CHAPTER 4 BIOTECHNOLOGY AND CROP ENGINEERING

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Background | Classroom Applications | Internet Resources | Appendices

BACKGROUND

The way that plants are **bred** has changed completely because of **biotechnology** and **gene research**. In fact, scientists can now introduce **traits** from other plants and even animals into the **genetic makeup** of a particular plant. Such genetic changes can increase **crop yield**, change growing patterns, and improve plant taste or health.

Some of the questions this chapter explores include:

- What is **crop engineering**?
- How has biotechnology changed methods of **plant breeding**?
- What are the benefits and potential disadvantages of this new technology?
- What will crop engineering mean around the world?

This chapter will give students a basic understanding of areas in which crop engineering is being used today. It also explores the controversies surrounding **genetically modified** foods and the different worldwide reactions to this technology. Teachers can use the lesson plans and materials to give students an understanding of these concepts and a command of the vocabulary necessary to discuss them.

Background Information
For more than 10,000 years, farmers have been experimenting with plants to find the best **seeds** to grow plentiful **crops**. In the mid 19th century, **Gregor Mendel**, an Austrian monk, began scientific experiments to produce a better pea.

This "new" science of plant breeding allowed scientists not only to grow more plentiful crops but also to create plants that **resist** insects, disease, and **drought**. However, since success depended on locating a desirable **plant trait** and breeding it over a number of years until the ideal plant species was created, this method was very labor intensive and required long periods of time.

Over the past 20 years, **biotechnology** has dramatically changed methods of plant breeding. Today, biotechnology allows scientists to move specific **genes** from one species to another to produce changes. It also makes conventional plant breeding more efficient by allowing scientists to select and **transfer** only genes for desired traits. Plants created using biotechnology are generally referred to as genetically modified (GM) or transgenic plants.

Perhaps the best-known example of a GM plant is **golden rice**. Created through the efforts of Ingo Potrykus, a professor at the Swiss Federal Institute of Technology in Zurich, this crop was genetically modified to contain **beta-carotene** (or **vitamin A**). This vitamin improves the rice's **nutritional** value and could improve the lives of millions of people for whom this is a primary food. It was Potrykus's dream that this **enriched** golden rice (so-called because of its pale yellow color) would feed hungry children all over the world. Since rice does not naturally contain beta-carotene, Potrykus needed to find a way to change the genetic makeup of normal rice. He and his colleagues introduced genes from **daffodils** and a bacteria into the **genetic code** of normal rice. They also "infected" white rice with another bacteria for beta-carotene. This new transgenic rice plant could then be bred with rice that grew well in different **climates**.

In addition to golden rice, other crops have been produced through biotechnology. These include cotton that has the ability to fight off **boll weevils** and corn and papaya that resist viruses.

Potrykus's dream of feeding millions with genetically modified crops is now a reality. Over 60% of foods sold in the United States today contain GM food ingredients. In many developing nations GM foods are improving the nutritional content of what people eat. The benefits are obvious. Before genetic modification, in experiments to produce new plants, scientists used either radiation or powerful chemicals on plants to produce genetic changes. Transgenic technology does not require this dangerous practice, thereby making the GM foods that we eat safer. Farmers who grow plants that have a genetic **resistance** to insects and disease do not need to use **pesticides**, which is good for the environment. Additionally, the technology needed to genetically engineer crops also requires little equipment. This means that farmers in developing nations, who are often unable to afford pesticides or expensive farming equipment, can produce and use genetic modification. Finally, transgenic crops can improve the nutritional value of foods, such as rice and corn, which are very important in the diets of people throughout the world. This means that a bowl of golden rice could prevent children in Southeast Asia from getting an eye disease caused by insufficient vitamin A. Similarly, a tortilla made from GM corn could satisfy the daily nutritional needs of a child in Central America, even if fruits, vegetables, or meat were not available. The world's population is growing, but the amount of land available to grow food is not. Genetic crop engineering might be an important way to improve global health and feed the world's population by enabling farmers to produce more food more efficiently.

