

actionbioscience.org lesson

To accompany the peer-reviewed article by Arpad Pusztai, Ph.D.:

“Genetically Modified Foods: Are They a Risk to Human/Animal Health?” (June 2001)

www.actionbioscience.org/biotech/pusztai.html

GM Foods: Are They Safe? (May 2002)

Lesson by **Ronald Brian Watts**, Ph.D., Professor, Dept. of Biology & Chemistry, CEGEP De La Gaspésie et Des Îles, Gaspé, QC, CAN

Grades & Levels:

- **Handout 1:** High school
- **Handout 2:** Undergraduate (year 1-2)

Educator's section: p. 1-4
Student handout 1: p. 5
Student handout 2: p. 6-7
Supplementary handout: p. 8

Time Recommendations:

- 1-2 class periods for review of article and related content questions
- up to 1 week for article extension activities
- time for activities in student handouts will depend on the activity selected and the way in which it is used; estimated minimum time for activities ranges from 2 class periods to 2 weeks

NSES (USA) Content Standards, 9-12:

- NSES 1.4. Unifying Concepts & Processes: evolution and equilibrium
- NSES 6.1. Science & Technology: abilities of technological design
- NSES 7.1. Science in Personal & Social Perspectives: personal and community health
- 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 ...

- examine reasons why current testing for safety of GM foods may not be adequate
- explain the concept of “substantially equivalent” as applied in safety testing of GM foods
- research potential benefits and possible hazards of select GM foods
- make recommendations about testing, labeling, and marketing of GM foods

Key Words Include:

adjuvant, allergen, anaphylaxis, antibiotic resistance marker genes, DNA, endogenous, genetic engineering, glykoalkaloids, *Iso* (prefix), mRNA fingerprinting, peer-reviewed publication, proteomics, reporter genes, sera, substantial equivalence, transcription terminators, vector, viral promoters
(see Supplementary Student Handout for definitions)

Preparation

Article Discussion:

- Have students read “Genetically Modified Foods: Are They a Risk to Human/Animal Health?” at www.actionbioscience.org/biotech/pusztai.html. (Students can read the article individually or in a group before answering the questions.)
- Conduct the “Article Discussion” activity on page 2.

Article Extension Activities:

These activities are divided into questions suitable to accompany Handout 1 or Handout 2 and require research time to complete.

Student Handouts 1 or 2:

- Distribute copies of Student Handout 1 or Student Handout 2. Discuss whether the projects should be performed individually or in groups. Assign a due date.
 - The Student Supplementary Handout can be distributed with either Handout 1 or 2. It contains key word definitions and reference resources. The latter could serve as research resources for activities.
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For Educators: Article Discussion

About the article by Arpad Pusztai, Ph.D.:

“Genetically Modified Foods: Are They a Risk to Human/Animal Health”

www.actionbioscience.org/biotech/pusztai.html

Content Questions

1. Why is there little solid information about the safety of GM foods?
2. What is the preferred approach of the industry to judging the safety of GM foods? Why is this an unscientific approach?
3. What happens at the genetic level when crop plants are genetically modified?
4. How could the FLAVR-SAVR™ tomato produced by Calgene be considered a unique GM crop?
5. What results throw doubt on the safety of this crop?
6. For what purpose were soybeans genetically modified?
7. Name three other crops that have been genetically modified.
8. What two features should more rigorous safety testing include?
9. Why is it difficult at present to establish the allergenicity of GM crops?
10. What does Dr. Pusztai cite as his “inescapable conclusion” from his review of safety testing of GM foods?
11. Why does he suggest that “more science, not less” is needed?

For Educators: Article Extension Activities

Extension activities will require some research time and can be assigned as homework.

For High School level:

1. List at least three properties or characteristics that Biotechnology companies try to introduce into food crops through genetic modification. Why are they doing this? (Give one or two reasons for each example.) Use the Internet and Dr. Pusztai’s article for your research.
2. Dr. Pusztai criticizes the scientific value of most of the safety tests that had been done on GM foods up to June 2001. Why? List three reasons why at least one test of one food is not scientifically adequate.
3. Do Biotechnology companies really cite the “substantially equivalent” criterion in support of the safety of their products? Search for one or two examples of such an instance. Write a one-page summary of your findings.
4. Some critics of the efforts of Biotech companies to genetically modify foods express concerns that even if such foods are harmless to humans, they have the potential to cause harm to other species. Perform a brief (1/2 hour in duration) web or library search to find 2 or 3 articles that discuss this problem.

