

Seeds of a New Era

This episode examines the controversies surrounding genetically modified organisms (GMOs) in agriculture, including those dealing with domestic and international foods. The video explains the process of modification using crown gall disease and *Agrobacterium tumefaciens* as models to demonstrate how genetic engineering works in plants. The episode explores the use of marker genes, DNA constructs, and real-world agricultural applications of transgenic plants. Positive applications and the controversy of genetic engineering in plants are both explored.

Lesson Planner

Day 1: Homework: Research GMO
Day 2: Journal notes: issues & opinions
View Segments One and Two
"It's a Puzzle" Activity
Day 3: View Segments Three and Four
"Separating Fact from Fear"
Activity
Homework: Research herbicide
Day 4: "Tastee-Genes" Activity
View Segment Five
Journal notes: Revise issues & opinions

SEGMENT ONE: GMO . . . YES OR NO?

This segment opens with Moxy Frúvous performing the final verse of the *Cracking the Code* theme, relating to agribusiness and the role of genetically modified organisms (GMOs) within it. This segment offers an introduction to the scientific and ethical controversies and issues surrounding GMOs, making it clear that farms are both the scientific demonstration ground and the ethical battleground for the sustained use of GMOs and their products.

Key Words

genetic engineering
GMO

Learning Objectives

Students will be able to:

- Define the term GMO.
- Give several examples of genetically engineered crops.

Pre-Viewing Activity

At the end of the class on the day prior to your planned use of this video segment, write the acronym "GMO" on the board or on a flipchart.

Tell your students to write the acronym in their journals; their assignment is to determine what that acronym stands for and to give an example of a GMO and a related issue or controversy. Students may use the Internet, discussions at home, the library, or classroom references. Students should keep notes on the process of their investigations. Be careful to give nothing

National Science Education Standards

Content Standard C:


The molecular basis of heredity; mutations, cell differentiation.

away—and instruct students that, if some already know what it means, not to say anything to their classmates.


At the next class, spend the first ten minutes of class brainstorming with the findings of your students on the term, the examples, and the issues or controversies cited. Have students make additional comments in their journals noting their personal opinions on these issues or controversies. Be sure to check for comprehension, and record the issues stated for use at the conclusion of this unit.

Let students know they're going to watch a segment of the series, *Cracking the Code: The Continuing Saga of Genetics*, dealing with GMOs. Have them listen carefully to determine how many of the GMOs found as examples and listed in the brainstorming exercise are mentioned in this next segment and if there are additional examples cited.


Viewing Activities

This opening segment is very short and lends itself to probably one or two PAUSE  points.

To provide a focus for viewing this segment, ask your students if they have any idea how many of the foods currently available in supermarkets have been genetically modified. Discuss briefly, and then let students know the answer will be found in this first segment of the episode and they should listen for that answer.

CUE the tape to the very beginning of the segment, including the opening graphic and the music. PLAY  the opening section, beginning with the musical group, Moxy Früvous (you will find the lyrics to the series theme on page 8.)


The segment focuses on four major crops which have been genetically modified: canola, soybean, cotton, and corn. They provide three quarters of North America's polysaccharides, proteins, and oils which include three of the four big macromolecules the human body needs to survive and thrive: carbohydrates, lipids, and proteins.

After the segment goes on to briefly explore the reluctance of foreign countries to accept North American GMOs, as well as the movement on this continent against these genetically modified crops, when the video asks the question, "Why? What is it about GMOs that has people so concerned?"—PAUSE  the tape.

Discussion Point

Based on the information you've been exposed to thus far, how might we consider a farm a battleground? Encourage all answers and discussion. Point out to your students that there are actually several fronts where battles are fought on a farm. Ask your students to name a couple. (Some answers they may come up with include disease—reference Mad Cow, avian flu, and e-coli—insects, subsidies, treatment of animals, and drought relief.)

Why do you think people are up in arms about genetically modified foodstuffs? What's the big deal? How do you feel about it?

REWIND the tape to the very beginning and have students listen carefully to the lyrics of the opening song. STOP  the tape at the conclusion of the song.

Discussion Point

The phrase "forbidden fruit" may make us think of the Garden of Eden . . . what does the phrase mean? Is genetic engineering forbidden fruit? Is the knowledge that we can manipulate nature to be better than originally planned something we human beings have any right to be doing? Is this, then, the basis of the controversy? Is "natural" really better?

SEGMENT TWO: THE PROCESS

This segment, through the use of animation and clear, concise explanation, offers a window to basic processes of biotechnology in plants.

Key Words

agrobacterium	plasmid
DNA construct	promoter
ligase	restriction enzyme
marker	transgene

Learning Objectives

Students will be able to:

- Define and explain the keywords associated with the section.
- Identify and explain the components of a DNA construct.
- Explain why introducing foreign DNA to plant cells was more difficult than introducing it to animal cells.
- Define crown gall disease and its significance in genetically engineered plants.