However, GM foods have also been called "Frankenfoods" (after the fictional monster Frankenstein, who is the symbol of uncontrolled and dangerous science). People are beginning to worry that Frankenfoods are harmful to their health and to the environment. One of the biggest concerns is that GM plants could become **toxic** to human beings. For example, changing some of a plant's genes could accidentally cause other inactive genes to become active. In a recent case, people who ate a certain brand of corn taco shells complained of becoming **violently ill**. Their **symptoms**, which included **rashes**, **diarrhea**, and **vomiting**, are possibly linked to the genetically modified corn used in the taco shells. Another concern is that people who have food **allergies** (such as nut allergies or **shellfish** allergies) may accidentally eat a food to which they are allergic. Such accidents have become more likely because scientists sometimes introduce a gene from a nut or a fish into corn to produce a desired trait.

In addition to worries related to human health, critics also worry about the effects on animals and other plants. For example, what if a gene that makes a crop plant **insect resistant** were passed to a wild plant? This could create "super **weeds**" that would be difficult if not impossible to kill. What if animals or insects ate GM crops that were toxic to them? In an actual case, butterflies that touched **pollen** from GM corn either died or developed abnormally. Farmers also worry that insects exposed to insect-resistant GM crops will become **immune** to the toxin in the crop.

At present there is little scientific evidence that GM crops are a direct danger to human health or to the environment. Further studies need to be done to determine the long-term effects of this technology. In addition, at least in the United States, both manufacturers and the government test GM products before selling them to the public. However, consumers have complained about GM foods, in part because the foods have been modified, but also because they feel the manufacturers are deceiving the public. The manufacturers have not provided clear information about the presence of genetically modified foods through advertising, package labeling, lists of ingredients, and other important consumer information.

CLASSROOM APPLICATIONS

Genetically modified foods can potentially be very helpful to humankind because they can increase global food production, improve nutrition, and help prevent disease. At the same time, however, they might upset the balance of nature and change existing patterns of crop supply and demand. Because this technology is so new, there are many fears about what may happen. This chapter introduces students to both the benefits and disadvantages of new developments in biotechnology and crop engineering, providing them an opportunity to explore the practical and ethical issues related to this topic.

PRELIMINARY LESSON PLANNING

Materials:

- Prepare enough copies of the student handouts in **Appendix C** and **F** for each student in the class.
- For the Warm Up and Cool Down Activity, bring enough large sheets of paper and pens for each group in the class.

Student Grouping:

- Decide on procedures for pairing or grouping students for each activity (see suggestions below). It is recommended that groups have no more than six participants.
- For most activities, you should group students heterogeneously—either by language proficiency level or, in those activities where language is less of an issue, by how much group members already know about the topic. In other activities, you may wish to group randomly. In classes where students have varied first language backgrounds, it is important to mix students from different backgrounds in the same group.

Vocabulary:

Before teaching the lesson, preview the glossary items and select those items that need to be taught before you begin the lesson (that is, those that are absolutely essential for introducing and understanding the topic). These will probably include the key concept words such as crop engineering, genetically modified (GM) or transgenic foods, plant traits, plant breeding, disease resistant, and crop yield.

WARM UP ACTIVITY

(approximately 8 minutes)

Purpose:

- To increase student interest in the topic of biotechnology and crop engineering
- To find out what students already know about this topic
- To provide a context in which students can learn and practice content-specific vocabulary
- To provide practice in question formation

Procedures:

1. On the blackboard, draw a blank K-W-L chart (Weaver 1994). See **Appendix B** for blackboard layout.

2. Tell students that in this unit they will be learning about how genetic engineering can improve plant productivity and health. Also tell them that they will be examining the benefits and disadvantages of this new technology.

3. Ask students to tell you what they already know about biotechnology and crop engineering. As they volunteer information, summarize this in the Know (K) column of the K-W-L chart.

4. Next, ask students what they want to learn about this topic. Ask them to state this as a question. Write the questions that students generate in the Want (W) column of the K-W-L chart.

5. For this activity, leave the final Learn (L) column blank. Do not erase the K-W-L chart from the blackboard because it will be used again in the Cool Down Activity.

6. Have students copy the chart onto a piece of paper or write it in their notebooks.

Transition from Warm Up to Activities

Ask student volunteers to read aloud the questions they have written in the Want (W) column of the K-W-L chart. Tell them that they will find answers to many of these questions as they complete the other activities in the unit. They should write these answers in their notebooks.