- Choose one of these articles, read it carefully, and summarize your analysis on the **Worksheet on page 4** (*WORKSHEET for Impact Analysis of GM Crop on Other Species*).
- Present your findings to your class or submit a one-page report along with your Worksheet, as indicated by your teacher.

For Undergraduate level:

1. Dr. Pusztai states early in his article that “Publications on GM food toxicity are scarce.” His article was published in June 2001. Is his statement still true? Make a brief web or library search for “Genetically Modified Foods/Crops” or “Genetically Engineered Foods/Crops” and

- count the number of articles listed
- note how many of these really deal with the toxicity of GM foods?
- make a list of foods that have been genetically modified and are available now or in the near future

2. What do the Biotech companies who have produced or are developing GM foods have to say about their products? Write to one of these companies for information about a GM food of your choice or use a web search to find the home page for such a company. Print and/or summarize any information or statement they make about one of their products.

- Do they report any safety test results?
- What criteria are cited or listed?
- Does their explanation seem to be scientific?
- Do you think they are reporting honestly?

3. Are there any documented cases of severe allergic reactions to GM foods? Try to find at least one example by doing a web search or research in your school library. Write a one-page summary of your findings.

4. Some critics of the efforts of Biotech companies to genetically modify foods express concerns that even if such foods are harmless to humans, they have the potential to cause harm to other species. Perform a brief (1/2 hour in duration) web or library search to find 2 or 3 articles that discuss this problem.

- Choose one of these articles, read it carefully, and summarize your analysis on the **Worksheet on page 4** (*WORKSHEET for Impact Analysis of GM Crop on Other Species*).
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5. After reading the scenario below with a partner: a) list the issues involved, b) discuss the issues c) suggest a resolution or solution.

Scenario: You are working as part of a team for *DreamGen Foods*, a biotech company. Your team is developing a new pesticide-resistant variety of rice, Super-Pro Rice. You think it might be possible to genetically modify the rice to produce proteins with a complete amino acid balance, similar to that provided by beef or pork proteins. This would provide a needed source of complete proteins for poor farmers in developing countries. Your supervisor authorizes your team to “fast-track” the development of this product and promises to take the proposal to the company’s executive committee.

Two months later, your team discovers that (1) the pesticide-resistance gene introduced into the rice is easily transferred to weed species, and (2) the new proteins produced by the rice take longer to digest in mice than do other plant proteins, indicating that they may be potentially allergenic. You suggest to your supervisor that another six months is needed to conduct more thorough testing. The supervisor indicates that another company lab has found Super-Pro Rice to be “substantially equivalent” to the currently used natural strains of rice, except of course, that the new strain is pesticide resistant and protein enriched. She tells you confidentially that the executive committee has already decided to market Super-Pro Rice next month.

To accompany Article Extension Activity #4

WORKSHEET for Impact Analysis of GM Crop on Other Species

Article: _____

GM Crop: _____

Produced by: _____ (Researcher)

_____ (Company)

When produced: _____

Trait or property introduced: _____

Expected or promised benefits: _____

Effects on ecosystems or other species: _____

Your conclusions: _____

GM Foods: Are They Safe?

Student Handout 1

1. Food Labels

Many people don't object to the production of GM foods but do object to the fact that they are not told whether or not the foods they buy have been genetically modified.

- Prepare a chart for your research into food product labels by listing foods mentioned in Dr. Pusztai's article, such as tomatoes, potatoes, peas, etc.
- Take a look in your kitchen or visit your local supermarket to randomly find five different prepared or packaged foods or food products.
- Look at the list of ingredients and note whether or not they indicate genetic modification; if there are no laws in your country requiring mandatory labeling of GM ingredients, research the products online
- write a one-page essay indicating whether or not you think these foods should have their GM ingredients clearly labeled and why.
- **OR** ...write a letter to the chairperson or CEO of the food manufacturer of one of these foods explaining why you think they are right or wrong to label (or not label) their product for GM ingredients

2. Debate on GM Crops

Prepare a debate between representatives of a third world country intending to plant a GM crop and environmentalists who oppose the sale of GM seeds to developing countries. Both sides of the debate must be carefully prepared, arguments and data researched, and positions presented. This will require a team of 4 students, 2 for each side of the debate. A fifth student or the teacher may act as moderator.