Pre-Viewing Activity

Ask if anyone can explain how the process of genetic modification is performed. Can something like GMOs be produced outside a laboratory?

Viewing Activities

CUE tape to the roomful of flats filled with Petri dishes. This beginning section presents a photomicroscopic visualization of the fertilization of an animal cell in a laboratory setting, and counters with a visual of a plant cell and its much thicker cell wall, impeding the genetic engineering process in plants.

Direct students to take notes. PLAY ► through the section where the animation explores the process of how plasmids within the bacteria promoting crown gall disease can release their DNA when they are near the damaged stem of a plant, and then recombine that DNA with that of the healthy plant cells. The cells then reproduce at a dizzying rate, resulting in crown gall tumors, containing the moved genes, or transgenes. PAUSE ⏸ the tape. Ask students to recount this section.

Discussion Point

How often do you think nature provides the answers scientists need in order to make breakthroughs in the laboratory? Ask for

predictions about why this bacterium may be significant to scientists interested in altering plant DNA.

PLAY ► the next step of the animation, which shows how scientists have used genetic engineering to insert new genes into plants. The video shows how, using restriction enzymes, genetic engineers were able to snip out tumor-causing genes, leaving the rest. After exposing the new plasmid to ligase (a glue-like enzyme that adheres the end pieces of the new gene together with the other plasmid genes), scientists were able to paste in genes of their choice. The new gene, or transgene, is recognized no differently than that of the crown gall genes by the transportation system within the plant, and becomes part of the structure. The difference is that now the plant is protected against the crown gall bacteria. PAUSE ⏸ the tape following this section to check for comprehension.

Discussion Point

The video mentions that after removing the crown gall DNA, scientists are able to replace it with other genes of their choice. What are the ethical implications of this?

Remind students to continue to make notes in their journals, paying particular attention in the next segment to the steps in the process that scientists use to alter DNA in plants. PLAY ► the next section of animation, which will make clear the make-up of a DNA construct. In the laboratory, plant embryos that are viable utilize the marker DNA, one that protects it from the toxin in the culture plate, and clearly shows the genetically changed plants (those that survived). Once these plants are fully grown, they will propagate as untreated plants do, and all future generations will contain the transgene. PAUSE ⏸ the tape to once again check for comprehension. If necessary, rewind and replay sections of this material.

To recap, PLAY ► the music segment to pull all the threads of this complicated tapestry of science together. STOP ■ the tape.

Discussion Point

The song mentions that money is being invested in research and implementation of the process shown in this past segment. Should government funding be diverted to this research? Why or why not?

Post-Viewing Activity

Distribute the “It’s a Puzzle” Student Activity Sheet and invite students to visit this Web site: www.geneticstv.org/peas_in_a_pod to practice organizing the steps that scientists use to alter the DNA, using Bt corn as an illustrated example.

Research Rachel Carson’s work with pesticides in the late 1950s and early 1960s. Tell students to be prepared to discuss Carson’s work at the beginning of the next class. Web sites of interest:

Ecology Hall of Fame, Rachel Carson:
<http://www.ecotopia.org/ehof/carson>

A Science Odyssey: People and Discoveries, Rachel Carson:
<http://www.pbs.org/wgbh/aso/databank/entries/btcars.html>

RachelCarson.org, A Web site Devoted to the Life and Legacy of Rachel Carson:
<http://www.rachelcarson.org>

SEGMENT THREE: PEST CONTROL

One of the benefits of genetically engineered plants is that they may be designed to fend off certain insects, decreasing the need for chemical insecticides.

Key Words

<i>Bacillus thuringiensis</i> , or Bt	organic farmers
fungicide	pesticide
insecticide	transgenic plants

Learning Objectives

Students will be able to:


- Explain how using genetically modified plants can allow some insects to thrive.

- Debunk the misconception that genetically modified corn is a threat to Monarch butterflies.
- Explain how transgenic plants combined with the specific use of herbicides can mean a reduction in the use of toxic chemicals for weed control.

Pre-Viewing Activity


Reference the homework assignment and mention that Rachel Carson’s book, *Silent Spring*, essentially paved the way to eliminate the toxic pesticide DDT from use in America and brought to light many of the dangers of pesticide use. Were her tenets well founded or not?

Viewing Activities

CUE tape to just following the Moxy Frivous song section. The visual will be an upright stalk of grain; PLAY .



The narrator discusses naturally occurring insecticide in important GM crops such as corn, cotton, and potatoes. One insect discussed is the Colorado potato beetle, and viewers are shown a field-study comparison between transgenic potato plants and those that do not have the Bt gene. The potato farmer clearly states that use of transgenic plants has dramatically reduced his need for toxic insecticides, and for chemical fungicides (because less leaf damage means less chance for fungal diseases to occur).