ACTIVITY 1

(Approximately 30 minutes)

Purpose:

- To introduce students to general facts about genetic crop engineering

- To provide students with an opportunity to engage in a “forced choice” activity, requiring them to determine whether aspects of the topic are primarily positive or negative

- To give students the chance to use key vocabulary and concepts associated with this topic

Procedures:

1. Make enough copies of the handout (**Appendix C**) for each pair of students.

2. Pair students and distribute one copy of the handout per student pair.

3. Tell students that they will read information about genetically modified plants. Ask them to look at the information in the first column of the handout and decide if the information is a positive or negative characteristic of genetic crop engineering. Depending on their decision, ask them to circle **+** (for positive) or **–** (for negative) for each piece of information.

4. Reconfigure the students into groups of four so that each pair of students works with another pair. Ask them to compare their answers and discuss any differences. (If the class size is small, answers can be compared as a class.)

5. While students are working in their groups, circulate to resolve any questions that arise.

ACTIVITY 2

(approximately 30 minutes)

Purpose:

- To provide an open discussion about the topic

- To provide practice in stating and defending an opinion orally

Procedures:

1. Write the term “genetically engineered crops” on the blackboard and ask students to give a definition and/or examples.

2. Have each student take out a piece of paper and tell them that they should take notes on the cases of genetically modified crops that you are about to read.

3. Read aloud the four cases of genetically modified crops (see **Appendix D**).

4. Divide students into groups of from two to five students. The total number of groups will depend on the number of students in the class. Ask them to compare their notes and reconstruct the basic information in each case using complete sentences. Tell them that they are free to ask you vocabulary questions as they work.

5. Ask for a volunteer from each group to write one of the cases on the blackboard or on an overhead transparency. Have the class correct any errors of language or information.

6. Ask students to work again in their groups, this time ranking the cases from one to four (with 1 being most valuable and 4 being least valuable). Tell them to be prepared to defend their choices.

7. Once students finish discussing, have each group choose two spokespeople.

8. Spaced across the top of the blackboard, write the numbers 1, 2, 3, and 4 (see **Appendix E** for blackboard layout).

9. Review each case one by one. Ask one of the two spokespeople from each group to come to the front of the class and stand under the number that represents its ranking for the case. Have the group spokespeople explain their reasons for their rankings. Tell the seated class members that they can ask questions of or disagree with the spokespeople.

ACTIVITY 3

(Approximately 45 minutes)

Purpose:

- To provide students with further information about how crop engineering is viewed globally
- To provide an opportunity for students to make inferences based on factual information

Procedures:

1. Make enough copies of the handout (**Appendix F**) so that each group of students will have a copy. The number of groups will depend on the total number of students in the class.

2. On the blackboard, create a table with four columns. In the left-hand column, put the names of the countries that appear in Appendix F. At the top of the other 3 columns, write “Strongly in Favor,” “Somewhat in Favor,” and “Opposed,” respectively (see **Appendix F** for sample blackboard layout)

3. Distribute one copy of the handout per student group.

4. Ask students to do the following:

a. Read the information given about each country.
b. Based on this information, decide what the attitude of this country is likely to be toward genetically modified foods.
c. Circle the response that your group thinks is correct.

5. On the blackboard, tabulate the responses from each group in the table that you created.

6. Ask students to provide reasons for their judgments. Assist students as necessary, providing the correct answers from **Appendix G**.

COOL DOWN ACTIVITY

(approximately 10 minutes)

Purpose:

- To provide practice summarizing new information
- To end the lesson

Procedures:

1. Review with students the information and questions they produced in the first two columns of the K-W-L chart in the Warm Up Activity.

2. Divide students into groups of from three to five students. The total number of groups will depend on the number of students in the class.

3. Tell students to do the following:
a. Take out the notes you have made as you worked through the various activities in this unit.
b. Together with the other members of the group, identify questions from the Want (W) column that you believe you can answer using the notes you have made.
c. Provide answers for these questions, discussing your notes so that the answers are as complete as possible.

4. Assign each group to write the answer to one question from the Want column in the corresponding Learn (L) column of the K-W-L chart on the blackboard.

5. Go over the answers in the Learn column with the class as a whole, encouraging students to add any additional information. Add this information to what is already written in the Learn column.

POSSIBLE EXTENSIONS TO LESSON

1. For the Warm Up Activity, instead of having the whole class fill in the grid, group students and give each group a large piece of paper onto which they can copy the K-W-L chart from the blackboard. They can then be instructed to fill this in, post their charts around the room, and share their responses with the rest of the class.