3. Designer Food

Take on the role of a member of a research team working for a Biotech company. Choose a widely grown food crop and suggest possible characteristics you would like to incorporate into it. Prepare a simulated presentation designed to convince the executives of your company (the rest of the class or another student team) to develop and market your proposed GM crop.

4. Biotech Company Interview

Contact a Biotech company, such as Monsanto, which produces genetically modified crops or foods. Inquire about their safety guidelines for the development of a GM product. Use the information you obtain to set up a mock interview with an executive of the company (another student takes on the role of the executive). Consider presenting the interview as a videotaped presentation or "live" as a dramatization.

5. GM Food Campaign

You are a member of *one* of the campaign groups listed in the "Get Involved" section at the end of Dr. Pusztai's online article. Create a visual presentation for a public exhibit that illustrates the campaign.

GM Foods: Are They Safe?

Student Handout 2

1. Comparative Risk

You are making a scientific presentation for an agricultural convention in your community. Prepare a display comparing positive and negative effects of GM Crops and Pesticides. The aim is to determine which is of greatest risk to other species and humans. Careful and thorough research will be required.

2. Production of Transgenic Plants

Create a visual explanation of the following methods for the production of transgenic plants:

- using *Agrobacterium tumefaciens*
- the Biolistic Particle Delivery System, or gene gun
- electroporation
- microinjection

3. GM Lobby

You are a lobbyist for a group that either advocates the release of GM crops or opposes the release until further research is done. Create material that you can distribute at government, public, or corporate events that explains your support or opposition. If you support the release, include examples of beneficial crops and why they are needed now. If you oppose the release, include information about possible (and documented) damage to ecosystems and public health.

4. Biotech Company Interview

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6. Farmer McTavish and the Law

While reading your local newspaper you notice the story about Farmer McTavish (page 7). Read the story and then

- perform a web or library search to determine the regulations or laws that would apply in your country
- write a one or two page summary of your findings
- make notes about cases that actually have occurred and their results
- assess if the laws governing such a case would be the same in two or three other countries
- present your findings to the class
- set up a class or group discussion based on this fictitious article or a real case you have found

Student Handout #2 (cont.)



FARMER McTAVISH CONVICTED OF STEALING GM CANOLA!

John McTavish, owner of Freeland County Farms, was convicted today of stealing and planting seeds of genetically modified canola produced by BLUE MOUNTAIN BioEngineering Corp. Judge J. Unger of the County First Circuit Court stated that farmer McTavish's claim that his previous year's seed crop had been contaminated by genetically engineered pollen from a neighbor's crop was invalid. The Judge ruled that BLUE MOUNTAIN was owed its licensing fee for the use of its pollen.

McTavish had testified: "My pesticide-free canola was planted from seed produced by last year's organically grown crop. This is a practice I have repeated during twenty years of organic farming. Last year, my neighbor, Bob Robertson, seeded his fields next to mine with BLUE MOUNTAIN's *Pest-Free Jiffy-Grow Canola*. He told me that he planted according to the company's requirements of a 50 foot border of non-genetically modified plants around the GM crop. So we both assumed that there would be no problem! However, unknown to me, BLUE MOUNTAIN took samples of this year's planting from my fields next to Robertson's farm. They claim that DNA analysis showed that 10% of my plants carry their patented pesticide-resistance genes. The genes must have been introduced by GM pollen blown over from Robertson's fields!"

Judge Unger ruled that since the pesticide-resistance gene was patented by BLUE MOUNTAIN, and Farmer Robertson had followed the company's planting requirements carefully, it did not matter how McTavish's canola gained the genes in question. Judge Unger fined farmer McTavish one-half the value of this year's canola crop from his farm and indicated any further transgressions would result in a prison term of up to five years.

Supplementary Student Handout

Sources: The following books, articles, and websites were used in the preparation of this lesson:

ACKERMAN, Jennifer. 2002. "Food: How Altered?," *Natl Geog.* 202(5): 32-52 (May 2002). See also the National Geographic website for a summary of the article.

FOX, Michael W. 1992. *Superpigs and Wondecorn*, Lyons & Burford Publishers, New York, NY.

GRACE, Eric S. 1997. *Biotechnology Unzipped: Promises & Realities*, Trifolium Books, Toronto, ON

LAMBRECHT, Bill, 2001. *Dinner at the New Gene Café*, Thomas Dunne Books, St. Martin's Press, New York, NY.