The segment goes on to explain how subspecies of the Bt gene are particularly engineered toward target insects known to be dangerous to a plant without being lethal to other beneficial insects.

The controversy surrounding the Monarch Butterfly and Bt-treated corn is examined, consisting of a laboratory study claiming pollen from Bt-treated corn plants is lethal to Monarch larvae and including a field study designed to gather data showing real-world risk to the Monarch butterfly population. PAUSE  the tape at the end of this section.

Discussion Point

Did learning about the fallacy of the theory about GM plants and their pollen being dangerous to Monarch butterflies make you wonder about other “studies” or “findings” we may have heard about in the media? Discuss the ramifications of poorly designed research.

PLAY  the tape through the next section where the issue of resistance is also discussed, where some insects may overcome Bt toxin and reproduce, leading to future generations of “super bugs.” Animation describes how management practices are in place so that the resistant insect population will mate with untreated populations to curb the resistant populations. At the end of this section, when the tape fades to black, STOP  TAPE.

Discussion Point

Have you heard of other concerns regarding resistance? (Consider the use of antibiotics and resistant bacteria such as hepatitis C.)

Darwin’s Theory of Natural Selection purports that survival of the fittest improves species diversity. Is GM science interfering too much with nature?

Post-Viewing Activity

Use the “Separating Fact from Fear” Student Activity with the Experimental Design Matrix worksheet. This activity can be started as homework and completed as a group activity in class.

SEGMENT FOUR: WEED CONTROL

This segment discusses the use of herbicides on fields where crops have been genetically treated to be resistant to the herbicide. Pairing herbicides with GM crops can reduce weeds and soil erosion in a safe and environmentally responsible way.

Key Words

broad-spectrum herbicides
resistance
soil erosion

Learning Objectives


Students will be able to:

- Explain the cause and effect as it pertains to transgenic plants and herbicides.
- Explain the connection between soil erosion and genetically engineered plants.
- Explain the real-world application of this aspect of genetic engineering.

Pre-Viewing Activity

Ask students to share their knowledge of herbicides. Students in rural settings with agricultural businesses nearby may be very knowledgeable. This discussion sets the stage and allows the instructor to get a feel for the level of student understanding of this topic.

Viewing Activities

CUE to the beginning of the segment showing a young farmer walking through a field of high grass. In this segment we learn that scientists have mastered a way to modify a plant allowing it to withstand a broad-spectrum herbicide. However, the weeds surrounding it do not possess this protective gene. Continue to watch as the video goes on to explain how the agriculture industry uses specific management practices to avoid this threat. When images of two farm machines applying herbicide in a field appear on the screen, and the narrator says, “The balance may be favorable, or not. As we have seen, the environmental benefits far outweigh the risks,” STOP  TAPE.

Discussion Point

Are organic farmers causing potential problems for the earth or protecting it by not utilizing genetically modified plants?

Do you think it’s possible that genetically modified crops and the introduction of other genetic material within them could someday become a form of chemical warfare?

Post-Viewing Activity

Students will select an herbicide from either Monsanto or Aventis and write a synopsis including the following: target crop and target weed(s); efficacy in best environment, proper application, proper storage, potential side effects on other organisms, proper disposal methods, how long in use.

SEGMENT FIVE: HUMAN CONSUMPTION

Viewers learn in this final segment that GM-treated crops are not indiscriminately introduced into the human food chain, but are instead scrupulously tested to avoid potential allergens. Also, that there is no current data indicating that since GM foods were introduced in 1994 there has been any case of human illness related to genetically engineered crops.

Key words

allergen
consumer

Learning Objectives

Students will be able to:


- Explain how Bt toxin is of no danger to mammalian biology.
- Explain how the protein added to a plant to make it tolerant to herbicides such as Round-Up™ has no effect on humans.
- Explain how GM plants are tested prior to dispersal in the agricultural market.

Pre-Viewing Activity

In small groups, conduct the “Tastee-Genes” Activity. Point out that the purpose of this activity is for students to understand and develop their own values and opinions related to the genetic modification of foods.

Viewing Activities

CUE TAPE to roughly 24 minutes into the segment. The visual will be a supermarket produce section sign saying, “THE FARM” across the screen. The narrator will say, “But there is another source of fear . . . that eating these crops with their foreign genes will somehow

damage our health.” This segment serves to reinforce the “Tastee-Genes” Activity. View segment through the final song. STOP  TAPE.

Discussion Point

We learned in this segment that some plants, such as broccoli, contain natural toxins that would, if they were put through the current testing for GM utilization, keep them off the supermarket shelves. Does that argument weaken the case for testing GM foods?

Moxy Frúvous sings about the profits generated by the use of GM crops not being seen by the farmer. Who does see those profits?

