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Are you what you eat? An inside look at high-tech food

If we abide by the familiar saying "you are what you eat," it is understandable that people may be concerned with the incredible advances in food science technology and their possible impacts on human health. For example, in recent years high-tech scientific processes such as genetic modification, irradiation, and cloning have all been used to increase the safety of the food supply, create foods that are more appealing to eat and easier to produce, and increase crop yields. This article will summarize a few hot topics in food science, address what is currently known about the safety of these processes, and present resources on the subject to use with your students.

What are genetically modified foods?

Genetically modified (also referred to as GM) foods are produced from sources whose genetic makeup has been altered through genetic engineering processes such as recombinant DNA or gene splicing. While this technology is relatively new, if viewed in a historical context, people have been selecting desirable plant and animal DNA through traditional selective breeding processes for centuries.

All plant and animal breeding that is selective—choosing particular parent stock, plant or animal, and cross-fertilizing (naturally or artificially) to produce offspring with desired traits of the parents—is, in actuality, low-tech "genetic engineering." While it is not normally thought of as scientific technology, it provides the foundation for how we have selected the desired traits for our food—color, taste, size, yield—for centuries. Even though humans did not have the capacity to isolate DNA until recently, by choosing certain individuals for breeding, they were in fact selecting the DNA that would be replicated.

In contrast, newer biotechnology in food production uses gene splicing, recombinant DNA, cloning, or other techniques to produce the desired plant or animal product. With gene splicing and recombinant DNA directly modifying only certain parts of the organisms' DNA, it is possible to produce a more consistent product than would be possible using simpler forms of genetic manipulation or selective breeding. The first genetically modified whole food product, a tomato that could be shipped vine-ripened without rotting rapidly, went on the market in 1994. Today, the top three genetically modified crops in the United States are soybeans, corn, and cotton. Crops are modified not only for better taste and decreased spoilage, but also for resistance to disease and insects, and tolerance to certain herbicides or pesticides.

Manipulating DNA through genetic modification also allows genes from animals to be inserted into plant genomes—an example would be inserting the "antifreeze protein" gene from the Arctic flounder into a tomato's genome to produce a tomato that freezes and thaws better than the traditional tomato. What results is an example of a *transgenic* plant. Another successful example is the insertion of bacterial DNA that kills certain insects into a plant's genome, thus making the plants pest-resistant.

Genetic modification is not limited to the addition of DNA to an organism. Scientists are also genetically modifying the DNA of certain plants to remove or to silence parts of its DNA that cause allergic reactions or gastric distress to those who consume the plants. For example, through *gene silencing*, researchers were able to alter soybeans so they did not produce a protein called P34, which causes an allergic reaction in 75 percent of the people allergic to soybeans (Bren 2003). Work is continuing on this technique with soybeans, because there are up to 15 different proteins in soybeans that cause allergic reactions. To be totally effective, scientists will have to determine which of the additional 14 proteins cause allergic reactions and find ways to knock out those proteins as well; it is hoped that within a few years they will be successful.

It is estimated that between 70 and 75 percent of all processed foods now available in U.S. grocery stores may contain ingredients from genetically modified plants. Additionally, it must be remembered that genetic modification is not limited to whole foods—ingredients may also be engineered. Today, foods such as bread, cereal, hot dogs, pizza, and soda contain genetically engineered ingredients.

Genetically modified foods are not required in the United States to carry special labels, unless their content is significantly different from other products of the same

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type of food (such as decreased nutritional value, added allergen components, and so on). U.S. law requires foods to be labeled with information concerning their material and its processing, not the *method* by which a plant is developed by a breeder. For example, orange juice that is labeled as "fresh orange juice" cannot have been subjected to heat or chemical processing or processed into concentrate at any time before sale; the word fresh is considered to refer to the material (contents). Alternatively, if the oranges from which that same orange juice was made were the product of a hybrid cross-fertilization procedure, the orange juice is not required to be labeled "hybrid orange juice" because "hybrid" refers not to the contents of the orange juice, but to the method by which the oranges themselves were created. In actuality, almost every product we eat would require special labeling as to the method that was used to produce it if labeling laws extended beyond materials (contents) to include production methods.

There are several concerns raised about genetically modified foods. Transgenic plants have received much more attention than transgenic animals, partly because most transgenic animals are usually used for pharmaceutical or research purposes rather than for food. Concerns about genetically modified foods fall into several categories:

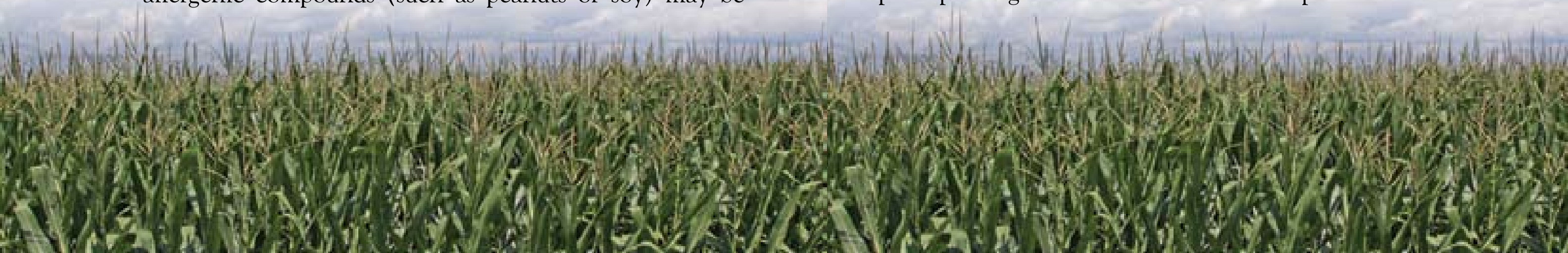
- Environmental—Pest-resistant crop plants may kill beneficial insects as well as pests. Some studies have shown that the pollen of transgenic corn plants is toxic to the larvae of monarch butterflies. Another concern is whether the introduced genes will spread from the crop plants into plants growing nearby. For instance, it is proposed that soybeans modified to be resistant to herbicide might cross-pollinate with weeds growing in the fields, thus creating "super weeds" that would be herbicide-resistant.
- Economic—Transgenic plants are expensive to produce because it takes expensive technology to create them. The companies that produce them (primarily in countries such as the United States) want to make a profit because they put a lot of resources into making them. It is suggested that poor countries that might benefit most from the technology would not be able to afford the seeds.
- Human health—Despite the fact that package labeling for potential allergic reactions is required by law for genetically engineered foods, there is still a concern that allergenic compounds (such as peanuts or soy) may be present in a food eventually consumed by an unknowing allergic person. While a consumer can read labels to control which foods are eaten at home, such control is lost when dining out. For example, a person with a peanut allergy could unknowingly consume a genetically modified food product containing a peanut compound at a restaurant or someone else's home. If the food being consumed normally would not contain peanuts, there would be no reasonable way for the diner to foresee that consuming it would produce a reaction, and that would place an allergic person at risk (Rajagopal 2001).

What are irradiated foods?

Food irradiation uses three different kinds of rays—x-rays, gamma rays, and electron beams—to expose food to radiation that eliminates disease-causing germs from the food source. Similar radiation technology has been used for decades to sterilize medical and dental devices. A simile provided by the U.S. Food and Drug Administration (FDA) attempts to address fears that irradiated foods may be radioactive themselves, stating simply that "irradiation does not make food radioactive, just as an airport luggage scanner does not make luggage radioactive" (FDA 2000).

Many studies have been conducted on irradiated foods and show that, when irradiation is used as approved on foods, (1) disease-causing germs are reduced or eliminated, (2) the food does not become radioactive, (3) dangerous substances do not appear in the foods, and (4) the nutritional value of the food is essentially unchanged (CDC 2005). For these reasons, food irradiation is believed to be a safe process, and is endorsed by the World Health Organization, Centers for Disease Control and Prevention, U.S. Department of Agriculture, and the FDA. It should be noted that irradiating foods can affect their taste, and may slightly decrease their thiamine content; however, similar changes are caused by pasteurization, canning, and other spoilage prevention methods. No other significant changes in amino acid, fatty acid, or vitamin content have been detected in irradiated foods.

Treating raw meat and poultry can eliminate *E. coli*, *Salmonella*, and *Campylobacter,* which cause millions of infections and thousands of illnesses each year. Treating produce can eliminate parasites such as *Cyclospora* and bacteria such as *Shigella* and *Salmonella* as well. Eliminating these organisms helps to prolong the shelflife of foods and prevent the



spread of the pathogens through the food chain, in addition to preventing direct infections from consumption. Of particular interest to students and teachers, U.S. school children have been consuming irradiated beef through the National School Lunch Program since 2004 (USDA 2003).

It should be noted that food irradiation does not replace safe food-handling practices. For example, irradiated foods must still be handled and processed using the same type of care (washing surfaces, not exposing foods to room temperature if refrigeration is required, and so on) as nonirradiated foods, as they can be exposed to disease-causing organisms once they are removed from their sterile packaging.

Irradiated foods carry labeling with either the words "treated with radiation," "treated with irradiation," or the international symbol for irradiation, the radura (Figure 1). If the irradiated component of the food is very small, such as in the case of spices or flavorings, the product may not carry any of these labels.

What are the facts behind food from cloned animals and livestock?

In December 2006, the FDA concluded after years of analysis that animal clones and their products (such as milk) are safe to eat. This finding is monumental because it sets the stage for cloned meat and animal products to eventually be introduced into the human food supply. However, what some people are calling the "yuck factor" (Brownlee 2007) and the expense associated with the cloning process may make cloned food a difficult sell to consumers.

In my March 2006 column on cloning, the process by which clones are produced and the exorbitant cost to produce even one cloned animal was discussed. When many people hear about cloned animals being introduced into the food supply, they mistakenly think that the idea is to produce massive numbers of cloned animals for human consumption. This is simply not the case—it is an economic impossibility that would make the cost of the food product astronomical. Rather, cloning is being used primarily for producing breed stock, and not for producing animals from which food products would be made.