2. Have students choose one question from the K-W-L chart and find a Web site, newspaper, or magazine that answers the question. Ask them to share the information they have found with the rest of the class.

3. As an extension to Activity 1 (either in class or as homework), students can be asked to select one of the statements about which they will write an “on the one hand/on the other hand” reaction. This type of writing asks students to write one or two paragraphs with the first part explaining the possible positive effects and the second part explaining the possible negative effects of the scenario they have chosen. Teachers can model this for students using the statement “Genetically engineered plants often increase crop yields significantly.” See the sample “on the one hand/on the other hand” reaction in **Appendix H**.

4. For Activity 2, ask several students to volunteer to represent a funding agency. Divide the rest of the students into 4 equal groups. (In a very large class, students could be divided into 8 equal groups). Assign each group one of the 4 projects in **Appendix D**. Give the groups 5 minutes to outline reasons

why their project should be given money and ask each group to appoint a spokesperson. At the same time, ask the students representing the funding agency to brainstorm criteria for giving the money. At the end of the brainstorming period, have the funding representative group put their criteria on the blackboard. Then, ask the spokesperson from each group to present their arguments for getting the funding. When all groups have presented, ask the funding representative to select which group should receive funding.

5. For Activity 3, assign students as homework to write about their country's position on crop engineering. Have them provide facts to explain why their country holds this position. If necessary, ask them to do research to find the information they need.

Refer to the Web sites listed below for more information and lesson planning ideas.

INTERNET RESOURCES AND REFERENCES

Internet Applications

(Websites with prepared lesson plans and activities)

The New York Times Learning Network on the Web:
Science http://learning.blogs.nytimes.com/category/science/
The site contains many lesson plans for science topics (see examples below) that are based are articles published in The New York Times newspaper. Search for these lessons in the Lesson Plan Archive link:

*The Cream of the Crop: Comparing Organic and Conventional Farming Methods (*In this lesson, students work in small groups to investigate the similarities and differences between organic and conventional agricultural practices.)

Food, Glorious Food?: Exploring International Positions on the Use of Genetically Modified Foods (In this lesson, students investigate American and European positions on genetically modified foods and write a position paper from the perspective of their designated country.)

Altered Genes: Exploring the Economic Implications of Consumer's Worries About Genetically Engineered Foods (In this lesson, students investigate the controversy surrounding the use of gene-altered crops in food products sold in the United States and several other countries. Students will explore the economic implications of the use of such crops and the refusal of some countries and companies to buy gene-altered crops. After reading and discussing the article, students participate in an "international trade meeting," taking the perspective of one of the parties represented in the article.)

Exploitable Content

(Web sites with information about the topic, but without any prepared lessons)

AG Biotech InfoNet http://www.biotech-info.net/index.html
This site offers many informative readings on the implications of agricultural biotechnology.

CQS: Health and Environment http://www.cqs.com/egeneral.htm#biotech
This site offers an extensive list of on-line articles related to biotechnology and genetic engineering.

GreenPeace: Genetic Engineering http://www.greenpeace.org/~geneng/
The Green Peace organization is very concerned with genetically engineered foods. This site contains background information, articles, and press releases.

Mad Sci Network http://www.madsci.org/
A staff of science experts is available to answer nearly any question you may have. Simply enter a "key term" for a question you have and you will see what answers have already been provided.

Official Documents
(Including government, UN, and UNICEF sites)

National Council for Science and the Environment http://www.cnie.org/
This Web site can be searched for links to numerous Congressional Research Service Reports and more.

United States Department of Agriculture http://www.usda.gov/
A U.S. government Web site with national news releases and audio/video highlights. You can search the site using key words.

References

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Tangley, L. (2000, April 10). *Of genes, grain, and grocers: The risks and realities of engineered crops.* US New and World Report, pp. 49–50.

U.S. Department of State. (1999). *Biotechnology: Food security and safety.*

Weaver, C. (1994). *Reading process and practice: From sociolinguistics to whole language (2nd ed.)*. Portsmouth, NH: Heinemann.

Endnote

The table in Activity 3 was adapted from Nash (2000).

APPENDIX A

Glossary

Allergy: (allergic, adjective) An abnormally high sensitivity to certain substances, such as pollens or foods. Common symptoms may include sneezing, itching, and skin rashes.