Post-Viewing Activity

Refer to the issues raised in the discussion at the beginning of this unit. Ask students to read their opinions again and to make a note whether or not their opinion is changed or strengthened since they have learned more about GMOs. A brief essay exploring whether their opinions did or did not change with supporting material can be used to assess individual student comprehension.

References

Botany of Desire: A Plants-Eye View of the World, by Michael Pollan (Random House, 2001). The impact of humans on promoting the success of certain species of plants which might otherwise have had little chance of survival. While not engineering at the molecular level, this book notes that for millennia, humans have engaged in promoting certain attributes of plants.

“Rappaccini’s Daughter,” short story by Nathaniel Hawthorne, in *Nathaniel Hawthorne: Selected Tales and Sketches* (Penguin Books, 1987). A man raises poisonous plants and renders his daughter both immune to them and a threat to others, including the young student who loves her.

Silent Spring, by Rachel Carson (Houghton-Mifflin First Mariners Books Edition, 2002). First published in 1962, this seminal work initi-

ated a groundswell of concern for the environmental hazards of chemical pesticide use.

National Science Education Standards

<http://nap.edu/readingroom/books/nses/html>

Content Standard C

As a result of their activities in grades 9–12, all students should develop understanding of the cell, molecular basis of heredity, biological evolution, interdependence of organisms, matter, energy, and organization in living systems and behavior of organisms.

The Molecular Basis of Heredity

In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA, a large polymer formed from sub-units of four kinds (A, G, C, and T). The chemical and structural properties of DNA explain how the genetic information that underlies heredity is both encoded in genes (as a string of molecular “letters”) and replicated (by a templating mechanism). Each DNA molecule in a cell forms a single chromosome.

Changes in DNA (mutations) occur spontaneously at low rates. Some of these changes make no difference to the organism, whereas others can change cells and organisms. Only mutations in germ cells can create the variation that changes an organism’s offspring.

The Cell

Cells can differentiate, and complex multicellular organisms are formed as a highly organized arrangement of differentiated cells. In the development of these multicellular organisms, the progeny from a single cell form an embryo in which the cells multiply and differentiate to form the many specialized cells, tissues and organs that comprise the final organism. This differentiation is regulated through the expression of different genes.

Links

“Rachel Carson and the Awakening of Environmental Consciousness,” by Linda Lear, at *Wilderness and American Identity Essays* (June 2002).

<http://www.nhc.rtp.nc.us:8080/tserve/nattrans/ntwilderness/essays/carson.htm>

“The Lies of Rachel Carson,” by Dr. J. Gordon Edwards, in *21st Century Science and Technology Magazine* (Summer 1992).

<http://www.21stcenturysciencetech.com/articles/summ02/Carson.html>

“Transgenic Pollen Harms Monarch Larvae,” by John E. Losey, Linda S Razor, and Maureen E. Carter, in *Nature* (May 20, 1999).

<http://www.biotech-info.net/transpollen.html>

“Media Literacy: Yes, It Fits in Math and Science Classrooms,” by Frank Baker, in *ENC Focus* (July 2001).

<http://www.enc.org/features/focus/archive/literacy/document.shtm?input=FOC-002081-index>

Cross-Curricular Activities

Language Arts: Working with the Language Arts teacher, introduce a cross-curricular project involving the reading of Rachel Carson’s *Silent Spring* while this unit is being taught in biology. Compare and contrast this book to political exposés.

Read Nathaniel Hawthorne’s short story, “Rappaccini’s Daughter,” and discuss how humans have long used plants for both beneficial and nefarious purposes.

Mathematics: Create and administer a poll to garner students’ or the community’s opinion of GM foods. Make the statistical analysis of this project hold heavy weight in the evaluation.

THEME SONG—AGRICULTURE

We're learning how to modify
The food we grow, the fish we fry.
Their DNA is now at our command.

The genes we want can now be moved.
The food we eat can be improved.
By adding traits that nature never planned.

This power is now the subject of dispute.
Are we biting into new forbidden fruit?



NEW-FANGLED SEEDS, PART ONE

We're farmers and we're puttin' lotsa cash in,
To new-fangled seeds that now are all the fashion.

Scientists have added genes
To our usual cuisines
Thanks to an earthy little bug named
tumefaciens.

That's how they get 'em through cell walls that
are so thick,
Once inside the nucleus that gene will stick.
Now the leaf's been engineered
Through a mating kinda weird
Crossing kingdoms, which is really quite a
trick.

That DNA gives new instructions
And each little bit of tissue's soon a clone.
Through asexual reproduction
Now there's many plants instead of one alone.

And that gene's in all the seeds those plants are
growin'.
And that gene's in all the seeds those plants are
growin'.