Cloning lets breeders make copies of exceptional animals, such as pigs that fatten rapidly or cows that are superior milk producers. The breeders are not genetically modifying the animals through this process; no genes are changed, moved, or deleted as they are in the transgenic or genetic-engineering techniques previously discussed. Instead, the breeder is attempting to create a genetic twin, or copy, of a superior animal in order to use it for future matings that will improve the overall herd over time. As a result, consumers will most likely get their food *not from the clone itself*, but from its offspring. The idea of producing clones as food sources is right now economically unfeasible—just one clone costs tens of thousands of dollars, and the success rate for cloning is still relatively low compared to natural breeding techniques.

FIGURE 1 **The radura symbol**

A recent survey by the Pew Initiative on Food and Biotechnology (*http://pewagbiotech.org/research/2006update*) showed that 64% of people were uncomfortable with food coming from cloned animals. However, in that survey people were asked if they had heard of animal clones, but were not educated as to the role of cloning in the production of food—this is a key distinction that appears to not have been a part of the survey. It is possible that the people polled were under the impression that clones would be produced for direct consumption rather than what is currently proposed.

U.S. federal scientists have also concluded that special labels are not required for cloned food products. This would be consistent with their position on not requiring labeling based on method because it is the method by which the cloned animal was produced and not the material of the food that is at issue. However, consumer groups say labels are a must because of people's discomfort with cloned foods, and the possible ethical objections.

Classroom resources

Almost every teacher can use food science in his or her classroom because of the interdisciplinary nature of life, physical, and environmental science being represented in these topics. They are true S-T-S (science, technology, society) topics that are likely to excite and engage students because of their applicability to one of adolescents' favorite things—food. Here are a few ideas and suggestions:

- Science News for Kids (*www.sciencenewsforkids.org/articles/20040128/Feature1.asp*) provides a kid-friendly article called "Animal Clones: Double Trouble" by Emily Sohn on cloning for food production.
- The University of Nebraska Lincoln's website (*http://citnews.unl.edu/hscroptechnology/index.html*) provides anima-

tions of the process of genetically modifying a plant, lessons, and other resources. While labeled for high school, some activities (particularly the animations) would be great resources for middle school students.

- Students can conduct their own survey, like the one done by the Pew Initiative on Food and Biotechnology (*http://pewagbiotech.org/research/2006update*), find out what the perception of fellow students is on issues of food and biotechnology, and compare their results to those of the adults in the survey. Results could be presented publicly, such as on school TV or in the school newspaper.
- NOVA Harvest of Fear website (*www.pbs.org/wgbh/harvest*) provides some fantastic resources students (and teachers) can use, including:
  **What About This Fish?* is a five-minute free online video where the first genetically modified salmon is presented, along with its risks and benefits. The complete two-hour tape of the program is also available from PBS Video, and a free transcript of the entire program is available online.
  *The *Should We Grow GM Crops?* section of the website presents multiple pieces of literature to the reader, and after each one the reader is asked if he or she believes GM crops should be grown. Then, depending on the answer, a new counter argument is presented and at the end the reader is asked again. This continues through six cycles, with the final presentation being one where the reader can see all 12 for and against arguments before making a final decision. Teachers without computer access for all students could print out the arguments and present them on paper, or do this activity in a group setting.
  *The *Engineer a Crop* web page allows students to use basic genetic engineering to manipulate animated crops.
  *The *What's for Dinner?* interactive web page allows students to scroll over a variety of foods and read what is under development for each.
- WebQuests: Students can explore GM foods using either DNA for Dinner by William E. Peace *(www.peaceco.net/webquest/webquest.htm)*, or GE Foods—Friend or Foe? by Sandra R. Holmes (*http://home.earthlink.net/~spcemonk/webquest.html*). DNA for Dinner has students taking on the role of congressmen with the task of drafting a law addressing the labeling of genetically engineered foods; GE Foods has students taking on roles of scientists, legislators, consumer advocates, and environmentalists to explore the issues of genetically modified foods. Both WebQuests are great ways to have students actively engaged in research and writing. It should be noted that the resources listed in each of these websites should be expanded to include samples from the most recently available literature.
- The Science and Our Food Supply Curriculum Kit *(www.nsta.org/fdacurriculum)* contains several useful components: separate guides for middle level and high school science teachers; an interactive video, *Dr. X and the Quest for Food Safety;* and the comprehensive Food Safety A to Z Reference Guide. It is guided by the *National Science Education Standards*, includes varied activities easy to incorporate into all curricula, insider interviews with real-life scientists, and a career guide.
- The October 2004 issue of *The Science Teacher* was dedicated to food science, and its articles are available to you online via the NSTA journal archives (*www.nsta.org/highschool*). While intended for high school, many of the activities and information therein are appropriate for middle school and can be adapted.
- The Institute for Food Technologists website (*www.ift.org*) also features teachers' materials that are appropriate for middle school use. It is linked to Discovery Channel's DiscoverySchool site for food science (*http://school.discovery.com/foodscience/science_resources.html*), which also has materials adaptable for middle school, including online videos, scientist career information, experiments, and more.

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