Beta-carotene: Gives a reddish color to plants such as carrots and tomatoes. The liver can convert it into vitamin A. Food sources of this vitamin include vegetables such as carrots, sweet potatoes, spinach, and other leafy green vegetables; and fruit such as cantaloupes and apricots (also see **vitamin A**).

Biotechnology: A set of biological techniques developed through basic research. Now applied to research and product development. In particular, the use by industry of recombinant DNA, cell fusion, and new bioprocessing techniques. Modern biotechnology products include antibiotics, insulin, interferon, and techniques such as waste recycling. Much older forms of biotechnology include bread making, cheese making, and brewing wine and beer.

Boll weevil: A worm that infects and kills cotton crops

Breed (v) **bred** (irregular past tense)**:** To develop new or improved kinds of animals or plants, chiefly through controlled mating and selection of offspring for desirable traits.

Climate: The weather in a location averaged over a long period of time.

Conduct: To do or manage an activity. “Further studies need to be conducted…”

Crop: (1) Cultivated plants (plants planted by farmers) or agricultural produce, such as grains, vegetables, or fruit. (2) The total amount of such produce harvested in a particular season or place.

Crop engineering (or **Genetic Crop Engineering**): The manipulation of a plant´s genetic makeup by introducing, enhancing, or eliminating specific genes through modern molecular biology techniques.

Crop yield: Total products (e.g. vegetables) resulting from growth or cultivation.

Daffodil: A kind of flower.

Diarrhea: Frequent and watery bowel movements, often accompanied with stomach pain.

Drought: A long period of abnormally low rainfall, especially one that negatively affects growing or living conditions.

Enrich (v), **enriched** (adj): To add nutrients to: The dairy enriched its milk with vitamin D.

“**Frankenfood” :** A negative way to refer to GM foods, named after the fictional monster Frankenstein, who is a symbol of “out of control” science.

Gene: A hereditary unit that determines a particular characteristic in an organism. Genes exist in a number of different forms and can undergo mutation.

Gene research: The study of genes and genetics.

Genetic makeup / **Genetic code:** The entire DNA coding of an organism.

Genetically modified (GM) food (or plant, crop) (n): The agricultural products of genetic engineering technology, for example, the introduction, enhancement, or deletion of particular characteristics in an organism by altering its DNA (genetic makeup). Examples of such modified foods or foods that will likely be modified in the near future include: apples, canola, corn, grapevines, lentils, lettuce, maize, papaya, peas, pineapples, potatoes, soy beans, sugarcane, tomatoes, and wheat.

Genetically modify (v): The use of modern biotechnology to change the genetic makeup of an organism (a plant) by inserting individual gene(s) that have been isolated in the laboratory into the genome of a living organism.

Golden rice: A genetically engineered form of rice (**http://www.biotech-info.net/golden.html**) which has been infused with vitamin A (a vitamin not usually found in rice).

Gregor Mendel: Founder of the science of genetics (1822-1884). An Austrian monk and botanist. His breeding experiments on garden peas and subsequent formulation of the laws of heredity formed the basis for the study of genetics.

Immune (v) (**Immunity**, (n): Protected against, infectious disease.

Ingredient: One part of a mixture or recipe.

Insect resistant: Description of a plant that is not affected (or is affected only minimally) by insects.

Monarch butterfly: A type of butterfly common in North America.

Nutrition: (1) Foods necessary for a healthy diet. (2) The physical and chemical process by which food is converted into body tissue.

Pollen: The powder produced by seed plants, and most plentiful in Spring. A common cause of allergic reactions.

Pesticide: A chemical that is used to kill unwanted organisms such as rats or weeds. These chemicals often act as nerve poisons, and they are hazardous to animals and humans. Some pesticides can cause nerve or liver damage, birth defects, and cancer in humans.

Plant breeding: The genetic modification of crop plants, with the hopes of improving insect resistance and the nutritional content, as well as creating plants with high yield and enhanced quality.

Plant trait: A genetically determined characteristic of a plant such as its height, resistance to insects and bad weather, and its typical crop yield.

Rash: A skin eruption or reddening of the skin, often with itchiness.

Resistant (adj) **Resist** (verb) **Resistance** (noun): (1) Relating to or conferring immunity (to disease or infection) (2) incapable of being affected “disease resistant”.

Seed: The fertilized ripened ovule of a flowering plant containing an embryo and capable normally of germination to produce a new plant.