LANGRIDGE, William R. 2000. "Edible Vaccines," *Sci. Amer.* 283(3): 66-71 (Sept. 2000). Also see the journal's web site.

NASH, J. Madeleine, 2000. "Grains of Hope," *Time Magazine* 156(5): 14-22. (July 31 2000).

WHEELRIGHT, Jeff. 2002. "Don't Eat Again Until You Read This," *Discover Magazine* 22(3): 36-43 (March 2001). You can also read this article on the magazine's web site.

Definitions of Some Key Words:

Sources: FOWLER, H.W., and F.G. FOWLER, eds., 1964. *The Concise Oxford Dictionary of Current English*, 5th Edition and STEEN, Edwin B., 1971. *Dictionary of Biology*, Barnes & Noble Books, Harper & Row Publishers.

Adjuvant: An agent that helps, enhances, or increases the effectiveness of another substance, as a medicine or medical treatment.

Allergen: An agent capable of inducing an allergic reaction. For example: pollen, drugs, dust, animal hair, and certain foods, especially proteins.

Anaphylaxis: A state of excessive sensitivity, which develops in an animal or human being, following injection of a proteinaceous allergen. Upon re-injection of the same allergen, marked reactions occur and in some cases anaphylactic shock may develop (marked circulatory disturbances and possibly death).

Antibiotic resistance marker genes: Genes which normally impart resistance to an antibiotic such as Penicillin in bacteria. Such genes are carried on plasmids and can be used as markers or "marker genes" during genetic engineering procedures. In these cases, plasmids carrying functional genes along with the antibiotic resistance marker gene(s) are introduced into the cells of another organism. Genetic engineers can then use the antibiotic in question to kill any cells that did not pick up both the marker gene and the introduced functional gene.

DNA: Deoxyribonucleic Acid, a substance found in the nucleus of eukaryotic cells. It consists of subunits called nucleotides each made up of one of four nitrogen-containing bases (Guanine, Cytosine, Adenine, and Thymine), the 5-carbon sugar Deoxyribose, and a phosphate group. DNA regulates protein synthesis and codes genetic information.

Endogenous: Originating within; due to or resulting from internal causes or factors.

Genetic engineering: Any human mediated procedure, which changes the genome or assortment of genes, found naturally within an organism's cells. This usually involves the introduction of one or more genes from one organism, such as humans, into another, such as a bacterium. The goal is to provide the target organism with some genetic property of benefit that it does not naturally possess.

Glykoalkaloids: A group of naturally occurring chemical compounds with a carbohydrate component (glyco...) and containing nitrogen within their structure (alkaloids). They are often produced by plants as part of their chemical defenses against predation or competition, have a bitter taste, and are active physiologically, some being extremely poisonous. Many are of medical importance: atropine, ergotamine, ephedrine, reserpine, caffeine, morphine, quinine, and strychnine.

Iso: A prefix meaning "the same" or "equal."

mRNA fingerprinting: A procedure where mRNA sequences are broken apart by restriction enzymes and the fragments are separated by electrophoresis. Different transcript molecules of mRNA, formed complementary to different genes, will yield patterns of banding on the gel which are unique. Similar to DNA fingerprinting but using mRNA.

Peer-reviewed publication: A procedure whereby a scientist's paper is reviewed by other knowledgeable scientists working in the same or related fields as the author. By this procedure all reports published in scientific journals are carefully checked for accuracy and whether their procedures followed scientific principles.

Proteomics: A new field of inquiry, which seeks to discover the structure and function of all proteins, produced by genes in humans and other organisms. Often considered as an essential follow-up effort to the Human Genome Project.

Reporter genes: Genes used to indicate that a genetically engineered organism has assimilated introduced DNA into its genome. These may or may not include antibiotic resistance marker genes.

Sera: Plural of serum -- any watery animal fluid that could include blood plasma, interstitial fluid, or collected cellular fluids.

Substantial equivalence: Term used by biotech companies engaged in producing and marketing genetically modified foods to indicate that their products do not differ in composition, allergenicity, or overall properties from the conventional equivalent. Term used to indicate that a GM food is safe for human consumption.

Transcription terminators: Any chemical that stops the process of transcription or formation of mRNA molecules complementary in base sequence to a DNA template.

Vector: An agent such as a virus or bacterium used to introduce a gene or DNA from one cell to another.

Viral promoters: A gene that is a normal part of the genome of a virus that promotes the transcription of viral genes once the DNA of the virus enters a cell.