# Supplemental Material

***CBE—Life Sciences Education***

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**Supplemental Materials**

**1. Content, behavior, and opinion questions given in the Qualtrics survey format.**

A. Content questions (correct answers in bold)

1. Over the course of about 7000 years, the average size of corn cobs (ears) has increased about 5 times in size. This is because:

**a. Early farmers saved and replanted seeds from the largest ears every season**
b. Natural selection acted preferentially on larger individuals to increase their frequency in the population
c. Smaller-eared plants produced seeds that were less viable
d. European explorers brought back larger ears of corn from the Americas to breed with local varieties

2. What are mutations?

a. Genes that provide new traits to organisms
b. Agents that damage DNA
**c. Changes in the DNA sequence of a gene**
d. Defects in the internal structure of a cell

3. Which of the following statements about mutations is NOT true?

**a. Mutations are usually harmful to the organism**
b. Mutations can cause changes in an organism's appearance
c. Mutations can be inherited from one generation to the next
d. Mutations are the basis of evolution

4. Which trait would be most advantageous to tomato plants experiencing constant drought?

a. Purple fruits (instead of red)
b. 20% faster rate of photosynthesis
c. 30% more leaves than normal
**d. Roots twice as long as normal**

5. A tomato plant that could not produce pollen would:

a. Be unable to produce fruit
b. Lack ovules
**c. Be unable to fertilize a tomato flower**
d. Be unable to attract bees

6. When farmers make crosses between plants they:

a. Rely on bees for pollination
**b. Are interested in certain traits**
c. Generate mutant offspring
d. Are creating a genetically modified organism (GMO)

7. The progeny of a self-fertilized plant will always have the same phenotype as the parent plant for a certain trait when:

a. The trait is dominant in the parent plant
b. The trait is recessive in the parent plant
c. The parent plant is heterozygous for that trait
**d. The parent plant is homozygous for that trait**

8. In a certain type of zucchini squash, solid green (G) is dominant over a striped pattern (g), and elongated shape (E) is dominant over round shape (e). If a plant that was homozygous for solid green color and heterozygous for shape were crossed with a plant that was heterozygous for color and homozygous for elongated shape, what percentage of the offspring would have elongated green zucchini?

a. 25%
b. 50%
c. 75%
**d. 100%**

9. What is the purpose of backcrossing in the process of selective plant breeding?

**a. To remove unwanted traits from the offspring**
b. To create a new variety of plant
c. To introduce desired traits to the offspring
d. To prepare the offspring for genetic modification

10a. Genetically modified corn and soybeans grown in the US today:

a. Are grown primarily on experimental farms
b. Are safe for animal feed, but not for human consumption
**c. Make up the majority of corn and soybean crops in the US**
d. Are not as extensively grown as organically grown corn and soybeans in the US

10b. How sure are you about your answer to question 10a? Explain.

11a. Ingredients from genetically modified (GMO) crop plants:

**a. Are widely used in commercially prepared foods in the United States**
b. Must be labeled as such to be sold in the United States
c. Have not yet been approved by the FDA for consumption in the United States
d. Are not tested to determine if they are toxic or if people are allergic to them

11b. How sure are you about your answer to question 11a? Explain.

12a. Which statement is INCORRECT?

a. Most crop plants grown today have been extensively modified by selective breeding

**b. Genetic modification and selective breeding are normally used separately for crop improvement**

c. Wild relatives of crop plants can provide novel traits for modern crop improvement

d. Spontaneous mutations can be used to improve crops through selective breeding

12b. How sure are you about your answer to question 12a? Explain.

13a. Which important difference between genetic modification (GM) and selective plant breeding is accurate:

a. Plant breeding can only be carried out by farmers, GM can only be done by scientists

**b. Plant breeding transfers thousands of genes through crossing; GM transfers individual genes to the recipient plant**

c. Plant breeding only increases yield, whereas GM can be used to introduce many different traits

d. Plant breeding can be used in developing countries with more primitive agricultural systems, GM must be used in developed countries with advanced agricultural systems

13b. How sure are you about your answer to question 13a? Explain.

<u>B. Individual interest questions</u>

1. How frequently do you read about or watch programs on GMOs (including books, news articles, opinion pieces, web sites, videos, TV programs, etc.)?

Never Rarely Sometimes Often

2. How frequently do you search for information on the internet about GMOs?

Never Rarely Sometimes Often

3. How frequently do you have conversations about GMOs (outside of class) with friends, peers or family?

Never Rarely Sometimes Often

4. How frequently have you explained the science of GMOs to others?

Never Rarely Sometimes Often

If you read about, watched, searched for, discussed, or explained GMO technology, explain why. If you did *not* read about, watch, search for, discuss, or explain GMO technology, explain why not.

C. Open-ended opinion questions

*Open-ended questions for pre test*

1. “Genetically engineered crop plants should be part of our food supply.”
Do you agree or disagree with the above statement? Explain your opinion.

2. “Genetics and biotechnology can be used to solve important issues facing society.”
Do you agree or disagree with the above statement? Explain your opinion.

*Open-ended questions for post test*

1. “Genetically engineered crop plants should be part of our food supply.”

A. Do you agree or disagree with the above statement? Explain your opinion.

B. Did experiences in Bio 101 (class discussions and/or teaching in public school classrooms) affect your answer to the above question? Explain why or why not.

2. “Genetics and biotechnology can be used to solve important issues facing society.”

A. Do you agree or disagree with the above statement? Explain your opinion.

B. Did experiences in Bio 101 (class discussions and/or teaching in public school classrooms) affect your answer to the above question? Explain why or why not.