Shellfish: Any aquatic animal whose external covering consists of a shell, for example, oysters, clams, lobsters, and crabs.

Symptom: Any evidence of disease or of a patient's condition as perceived by the patient, diagnosis, or a change in a patient's condition.

Toxic: Poisonous.

Trait: A genetically determined characteristic or condition.

Transgenic: Having genes that have been transferred from another species or breed, for example, a transgenic plant, transgenic rice, transgenic technology, transgenic crops, and transgenic foods.

Transfer (v): The movement of something from one place to another.

Violently ill: Extremely sick.

Vitamin A: A vitamin occurring principally in fish-liver oils, milk, and some yellow and dark green vegetables. Its deficiency causes hardening and roughening of the skin, night blindness, and degeneration of mucous membranes.

Vomit (v): To lose the stomach contents through the mouth, often when feeling ill.

Weed (n): A plant considered undesirable, unattractive, or troublesome, especially one growing where it is not wanted, as in a garden.

On-Line Dictionaries

Dictionary.com **http://www.dictionary.com**
Checks several on-line dictionaries at once.

Online Glossary **http://filebox.vt.edu/cals/cses/chagedor/glossary.html**
An annotated agricultural and environmental biotechnology annotated dictionary.

Layout for Warm Up Activity

What I Know	*What I Want to Know*	*What I Learned*

APPENDIX C: HANDOUT FOR ACTIVITY 1

1. People with an allergy to nuts or shellfish might have an allergic reaction to a genetically modified food (such as a tomato modified with an oyster gene).	+	-
2. Millions of children today develop an eye disease or even go blind because they don't eat foods with enough vitamin A. Yet scientists can genetically modify rice to contain vitamin A.	+	-
3. Scientists have been able to modify plants such as cotton and corn so that they resist insects and disease.	+	-
4. Because scientists can now produce plants that resist certain insects , farmers may no longer need to use pesticides.	+	-
5. Genetically engineered plants often greatly increase crop yields.	+	-
6. Many food manufacturers are unwilling to state that their products contain genetically modified food ingredients on the product label.	+	-
7. Genetically engineered plant genes might accidentally cross over from a genetically modified kind of plant to a non-genetically modified kind of plant. This might destroy natural or wild kinds of this plant.	+	-
8. Through biotechnology, scientists can now develop grains (for example, corn and rice) that contain many of the essential nutrients required for healthy physical development.	+	-
9. Recently, U.S. consumers of a brand of corn taco shells became ill after eating the product. These taco shells had been manufactured using genetically modified corn.	+	-
10. Genetic engineering requires less technology and time than other methods of plant breeding, which often require several years to grow plants with the desired traits.	+	-
11. In a study conducted at Cornell University in the United States, it was found that pollen from genetically engineered corn killed monarch butterfly caterpillars .	+	-

APPENDIX D: CASES FOR ACTIVITY 2

1. Scientists at the Swiss Federal Institute of Technology have modified the genes in rice to contain beta-carotene (or vitamin A). This improves its nutritional value and may help fight diseases related to a lack of vitamin A.

2. Scientists are currently modifying plant genes to improve their taste. For example, at the University of California at Davis, scientists created a species of "flavor-savor" tomato and are studying the genes that cause fruit to be sweet.

3. GM corn and cotton have been engineered to resist certain diseases and bugs, thereby increasing crop yield and decreasing the need for pesticides.

4. Biotechnology researchers are trying to make some foods more attractive. For example, they are attempting to develop a GM onion that won't make your eyes water when you cut it.