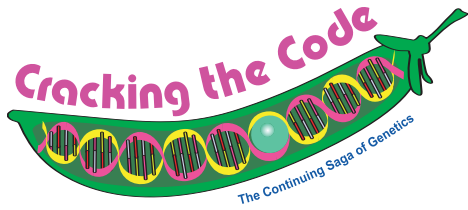
NEW-FANGLED SEEDS, PART TWO

Now our crops they are arousin' lotsa passion,
After harvesting they face another thrashin'.
Do the genes that modify
Really rate this hue and cry?
Do the facts really support this GM bashin'?

You see, these crops go through an awful lot of
testin'
And there hasn't been a problem in ingestin'
The food that they produce.
And they help us to reduce
The chemicals we spray to keep us from
infestin'.

One gene protects against bad insects—
We don't have to zap 'em with insecticides.
One gene succeeds in fighting weeds
While reducing damage caused by herbicides.

But we still don't get the profits they provide.
We don't get the big, fat profits they provide.



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AGROBACTERIUM TUMEFACIENS — “IT’S A PUZZLE!”

Agrobacterium tumefaciens is a bacterium capable of causing a tumor in a plant. The bacterium contains a **plasmid**, dubbed tumor-inducing (Ti) by scientists. In nature, when the plasmid is transferred to the plant host, genetic information is incorporated into the host DNA and will cause a tumor. The resulting condition is known as Crown Gall Disease, primarily associated with broad-leaved plants such as roses. This is nicely illustrated in *Cracking the Code, Episode Six: Seeds of a New Era*.

Scientists have used this natural mechanism to their advantage. In the laboratory they modify *Agrobacterium tumefaciens* to be non-virulent (non-disease causing) but still capable of transferring plasmid. They attach desired gene(s), including marker gene(s) to the Ti plasmid DNA of modified *Agrobacterium*. Manipulating the *A. tumefaciens*, as stated, is known as building a **DNA construct**. The reconstructed plasmid can then be inserted into a plant genome. Infected plant tissue is grown in tissue culture medium, and new plant tissue is screened for the desirable features. In doing this screening, scientists look for the presence of the marker gene, such as one that causes resistance to a particular antibiotic. By raising the plant tissue in media containing the antibiotic, the marker gene allows transformation screening to be far more clear and efficient. Plantlets are then removed and put through an acclimatization process, called “hardening off,” to help them survive in a more natural environment. The resulting plants are grown for their seed. Farmers buy this seed, and the subsequent crops are grown having a resistance to a variety of diseases/herbicides/pesticides.

Using what you’ve learned from the video about this remarkable process, access this URL—www.geneticstv.org/peas_in_a_pod—and put together the following puzzle that will answer the question:

“What is the process of creating a DNA construct utilizing *Agrobacterium tumefaciens*?”

