

actionbioscience.org lesson

To accompany the peer-reviewed article by Miguel A. Altieri, Ph.D.

“The Ecological Impacts of Agricultural Biotechnology” (Feb. 2001)

<http://www.actionbioscience.org/biotech/altieri.html>

Biotechnology: An Agricultural Dilemma (Jan. 2003)

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Grades & Levels:

- **Handout 1:** high school (general level)
- **Handout 2:** grades 10-12 (advanced/AP) – undergraduate (year 1)

Time Recommendations:

- 1-2 days for article review and discussion
- up to 1 week for completion of projects in either Student Handout

NSES (USA) Content Standards, Grades 9-12.

- NSES 1.4. Unifying Concepts and Processes: evolution and equilibrium
- NSES 2.2. Science and Inquiry: understanding about scientific inquiry
- NSES 4.4. Life Science: interdependence of organisms
- NSES 6.1. Science & Technology: abilities of technological design
- NSES 7.6. Science in Personal & Social Perspectives: local, national & global challenges

Note: View the NSES content standards on this site to choose other curricular applications for additional activities at: <http://www.actionbioscience.org/educators/correlationcharts.html>

Learning Objectives: Students will...

- develop an understanding of agricultural needs in developing nations
- research the types of genetically modified crop plants
- examine the impacts of genetically modified plants on the environment
- analyze the benefits and risks of genetically modified crop plants
- support and debate a view based on biological knowledge
- apply scientific information to resolve a societal issue

Key Words:

agriculture, agrochemicals, biodiversity, biotechnology, botany, Bt, cultivar, developing nations, ecology, exudates, gene transfer, genetically modified organisms (GMOs), herbicide resistant, monoculture, pathogen, soil biota, transgene, transgenic, transnational, World Health Organization

Preparation

Article Discussion:

- Distribute or ask students to download and read Dr. Altieri's article at <http://www.actionbioscience.org/biotech/altieri.html>
- Follow the reading with questions about the article. Suggested questions are listed on page 3. Students can answer questions orally in class, brainstorm answers in groups, or complete questions as a written assignment. *Note:* Some extension questions may require research.

Student Handout 1:

Follow article discussion with project assignments suggested in the handout. These can be assigned as a class or team activity.

Student Handout 2:

It consists of a single class activity that requires research and preparation, as discussed below. **Note:** Some projects listed in Student Handout 1 may be added to handout 2 or used as alternative activities.

Student Handout 2: “Public Meeting on India’s Agriculture”

Background

The environmental risks of using agricultural biotechnology in developing nations are often weighed against the economic and public health benefits. The activity in Student Handout 2 helps students understand the decisions behind policies regulating the use of potentially hazardous technologies. It uses examples of genetically modified plants that have positive public health impacts but unknown environmental effects.

Instructions

1. Organize the students to play the roles indicated in the Student Handout 2 instructions (page 5).
2. Make enough copies to hand out appropriate Role Cards to students or have students download and cut out their own cards.
3. Tell students to research the Role Card to learn how representatives portrayed on the particular card would present and support the stated viewpoint. Allow enough time for the research.
4. Encourage students to use the Information Systems for Biotechnology website (see “useful links” at the end of the article in the *Educator Resources* section) to gather background about the variety of genetically modified crops currently in use and in development.
5. Announce that they should be prepared to debate their views in front of the class. Tell them to be prepared by having their facts and arguments written down and organized on paper. Caution the students that they will have only 5 minutes to present or argue their view.
6. This activity can be assessed using multiple-choice questions asking facts about the genetically modified plants being discussed. A short essay inquiring about the activity’s learning objectives would be a way to test higher-order learning.

Internet Searches

Tell students that their Internet searches can begin with the links that follow the article they have just read and discussed. They are listed in the sections *Learn More*, *Get Involved*, and *Educator Resources*. The “useful links” in *Educator Resources* are selected links that help students with activities in the handouts.

For Educators: Article Discussion

About the article by Miguel A. Altieri, Ph.D.:

“The Ecological Impacts of Agricultural Biotechnology”

<http://www.actionbioscience.org/biotech/altieri.html>

Content Questions:

1. Describe three consequences of the spread of transgenes from genetically modified crops (GMCs) to related wild plants.
2. Explain why some critics assert that herbicide-resistant crops could lead to an increase in herbicide use rather than the intended reduction of their use.
3. How would biodiversity be affected if the Bt toxin gene was transferred naturally to wild plants?
4. What kinds of problems do genetically modified crops with transgenes pose for farmers who do not grow the altered crops?
5. What are some pest management methods other than bioengineering that farmers can use?
6. How might GMCs affect soil organic matter and processes?
7. Give three examples of the rationale that biotechnology companies use to support the use of genetically modified crops.
8. Explain Dr. Altieri’s statement that “the spread of transgenic crops threatens crop diversity by promoting monocultures which leads to environmental simplification and genetic erosion.”
9. Why is crop diversity important?
10. The author states, “Transgenic crops can produce environmental toxins that move through the food chain and also may end up in the soil and water ...” How can these toxins affect non-plant species?