APPENDIX E: BLACKBOARD LAYOUT FOR ACTIVITY 2

1 **2** **3** **4**

most valuable least valuable

Country and Population	Circumstances	Attitude toward Genetic Engineering of Crops		
Canada population 31,147,000	Grains make up 24.8% of the diet. It is a major exporter of foods. It is the second-largest producer of GM foods.	Strongly in Favor	Somewhat in Favor	Opposed
Argentina population 37,031,000	Grains make up 29.5% of the diet. It is the 3rd largest producer of GM crops.	Strongly in Favor	Somewhat in Favor	Opposed
Brazil population 170,116,000	Grains make up 31% of the diet. It exports foods and most of its customers are in Europe.	Strongly in Favor	Somewhat in Favor	Opposed
Great Britain population 58,803,000	Grains make up 22.8% of the diet. It has recently experienced problems with its food supply (including mad cow disease in humans and illness in rats caused by GM potatoes). The government controls food imports.	Strongly in Favor	Somewhat in Favor	Opposed
France population 59,079,000	Grains make up 24.3% of the diet. Impure food has been a problem here. France does not easily allow U.S. food imports because it wants to protect its own farmers.	Strongly in Favor	Somewhat in Favor	Opposed
Japan population 126,714,000	Grains make up 40.7% of the diet. Japanese citizens are concerned about food quality. There have been several incidents of food poisoning recently. Like France, Japan does not allow food imports to protect its own farmers.	Strongly in Favor	Somewhat in Favor	Opposed
China population 1,277,558,000	Grains make up 54.7% of the diet. It has a large population. Hunger was in part responsible for the Chinese revolution.	Strongly in Favor	Somewhat in Favor	Opposed
India population 1,013,661,000	Grains make up 62.6% of the diet. The per capita income is very low. Like China, it has a large population. In the 1960's, developed countries tried to tell Indian farmers what crops to grow, with disastrous results.	Strongly in Favor	Somewhat in Favor	Opposed
United States population 278,357,000	Grains make up 23.6% of the diet. It is a major food exporter. It also has many large agricultural businesses. It has a history of strong consumer groups that influence government policy. It also has a government agency that directs food and drug safety.	Strongly in Favor	Somewhat in Favor	Opposed

Sample Blackboard Layout for Activity 3

Country	Strongly in Favor	Somewhat in Favor	Opposed
Canada Argentina Brazil Great Britain France Japan China India United States			

APPENDIX G

Answer Key for Activity 3

Country and Population	Circumstances	Attitude toward Genetic Engineering of Crops
Canada population 31,147,000	Grains make up 24.8% of the diet. It is a major exporter of foods. It is the second-largest producer of GM foods.	Strongly in favor
Argentina population 37,031,000	Grains make up 29.5% of the diet. It is the 3rd largest producer of GM crops.	Strongly in favor
Brazil population 170,116,000	Grains make up 31% of the diet. It exports foods and most of its customers are in Europe.	Somewhat in favor
Great Britain population 58,803,000	Grains make up 22.8% of the diet. It has recently experienced problems with its food supply (including mad cow disease in humans and illness in rats caused by GM potatoes). The government controls food imports.	Opposed
France population 59,079,000	Grains make up 24.3% of the diet. Impure food has been a problem here. France does not easily allow U.S. food imports because it wants to protect its own farmers.	Opposed
Japan population 126,714,000	Grains make up 40.7% of the diet. Japanese citizens are concerned about food quality. There have been several incidents of food poisoning recently. Like France, Japan does not allow food imports to protect its own farmers.	Opposed
China population 1,277,558,000	Grains make up 54.7% of the diet. It has a large population. Hunger was in part responsible for the Chinese revolution.	Strongly in favor

India population 1,013,661,000	Grains make up 62.6% of the diet. The per capita income is very low. Like China, it has a large population. In the 1960's, developed countries tried to tell Indian farmers what crops to grow, with disastrous results.	Somewhat in favor
United States population 278,357,000	Grains make up 23.6% of the diet. It is a major food exporter. It also has many large agricultural businesses. It has a history of strong consumer groups that influence government policy. It also has a government agency that directs food and drug safety.	Somewhat in favor

APPENDIX H

Sample "On the one hand/on the other hand" Paragraph for Extension 3

Genetically engineered plants often increase crop yields significantly.

On the one hand, we know that genetically engineered plants produce larger crops. This means that farmers have to spend less money on seeds and will earn more money with their larger crop yields. It also means that developing nations can feed their populations at a lower price and that this technology can help to reduce world hunger. On the other hand, if many farmers in a country plant the same crop and have increased crop yields, the price they get for their crops will go down. This will occur because, as the supply of a particular crop increases, the demand for it automatically decreases, thereby lowering the price the farmer can ask. This is bad news for farmers since it will not improve their economic situation and may even make it worse. Increased crop yields may also have a negative effect on the environment. Farmers tend to plant those crops that will bring in the most money. This means that they may overplant one type of crop and stop planting others. Eventually, this wears out the soil and causes other environmental problems.

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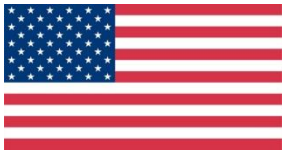

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