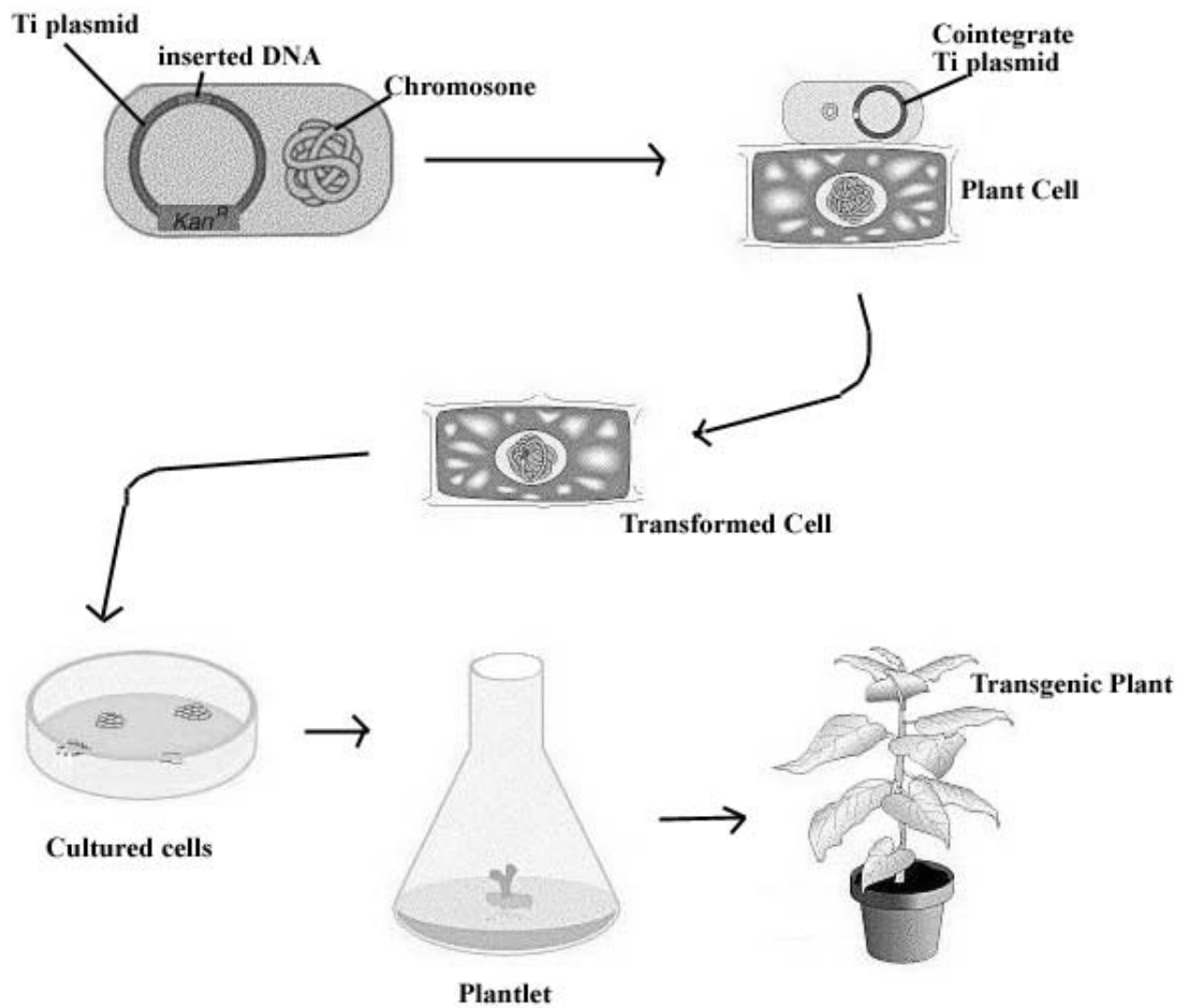
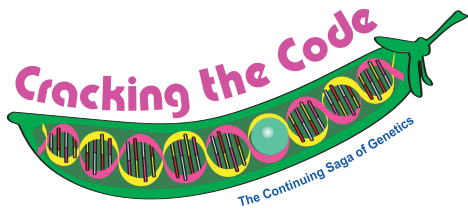


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Seeds of a New Era

SEPARATING FACT FROM FEAR

Understanding science certainly allows the public to ask better questions and expect cogent answers. Case in point: “How long has modification of crop plants to improve their suitability been practiced?” The general public would most likely answer, “Between 10 and 100 years.” But the informed individuals would know the answer to be at least 10,000 years. Early farmers saved seed from plants that exhibited desirable traits and humans have augmented natural selection by giving an advantage to species we prefer. In the last century, a more rigorous approach has been employed to influence nature, and with it comes controversy. Biologists created the first transgenic plants in the early 1980s. So, where are we today? Concerned citizens are weighing the pros and cons raised by scientific endeavors. The uninformed are at the whim of the headlines and sound bites of the media.

The following activity is designed to help you be an informed citizen.

Your first task is to access this URL: www.biotech-info.net/transpollen.html

–OR–

Use a library to locate and read this article: “Transgenic Pollen Harms Monarch Larvae,” by John E. Losey, Linda S Razor, and Maureen E. Carter of the Department of Entomology at Cornell University, in the May 20, 1999, issue of *Nature*.

Remember, you are a discerning reader. Using your knowledge of the scientific way of thinking and what makes for optimal experimental design, record notes that you take while reading into the grid on Worksheet 1-A.

In the first box, list what you think are the logical observations that may have been before the research plan was designed. Focus on factual information about milkweed, corn, *Bacillus thuringiensis*, and weather. For example, you might list:

- Milkweed may be found growing in or around corn fields.

Next, record the components of Losey *et al.*'s experimental design. For example:

- For four days the investigators recorded leaf consumption, survival rates, and weights of the larvae.

Finally, reflect the results obtained from the experiment. For instance:

- Larvae eating Bt-treated leaves weighed less than the control larvae.

In class compare your lists with a partner and collaborate on a combined set of lists. Your teacher will then build a class set of lists. Science benefits from the experiences of all researchers, and dis-

cussion may stimulate further data. Now, break up into small groups and develop answers to the following questions.

1. Do the experimental results warrant the use of the title the authors chose for their report? Why or why not?
2. If the experiment had been done in or near a cornfield rather than in a laboratory, might there have been different results? Why or why not?
3. Could the experimental controls have been improved? How or why not?

Once you have critically analyzed the Losey *et al.* experiment, meet in groups and design an experiment to investigate the relationship of Bt corn and monarch butterflies. Use the matrix below and the blank on Worksheet 2-A to assist you in your design. Your experiment may be designed to confirm, refine, or refute the original work done by the Cornell University investigators.