Extension Questions:

1. Define the term *gene flow* and explain how gene flow occurs.
2. What does *Bt* stand for and why?
3. The author writes, “The refuge strategy of setting aside 20-30% of land to non-Bt crops to delay resistance is very difficult to implement regionally.” Why do you think this is so?
4. How would Dr. Altieri react to the decision of many developing nations to encourage the production of genetically modified crops in their countries? What would he tell any nation considering the use of genetically modified crops?

Biotechnology: An Agricultural Dilemma

Student Handout 1

1. Biotech Agency

You and your partners have launched an advertising agency that specializes in biotechnology clients.

- Create a full-page newspaper ad that touts the benefits of genetically modified crops (GMCs).
- Use examples of GMCs in development that can help humankind, e.g., rice with built-in Vitamin A that can help prevent blindness in 100 million children suffering from Vitamin A deficiency.

2. Animal Protection Activist

Your team belongs to an organization that wants to ban GMCs because of the potential harm they can have on animals. Research the evidence that has shown that:

- the declining monarch butterfly population may be linked to Bt crops being used in the United States
- a native farm bird of Britain, the Skylark, was indirectly affected by the introduction of GM sugar beets designed to resist herbicides

Then, get up in front of the class and state your position using your researched examples.

3. Fighting Superweeds

Your team lives in an agricultural area and you are concerned by the possibility of superweeds taking over farmland. First, find out:

- What are superweeds and what are two ways that they can be developed?
- What are some strategies scientists are using to prevent the production of superweeds?

Then, speculate how would you control superweeds if they invaded most of the farm fields in your area. Write up a plan of action.

4. Agricultural Fair

Your team is assigned to educate the public attending the local agricultural fair. Your task is to:

- create a flyer or poster explaining the similarities and differences between conventionally-bred and genetically-modified crops
- use illustrations or other graphic explanations to make the message clearer for a non-scientific audience

5. Pro or Con?

Support or dispute one of the following viewpoints:

- a) “Plants with transgenes for human vaccine are safe and pose no environmental threat. The vaccine’s role in nature is restricted to human immunity.”
- b) “Agricultural biotechnology has less impact on the environment than conventional farming because it helps farmers produce higher yields on less land.”

Use the Internet to get background information on one of the above topics before presenting your position or debating it.

Biotechnology: An Agricultural Dilemma

Student Handout 2

PUBLIC MEETING ON INDIA'S AGRICULTURE

You will be taking part in a public meeting to determine the fate of agricultural biotechnology in India.

Instructions:

1. Choose a role for yourself from the following list:
 - Biotechnology company 1, AgRice Ltd., representative (1 student)
 - Biotechnology company 2, NewSoy Ltd., representative (1 student)
 - Biotechnology company 3, CarrVax Ltd., representative (1 student)
 - Rural farmers in India (4 students)
 - United Nations World Health Organization (WHO) representatives (2 students)
 - World Wildlife Federation representative (2 students)
 - Botanists (2 students)
 - Government of India (8 students)
 - Citizens of India (remaining students in class)
2. Review the information on the Role Card for your role. Students with similar Role Cards should consult with each other before the debate is to begin.
3. Research background information on the Internet to strengthen your presentation before the meeting.
4. Begin the meeting with the biotechnology representatives, in the order listed above, with each biotech rep having 5 minutes to present the company's views to the Government and Citizens of India. Students representing the Government will time each speaker, cutting the speaker off after 5 minutes of presentation.
5. Farmers, Organizations, and Botanists can now pose questions to the biotechnology representatives. The Indian Government will hold the questions and responses to about 3 minutes per question & answer (let this dialogue run no longer than 30 minutes).
6. The Indian Government then asks citizens to indicate whether they are for or against growing *each* Bt crop (someone can keep a tally of a head count where those in favor stand up).
7. The Indian Government representatives will consult, vote, and announce the vote to the Indian citizens, providing a short, clear rationale for each vote.
8. Indian citizens submit written comments of support or opposition to the government's decisions.

