes

1d. What could be examples of changes that would/could be detrimental to society?

Use the chalkboard to list student comments

Make corn **susceptible** to root rot
Create a dangerous insect that would be immuned to an insecticide
Change plant leaves so they are not able to support photosynthesis
Change a living organism for agroterrorism purposes

1e. How can living organisms be changed?

Did any student find this term on a web site?

GENETIC ENGINEERING – the process of moving one or more gene from one living organism to a different living organism, or removing a gene from an organism, modifying that gene, and placing it back into that organism

1f. What are some terms that are associated with biotechnology that you might have heard on the news, read in an article, or seen on a web site?

<http://www.usda.gov/news/bioqa.htm>
Biotechnology for Plants, Animals, and the Environment, CD

GENE – that part of a cell that contains the physical and functional characteristic of a specific trait of a living thing, sometimes called the unit of heredity

www.nysaes.cornell.edu/agbiotech
“Informing the Dialogue”
http://www.biotech.iastate.edu/biotech_info_series

Students could be assigned these terms and asked to report back to class

CELL – thought to be the smallest structure or unit of life

DNA (deoxyribonucleic acid) a chemical compound within the cell that holds the genetic code of a trait and transmits this trait to another living organism

GENOME – all of the genetic material within a cell

CLONING – process of reproducing genetically identical animals

TRANSGENIC ORGANISM – an organism produced by altering a gene, either by transferring one or more genes from another organism to that organism or modifying a gene within an organism (the process called genetic engineering)

These products are sometimes called “genetically modified organism (GMO),” “genetically engineered organism (GE products),” or “living modified organism (LMO)”

2.a. What are early examples of the use of biotechnology concepts in the modification of living organisms?

Biotechnology for Plants, Animals, and the Environment, CD

www.nysaes.cornell.edu/aqbiotech

“Informing the Dialogue”

Selective breeding in animals to obtain a desired trait, including cross breeding

Using yeast to make bread, beer, yogurt, and cheese

Production of hybrid corn

Most foods today have evolved over the centuries to make them more nutritious and tasteful to people, e.g. potatoes, corn, wheat, apples, tomatoes, cattle

2b. What are more contemporary uses of biotechnology today?

<http://www.accessexcellence.org/AB/BA>

HUMAN OR ANIMAL USE

Producing human insulin in bacterial cells
Plants modified to resist viral diseases, insects, and herbicides
Bovine protein (BST) used to increase milk production
Potato plants that are resistant to the Colorado beetle
Livestock cloned from cells of adult animals
Microbes used to clean water and soil
Crops with built in tolerance to marginal conditions(temperature, pH, salinity)
Horticultural products with better color
Plants that produce edible vaccines
Foods with improved taste
Foods with improved nutritional values
Plants that produce plastic, fuels
Plants for environmental cleanup
Animals with built-in disease resistance
Hormones reintroduced into animals to increase production, leaner meats
Hormones used to grow fish faster for the market
Animals used to produce human proteins for drugs and insulin
Animals used to produce organs suitable for humans
Plants and microorganisms to break down animal waste
Techniques that detect the presence of food spoilage

NON-FOOD USE

Production of detergents, soaps

Production of textiles, pulp and paper, plastics,
particle board
Leather tanning
Fuels, lubricants
Production of paints, inks, dyes, varnishes
Plants that change color where a land mine is
buried in the area(military use)

3. What have been the value or positive outcomes of biotechnology to agriscience and society?

<http://www.biotech.gov/news/bioqa.htm>

Combating human diseases
Insulin to treat diabetics
Blood clot-busting enzymes for heart attacks

**Biotechnology for Plants, Animals,
And the Environment, CD**
www.nysaes.cornell.edu/agbiotech
“Informing the Dialogue”

Promoting human health
Boosting nutritional value of food
Foods with improved handling and
processing qualities

Combating animal diseases
Vaccine to protect animals against rabies
Vaccine for shipping fever
Animals with built-in disease resistance

Combating plant diseases/increase yields
Growing wheat on previously unprofitable
land
Potato hybrid resistant to late blight which
caused the Irish potato famine in the 1840s
New diagnostic kits for on-site diagnosis of
plant diseases

Protecting the environment
Bt cotton kills several cotton pests
Reduce the pesticide use

Economic impact

In a survey of farmers as to why they used genetically altered crops, they indicated:
it was a way to increase yield through control of pests
Reduce cost of using pesticides

<http://www.ers.usda.gov/Briefing/Biotechnology/>
<http://www.ers.usda.gov/briefing/biotechnology/chapter1.htm>
http://www.fda.gov/fdac/features/2003/603_food.html

4. To what degree are genetically grown crops used in the U.S. and the world?

145 million acres of herbicide tolerate (HT) and/or insecticide tolerate (IT) **crops** were grown worldwide in 2002

That was an **increase of 12 percent** over 2001 worldwide

Crops grown in the U.S. account for **66 percent** of these world wide grown crops

HT soybeans grown in the U.S. in 2003 were **81 percent**

HT cotton grown in the U.S. in 2003 was **59 percent**

Bt (insect resistant) **cotton** grown in the U.S. in 2003 was **41 percent**

Bt corn grown in the U.S. in 2003 was **29 percent**

50 percent of rape (used to make canola oil and grown in Canada) in 2002 was grown using genetically altered varieties for weed control

Estimated that **60-70 percent** of the processed foods in the U.S. contain at least **one ingredient** of a GMO plant, since corn and soybeans are used widespread in processed products.

Students could be assigned papers to investigate these questions; debates could be set up on the pros and cons of each

concern/issue; public speaking topics could be identified in these areas; guest speakers knowledgeable in these areas could be invited to class

Ask student to go to a grocery store and look at the small stick- on labels found on the produce. Ask them to record the numbers.