Experimental Design Matrix

Title of the Experiment What are you trying to find out? "The Effect of _(independent variable)_ in _(organism studied)_"					
Hypothesis What do you predict will happen during the experiment? "If _(you do this)_, then _(this will happen)_"					
Independent Variable What are you testing or changing in your experiment? What are your units of measurement?					
Levels of Independent Variable	amounts of independent variable		in increasing order		
Number of Repeated Trials	number of times tested				
Dependent Variable What results will you measure? What are your <i>units</i> of measurement?					
Controlled Factors or Constants (at least 3) List at least three things that should remain constant and would be important to keep the same during your experiment so that it will be a fair test of your hypothesis. Some examples could be: keeping temperature the same, using the same person to time with a stop watch, using the same pipette, using the same water bath, etc.					
Control or Explanation of Why It Is A Controlled Experiment What is the control in your experiment—or why do you think your experiment is a controlled experiment?					

Title of The Experiment

A statement of what is being investigated that should include the independent variable, the dependent variable, and the organism being studied. For example: *The Effect of Talking to Paramecium caudatum and Their Subsequent Behavioral Changes.*

Hypothesis

A prediction about the relationship between the variables that can be tested. Your hypothesis should be expressed in the form of an "If . . . then . . ." statement. For example: "If *P. caudatum* are exposed to incessant talking, then they will alter their normal behavioral patterns."

Independent Variable

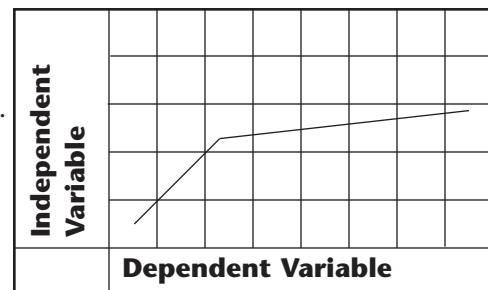
The variable that is purposefully changed by the experimenter and the units in which this variable is being measured. For example: Incessant talking over minutes of time. Independent variable is placed on the X axis of a graph.

Levels of Independent Variable

List the levels at which the independent variable is being tested in the appropriate number of rectangles of the matrix. For example: "1-minute duration, 2-minute duration, 3-minute duration," etc.

Number of Repeated Trials

The number of experimental repetitions, objects, or organisms tested at each level of the independent variable. List the number of trials being performed at each level in the rectangles of the matrix. For example: "three trials at 1-minute duration, 3 trials at 2-minutes duration, 3 trials at 3-minutes duration," etc.



Dependent Variable

The variable that is measured as the result of the experiment, and the units in which this variable is being measured. For example: "Number of paramecium somersaults done as a result of minutes of incessant talking." This variable is placed on the Y axis of a graph.

Controlled Factors or Constants (at least 3)

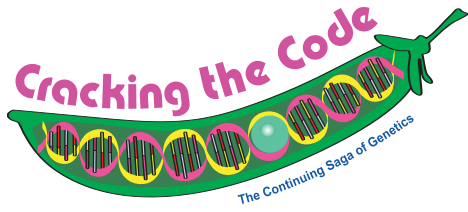
All factors that are kept the same and have fixed values. For example: "light, water, temperature, paramecia culture, person talking, microscope used," etc.

Control (or explanation of why it is a controlled experiment)

The group that is used as a standard for comparison in the experiment; usually the group that receives no treatment. For example: "the control is the culture of *P. caudatum* that was not exposed to incessant talking." Or: "only the incessant talking time was changed. All other factors were kept the same." Also, some controls may be positive controls where you know what the results will show. Other controls may be negative controls where you know that whatever you do, there will be no change.

WORKSHEET

Student Name: _____



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SEPARATING FACT FROM FEAR

Losey, Razor, Carter 1999 Study
on the Effects of Bt corn on Monarch Butterflies

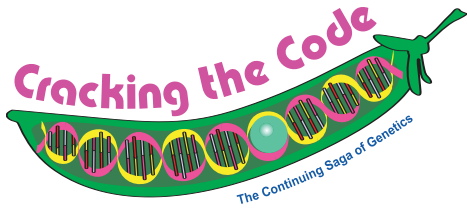
Logical observations before study:

Experimental design used:

Results obtained:

WORKSHEET

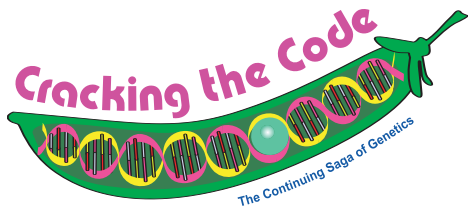
Student Name: _____



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EXPERIMENTAL DESIGN MATRIX

Title of the Experiment					
Hypothesis					
Independent Variable					
Levels of Independent Variable					
Number of Repeated Trials					
Dependent Variable					
Controlled Factors or Constants (at least 3)					
Control or Explanation of Why It Is A Controlled Experiment					



Seeds of a New Era



Hi, there—and welcome to Tastee-Genes! I'm Suzie, your server!