ROLE CARDS

Rural farmer in India

Your job is to evaluate the merits of each of the genetically modified crop plants being investigated for growth in India. The crops are:

- rice that is genetically altered to produce vitamin A
- a soybean that produces amylase inhibitor to kill only pest insects
- a carrot that gives immunity to cholera in humans by producing cholera vaccine

You will listen to the testimony of three biotechnology company representatives speaking about their crops. Think about some questions to ask the representatives about the *agricultural* benefits and risks of their crops. You will have time after their presentations to ask questions.

United Nations World Health Organization (WHO)

Your job is to evaluate the merits of each of the genetically modified crop plants being investigated for growth in India. The crops are:

- rice that is genetically altered to produce vitamin A
- a soybean that produces amylase inhibitor to kill only pest insects
- a carrot that gives immunity to cholera in humans by producing cholera vaccine

You will listen to the testimony of three biotechnology company representatives speaking about their crops. Think about some questions to ask the representatives about the *health* benefits and risks of their crops. You will have time after their presentations to ask questions.

World Wildlife Federation

Your job is to evaluate the merits of each of the genetically modified crop plants being investigated for growth in India. The crops are:

- rice that is genetically altered to produce vitamin A
- a soybean that produces amylase inhibitor to kill only pest insects
- a carrot that gives immunity to cholera in humans by producing cholera vaccine

You will listen to the testimony of three biotechnology company representatives speaking about their crops. Think about some questions to ask the representatives about the *environmental* benefits and risks of their crops. You will have time after their presentations to ask questions.

Botanist

Your job is to evaluate the merits of each of the genetically modified crop plants being investigated for growth in India. The crops are:

- rice that is genetically altered to produce vitamin A
- a soybean that produces amylase inhibitor to kill only pest insects
- a carrot that gives immunity to cholera in humans by producing cholera vaccine

You will listen to the testimony of three biotechnology company representatives speaking about their crops. Think about some questions to ask the representatives about the *environmental* benefits and risks of their crops. You will have time after their presentations to ask questions.

Biotechnology company 1 – AgRice Ltd.

Your job is to convince the Indian Government that your company's *genetically modified rice plant* is invaluable to India's future. Some points to consider:

- The rice is genetically altered to produce vitamin A in its grain for human consumption.
- A bacterial gene for vitamin A production was inserted using a plasmid.
- Vitamin A deficiency, often the cause of childhood blindness, is common in developing nations.
- It is inexpensive to grow in the field.

You will be asked questions after your presentation is over.

Biotechnology company 2 - NewSoy Ltd.

Your job is to convince the Indian Government that your company's *genetically modified soybean plant* is invaluable to India's future. Some points to consider:

- The soybean is genetically altered for human consumption to produce amylase inhibitor in its seeds.
- A plant gene for amylase inhibitor production was inserted using a plasmid.
- This particular amylase inhibitor stops beetles and other pest insects from eating stored soybeans.
- At least 60% of the stored soybeans can be ruined by insects.
- It is inexpensive to grow in the field.

You will be asked questions after your presentation is over.

Biotechnology company 3 – CarrVax Ltd.

Your job is to convince the Indian Government that your company's *genetically modified carrot plant* is invaluable to India's future. Some points to consider:

- The carrot is genetically altered to produce a vaccine against the disease cholera.
- A bacterial gene for cholera antigen production was inserted using a plasmid.
- Cholera is a common devastating disease in developing nations.
- It is inexpensive to grow in the field.

You will be asked questions after your presentation is over.

Government of India

Your job is to evaluate the merits of each of the genetically modified crop plants being investigated for growth in India. The crops are:

- rice that is genetically altered to produce vitamin A
- a soybean that produces amylase inhibitor to kill only pest insects
- a carrot that gives immunity to cholera in humans by producing cholera vaccine

You will listen to the arguments of representatives from the biotechnology industry and concerns of farmers, the World Health Organization, the World Wildlife Federation, and botanists. You will also take a poll of your citizens by head count. You *cannot* ask questions. At the end of the meeting, you will make 3 decisions by voting on the acceptance or rejection of each crop.

Citizens of India

Your job is to evaluate the merits of each of the genetically modified crop plants being investigated for growth in India. The crops are:

- rice that is genetically altered to produce vitamin A
- a soybean that produces amylase inhibitor to kill only pest insects
- a carrot that gives immunity to cholera in humans by producing cholera vaccine

You will listen to the arguments of representatives from the biotechnology industry and concerns of farmers, the World Health Organization, the World Wildlife Federation, and botanists. You *cannot* ask questions. At the end of the presentations, you will decide where you stand on the growing of each crop, listen to the Indian Government's decisions, and submit written comments in support of or opposition to their votes.