**2. Post-teaching Reflection**

Write a one-and-a-half to two-page reflective essay describing your experiences in this high school service-learning project. The purpose of this reflection is to provide important feedback about your teaching experience and your learning gains from the experience.
**Be sure you include discussion of all of the following in your reflection:**

-Describe your feelings about learning the curriculum and preparing to teach?
-What would you change about the curriculum, if anything?
-What would you change about the preparation you did, if anything?
-Did you make any changes to the way you taught over the course of the service-learning project?

-Describe your experiences interacting with the students. How did the students respond to your teaching?
-What approaches were successful in engaging the students in the curriculum?
-How did the students respond to the content of the curriculum?

-Reflect on your interactions with the high school students. Describe any notable interactions or connections.
-Reflect on how you and your lab partner worked together to prepare to teach and during the teaching experience. (Note: please do not refer to your lab partner by name.)

-Describe how the teaching experience changed your understanding of the concepts you taught?
-Describe how the teaching experience changed your perceptions of GMOs and crop improvement?

-What was the most challenging part of this experience?
-What was the best part of this experience?

**3. Handout with FAQs and additional information about GMOs**

**FAQs about GMOs**

What tests are done before GMOs are approved for human or animal consumption?
Like any technology, GMOs have benefits and risks. Risk assessment is performed on GMOs to see if the benefits outweigh the risks. GMOs are tested for the risk of harm to human health; the risk to non-target organisms (like beneficial insects); the risk of potential movement of the novel gene to other crops or wild organisms; and the risk of evolution of resistance of target pests or pathogens. Management of some of these risks is dependent on farmers carrying out certain farming techniques.

Are GMOs safe to eat?
Yes. GMOs are extensively tested for potential toxicity before being approved by the US Department of Agriculture for animal or human consumption. **There have been no reported adverse health effects of any GMO on the market today.**

Do GMOs cause allergies?
No. GMOs are extensively tested for allergenicity before being approved by the USDA.

Do GMOs harm beneficial insects, such as monarch butterflies?
Not any more than conventional agriculture. The Bacillis toxin that is found in Bt corn and Bt cotton is toxic to several orders of insects, including pest insects and beneficial insects. Theoretically, Bt crops could kill beneficial insects if they ate them, but most don't like to feed on these agricultural crops. Monarch butterfly larvae feed exclusively on milkweed plants. Pollen from Bt corn or Bt cotton, which is toxic to s monarchs, could theoretically drift onto milkweed plants, and kill monarch larvae feeding on those plants. However, the risk is very small. Pesticide use in conventional agriculture and habitat destruction kill many more monarchs than GMO crops.

Will genes from GMO crops contaminate wild populations of plants?
Closely related species of plants can cross-pollinate. Pollen from a GMO crop could potentially fertilize a non-GMO crop of the same type, or a close relative, and transfer the novel gene to the non-GMO plant through normal reproductive methods. To minimize this possibility, GMO crops are required to be grown certain distances away from non-GMO crops and from closely related plants. When farmers do not follow these rules, the risk of gene transfer increases.

Are GMO foods labeled?
In the US there are currently no laws requiring GMO-containing foods to be labeled. Several companies voluntarily label their foods as non-GMO. Food labeling bills have been on the ballot in several states, but none has been voted into law. For 'Organic certification' by the USDA, products cannot contain GMOs.

How are genes transferred into crop plants to make GMOs?
Many of these plants are made by using a naturally occurring bacterium that evolved a mechanism to transfer genes into plants. Scientists place the gene of interest into this bacteria and the bacteria then inserts the genome into the plant.

**Links to internet resources**

Monsanto's website describing their GMO crop products:
www.genuity.com

YouTube video about conventional plant breeding to combat a new bacterial disease in tomatoes:
https://www.youtube.com/watch?v=mtVtpO7FOaA

YouTube animated video comparing conventional plant breeding with GM technology:
https://www.youtube.com/watch?v=S36aE9_m_Xo

Union of Concern Scientists website about industrial agriculture, including GM technology:
http://www.ucsusa.org/food_and_agriculture#.VgqveLRVhHx

Website describing how corn, peaches, and watermelon have been modified from their wild varieties into the foods we know today:
https://jameskennedymonash.wordpress.com/category/infographics/artificial-vs-natural-foods/

Website of the International Service for Acquisition of Agri-biotech Applications (ISAAA). Has information about all approved GMO crops (US and international), including all that are approved but not commercially available:
http://www.isaaa.org/gmapprovaldatabase/default.asp

Article about safety studies on GMOs. The main website (geneticliteracyproject.org) has many links to articles about GMOs:
http://www.geneticliteracyproject.org/2015/09/23/myth-busting-anti-gmo-activist-claims-no-long-term-safety-studies-demolished/

Article about girl scouts refusing to remove GMO derived ingredients from there cookies, also from the geneticliteracyprojct.org.
http://www.geneticliteracyproject.org/2015/01/16/girls-scouts-reject-attempts-by-anti-gmo-parents-to-use-their-kids-in-fear-campaign/

Three articles about the Innate GMO potatoes, which have decreased browning:
http://www.npr.org/sections/thesalt/2015/01/13/376184710/gmo-potatoes-have-arrived-but-will-anyone-buy-them

http://www.nytimes.com/2014/11/08/business/genetically-modified-potato-from-simplot-approved-by-usda.html?_r=1

http://www.geneticliteracyproject.org/2014/11/09/mcdonalds-mulling-embrace-of-simplots-bruise-reducing-innate-gmo-potato/