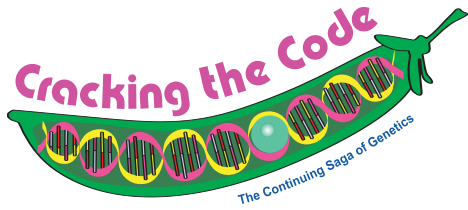
"What would you like to order? Our specials for today are the Insecticide-Free Corn Dog, created from Bt corn and Bt corn-fed pork, which was grown without the need for so many incredibly toxic pesticides. And then there's the Frost-Free Strawberry Shake, with strawberries that have been genetically engineered so that they withstand colder temperatures without suffering frost damage! And my personal favorite, the Chickie-Rice Burger! Made from rice, tastes like chicken, and it's a complete vegetable protein."

Do you think this is all pretty silly? Well, guess what . . . the examples listed above either already exist or are under development in labs.

GROUP DISCUSSION

When you get back to your imaginary table with your group's genetically modified dinner, sit down and discuss the following issues:

- What if a genetically modified (GM) crop could help eliminate starvation in an impoverished area? What if GM crops could prevent the spread of virulent disease? What if GM tomatoes could be made more square-shaped so that they could be packed and shipped more economically? What purposes justify the science of genetic modifications?
- Should all GM foods be clearly labeled? What if the cost and impact of labeling impedes the development or use of GM foods?
- In many parts of the world, there are religious and/or cultural ramifications surrounding food. In the Jewish faith, for example, if a string bean were genetically modified to include a gene from a pig, would that string bean no longer be kosher? Or if a gene from a cow or chicken were introduced into a tomato or lettuce, would that make your formerly plain salad a meat product and off limits to a vegetarian or vegan?
- If GM produce and meat products were clearly labeled, should products that are processed from produce or meats also be labeled? Do the processed foods now need to be labeled as well? What if only 1% of the processed food contained GM food material?
- If GM produce is farmed without the use of insecticides or herbicides and the food is grown according to organic standards—should it be considered an organic food or not?
- Corporations that invent GM crops can gain a patent on the new genes. Yet it is possible that the GM crop's pollen could migrate to a neighboring farm. If the neighboring farmer collects and plants his own seeds, and they contain the new genetic material, should that farmer have to pay the corporation on their patent?



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TASTEE-GENES ACTIVITY SHEET FOR THE TEACHER

Several points made in this activity may require further elaboration from the instructor.

Kosher

In the Jewish faith, there are specific rules that define how life is to be lived according to Jewish law and tradition. These laws extend to the way food is gathered, slaughtered, stored, prepared and eaten. For example, a kosher animal must both be a ruminant (any of a group of hooved mammals that chew their cud; i.e., that regurgitate and chew again food that has already been swallowed) and have split hooves—cows, sheep, goats, and deer. Birds of prey, such as eagles, hawks, etc., are not kosher; while most common fowl, such as chickens, ducks, and geese, are. Any food product of a non-kosher animal is also non kosher. For more information, please see the annotated Web site below.

Jewish Food: www.jewishpeople.net/KOSHERGOURMET.html

Vegan

Most commonly pronounced VEE-gun, a vegan is someone who does not eat animal products, including meat, fish, seafood, eggs, and dairy. Veganism is more of a philosophical standpoint than a food plan. Vegans demonstrate respect for all life—their own, the planet's, and the animals'—not only by eating plant-based foods but also by choosing non-food items (such as shoes, belts, or purses) that are produced without animal by-products (i.e.: non-leather). Many vegans also choose cosmetics that do not contain animal by-products and are not tested on animals.

The Vegan FAQ: www.vegan.com/faq.php

Processed Food

A processed food is one that is not in its original form picked from the tree or plant, or immediately slaughtered to be eaten. Some examples of processing include: cooking, baking, curing, heating, drying, mixing, grinding, churning, separating, extracting, cutting, fermenting, distilling, eviscerating, preserving, dehydrating, freezing, chilling, or otherwise manufacturing. Processing also includes the packaging, canning, or otherwise enclosing of food in a container.

Organic

This term is generally used to indicate produce that is raised in an environment that does not use chemical pesticides. It may also refer to a style or production that includes the humane treatment of livestock raised without chemical growth agents or antibiotics. However, the legal use of the term may mean different things depending on where you live. In the United States, the U.S. Department of Agriculture has specific guidelines that must be met to earn the label “organic,” though many small farmers follow organic practices but cannot provide the documentation to earn the official label. Currently, GM foods may not be labeled “organic” in the United States.

USDA's National Organic Program: www.ams.usda.gov/nop/NOP/NOPHome.html