Instructional aids – Have different fruits and vegetables on hand to show students the labels and numbers.

Assign students to check the following site for coding standards

<http://www.plucodes.com/>

5. How can you tell how the produce sold at a grocery store was grown?

Label Code

Four digits – Food was conventionally grown
Five digits starting with an “8” – Food was genetically engineered
Five digits starting with a “9” – Food was organically grown (without the use of pesticides or synthetic fertilizers)

6. What are the major concerns and issues related to the current use and future use of biotechnology?

<http://www.usda.gov/news/bioga.htm>
<http://www.usda.gov/factbook/chapter1.htm>

Consumer **mistrust** of Government’s ability to guarantee safe food when basic foods are altered

www.nysaes.cornell.edu/agbiotech
“Informing the Dialogue”

European’s **ban** on imported GMO products

Which is **better**, genetic engineering or traditional plant and animal breeding?

<http://www.biotech.ucdavis.edu>

Impact of biobased economy on farmers and consumers?

Long term impact of GMOs on human health

Long term impact of GMOs on the environment

http://www.agbioworld.org/biotech_info/articles/usaid.html
<http://www.usda.gov/factbook/>

GMOs plants may **cross pollinate** with wild plants and other plants to produce undesirable plants

Insects become **resistant** to current pesticides

What is the **role** of biotechnology in the world's food system?

Who **owns** the new biotechnology products developed through research?

Is it **ethical** to alter crops and animals from their original genetic makeup?

Which is **better**, food sustainability through agricultural biotechnology or organic agriculture?

Should GMO food products be **labeled**?

How can biotechnology **issues** be handled in the media in a non-sensational manner to prevent undue concern or public reaction?

7. What are some of the underlying reasons for the concerns and issues related to the use of biotechnology?

Student discussion

Review papers for current articles and/or web sites on this subject

Guest speakers

<http://www.geo-pie.cornell.edu//gmo.html>
http://www.agbioworld.org/biotech_info/articles/usaid.html

Biotechnology is a **complex** scientific process and the world today is a very complex place. There are no simple yes and no answers.

The **solving** of complex ethical, scientific, technological, and economic issues requires discussions among many diverse groups, (in some instances from different countries and cultures) who bring to the discussion **varied opinions and agendas**

When new biotechnology developments are possible, who are **impacted** the most?
The traditional producers?
The consumers?
The innovator who wants to use the new technology?

Current food labeling policies **do not require** an explanation how the food was produced as long as the nutritional content has not been changed

Tremendous amount of **money is at stake** as new products are developed. Who is entitled to this money? Scientists? Companies? Producers? Research institutions?

Who or what organization(s) have the **authority** to determine what is genetically altered?

Who **safeguards** the public with advancements in biotechnology?

8. What governmental agencies regulate biotechnology and what are their responsibilities?

<http://www.usda.gov/news/bioqa.htm>

<http://www.aphis.usda.gov/>

USDA's **Animal and Plant Health Inspection Service (APHIS)**: Responsible for protecting American agriculture against pests and diseases

<http://www.fsis.usda.gov/>

USDA's **Food and Safety and Inspection Service (FSIS)**: Ensure the safety of meat and poultry consumed as food

<http://www.fda.gov/>

Department of Health and Human Service's **Food and Drug Administration (FDA)**: Governs the safety and labeling of drugs and the nation's food and feed supply, excluding meat and poultry

<http://www.epa.gov/>

Environmental Protection Agency (EPA): Ensures the safety and safe use of pesticidal and

herbicides in the environment and for certain industrial uses of microbes in the environment

<http://www.nih.gov/>

Department of Health and Human Services
National Institute of Health has developed guidelines for the laboratory use of genetically engineered organisms. Guidelines must be followed if research is conducted with Federal grants.

9. What do you think the future holds for biotechnology?

Teaching method – brainstorming

Give students 3x5 cards or give them 15 minutes to write on a sheet of paper their ideas/views/projections on these questions. No names on papers. Collect and place on board or flip charts and discuss. There are no right or wrong answers, all input should be considered serious and possible.

- a. new products?**
- b. modified products?**
- c. new issues?**
- d. impact of relationships between countries?**
- e. ethical concerns?**
- f. consumer acceptance?**
- g. labeling requirements?**
- h. economic impact on producers/consumers?**
- i. nutritional value of food?**
- j. impact on feeding the poor and hungry?**
- k. food for space travel?**
- l. applications in the military?**
- m. Pharm” factories in the future?**

Discuss the merits of each as the students see them. Where needed, try to point out consequences (positive and negative) of such changes to living organisms, society, consumers, producers, world.

Summary

1. Daily summaries should highlight the content and discussions held that day in class.
2. Assignments could be given on researching various web sites and/or watching local newspapers for any articles that report biotechnology developments.
3. Specific attention should be given to a review of the content related to the enabling objectives covered that day.

Plans for Application

1. This is an excellent opportunity for students to prepare and give presentations when public speaking is covered, when topics are chosen for public speaking contests, and/or when the Internet is discussed as a source of current information as it relates to the reliability and validity of information that is posted.
2. Debates could be held where students take sides and argue the merits of each opposing view.
3. Taking the national percentages of GMO crops grown, have students calculate the acreage of GMO crops grown in their state, assuming that the same relative percentage applies to their state.

Evaluation

1. Daily or weekly quizzes or assignments could be given.
2. Consideration should be given to subjective type of questions, where students are required to write a complete thought/opinion/viewpoint on an issue and state why they hold that view.