

## **ISSUES – FIGURE SET**

### **What Are the Ecological Impacts of Plant Biotechnology?**

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Green and red peppers, © B. W. Grant

#### **THE ISSUE:**

Using student-active learning to investigate the costs and benefits of crop biotechnology for humans and the environment.

#### **ECOLOGICAL CONTENT:**

Human induced alterations to ecosystems, beginning at the genetic level; persistence of escaped transgenes; chemical pesticide usage; and gene transfer and resistance

#### **STUDENT-ACTIVE APPROACHES:**

citizen's argument, formal group work, pairs check, and pairs share

#### **STUDENT ASSESSMENTS:**

minute paper, oral presentation, essay, concept map

#### **ACKNOWLEDGMENTS:**

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## OVERVIEW OF THE ECOLOGICAL BACKGROUND

### What Is the Ecological Issue?

For thousands of years, humans have relied upon science and technology to improve their lives. Some advances have been relatively harmless to the environment, while others bear the potential for long-term environmental problems. More often than not, human inventions, such as biotechnology, lie somewhere in between these two possibilities. Humans are responsible for ensuring that these tools do not meet their potential for harm or even destruction.

In this issue, we explore the topic of plant biotechnology. With a rapidly growing population, policymakers and scientists are asking: How will humans produce enough food to feed our growing numbers? Biotechnology is viewed by many scientists and the public as a solution to a potential food supply crisis in the coming decades. Plant biotechnology involves the manipulation of living organisms, particularly their genetic material. The beneficial qualities of a plant are retained and positive traits from other plants may be added, while undesirable qualities are negated or removed. Currently, important crops, such as corn and soybeans, are grown using genetically engineered seeds. These crops are often designed to withstand insect and weed infestation (in some cases by engineering higher tolerance to chemical pesticides and herbicides), thrive despite poor growing conditions, or possess enhanced nutritional value. In general, the main purpose of genetically engineered seeds is to produce larger crop yields more efficiently at lower direct financial and indirect environmental costs.

Human manipulation of living organisms is not new. Since the beginning of the Neolithic Agricultural Revolution about 8000-12,000 years ago, farmers collected seeds from the plants that yielded the best crops. They selected and planted seeds from "better" plants in the following years to grow better crops. During the early 1700's, Thomas Fairchild created Europe's first hybrid plant (a cross between genetically different parents), but it was not until 1982 that the first "biotech" plant was produced (see definition of biotechnology in <http://filebox.vt.edu/cals/cses/chagedor/glossary.html>). A tobacco plant was made resistant to an antibiotic by transferring antibiotic resistance genetically. This event paved the way for beneficial traits to be transferred to plants. In 1995-1996, biotech soybeans and corn were approved for sale in the United States. We are now capable of modifying plants by transferring specific genes from a distantly related species.

Debates about the use of genetically engineered crops are now growing in intensity. As of 2003, there are no laws in the United States requiring appropriate labeling of genetically modified organisms. However, some consumers contend they have the right to know if the food they eat is genetically engineered because the safety of this food has been called into question.

Another debate concerns the effectiveness of biotech plants. The popularity of biotech plants rests on the idea that they will produce higher and more stable yields than non-biotech plants, but long-term evidence has not been gathered.

Aside from political, economic, and scientific arguments, an ethical question emerges: Is it appropriate to modify the genes of an organism? Some believe it is acceptable, particularly if it helps people. Others believe that biotechnology will permanently change organisms and ecosystems after millions of years of evolution and raise questions about our right to make such a drastic impact on the earth.

## FIGURE SETS

These are published figures from peer-reviewed research journals and monographs that engage students in data analysis and critical thinking organized by teaching approach, Bloom's Taxonomy cognitive skills, and class size. The student-active approaches listed here are suggestions and examples; modify them as appropriate for your teaching.

<b>Figure Set and Ecological Question</b>	<b>Student-Active Approach</b>	<b>Cognitive Skills</b>	<b>Class Size/Time</b>
(1) Evidence for Brazil Nut Allergen in Transgenic Soybeans (Nordlee et al. 1996)	pairs share	comprehension analysis evaluation	any/ 30 mins
(2) Bt Corn and Its Effect on Monarch Butterflies (Losey et al. 1999; Hellmich et al. 2001; Stanley-Horn et al. 2001)	pairs check	comprehension analysis synthesis	any/ 5 mins
(3) How Engineered Genes Persist in Wild Populations (Arriola and Ellstrand 1997; Klinger and Ellstrand 1994)	citizen's argument	knowledge comprehension application analysis	small to medium/ 1 hour
(4) Glyphosate Tolerant Soybeans (USDA NASS 2000, USDA NASS 1991-2000, Carpenter 2001)	informal group work	comprehension analysis synthesis	any/ 45 minutes

## RESOURCES

The following websites provide useful information concerning biotechnology:

- Council for Biotechnology Information - published by biotechnology companies to communicate "science-based information about the benefits and safety of agricultural and food biotechnology" has sections for Consumers, Farmers, Journalists, and Teachers & Students (<http://www.whybiotech.com>)
- Biotechnology Dictionary - by Charles Hagedorn and Susan Allender-Hagedorn, respectively a soil microbiologist and a writing instructor at VA PolyTech; will be updated periodically (<http://filebox.vt.edu/cals/cses/chagedor/glossary.html>)
- Biotech Knowledge Center - sponsored by Monsanto; includes News, Basics, Glossary, and a set of essays in Topic Library with www links (<http://www.biotechknowledge.com>)
- Biotech Chronicles - published by the National Health Museum, established by the Surgeon General in 1996; the Chronicles includes "BioTech Thru the Ages," Pioneer Profiles, BioTech Processes, and essays called BioTech Briefs (<http://www.accessexcellence.org/AB/BC>)
- National Center for Food and Agricultural Policy - published by a private, non-profit includes News with case studies, BioTech in the United States and Europe, Pesticides, Trade & Development, and Farm and Food Policy sections (<http://www.ncfap.org>)
- Ag Biotech InfoNet -claims to be independent and commercial free; includes links to papers in a variety of sources - including Science and Nature - on Gen. Engineering Applications, Insect and Disease Resistance, Herbicide Tolerance, Environmental Impacts, and Health Risks (<http://www.biotech-info.net>)
- Ag BioForum - Journal of AgrobioTech Management and Economics funded by the Illinois Missouri BioTechnology Alliance and edited at the University of Missouri-Columbia (<http://www.agbioforum.missouri.edu>)
- Rediscovering Biology: Genetically Modified Organisms- published by Annenberg/CPB, includes videos and images, expert interviews, glossary, and resources (<http://www.opb.org:8900/units/gmo/index.html>)
- ActionBioscience.org: Biotech Issues, published by the American Institute of Biological Sciences, includes peer-reviewed articles on genetically modified foods and crops. ([www.actionbioscience.org/biotech/index.html](http://www.actionbioscience.org/biotech/index.html))
- Fernandez-Cornejo, J., and W. D. McBride. 2002. Adoption of Bioengineered Crops. Economic Research Service (ERS) U.S. Department of Agriculture ERS Agricultural Economic Report No. AER810. 67 pp, May 2002. The ERS is the main USDA source of economic information and research "This report uses USDA survey data to examine the extent to which US farmers have adopted bioengineered crops, factors affecting adoption of these crops, and the impacts of bioengineered crops on input use and farm-level net returns." ([www.ers.usda.gov/publications/aer810/](http://www.ers.usda.gov/publications/aer810/))

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