B

Biology Standard
B.5.c.

Student Workbook

California Education and the Environment Initiative

High-Tech Harvest: Genetic Engineering and the Environment

California Education and the Environment Initiative
Approved by the California State Board of Education, 2010

The Education and the Environment Curriculum is a cooperative endeavor of the following entities:
California Environmental Protection Agency
California Natural Resources Agency
Office of the Secretary of Education
California State Board of Education
California Department of Education
California Integrated Waste Management Board

Key Leadership for the Education and Environment Initiative:
Linda Adams, Secretary, California Environmental Protection Agency
Patty Zwarts, Deputy Secretary for Policy and Legislation, California Environmental Protection Agency
Andrea Lewis, Assistant Secretary for Education and Quality Programs, California Environmental Protection Agency
Mark Leary, Executive Director, California Integrated Waste Management Board
Mindy Fox, Director, Office of Education and the Environment, California Integrated Waste Management Board

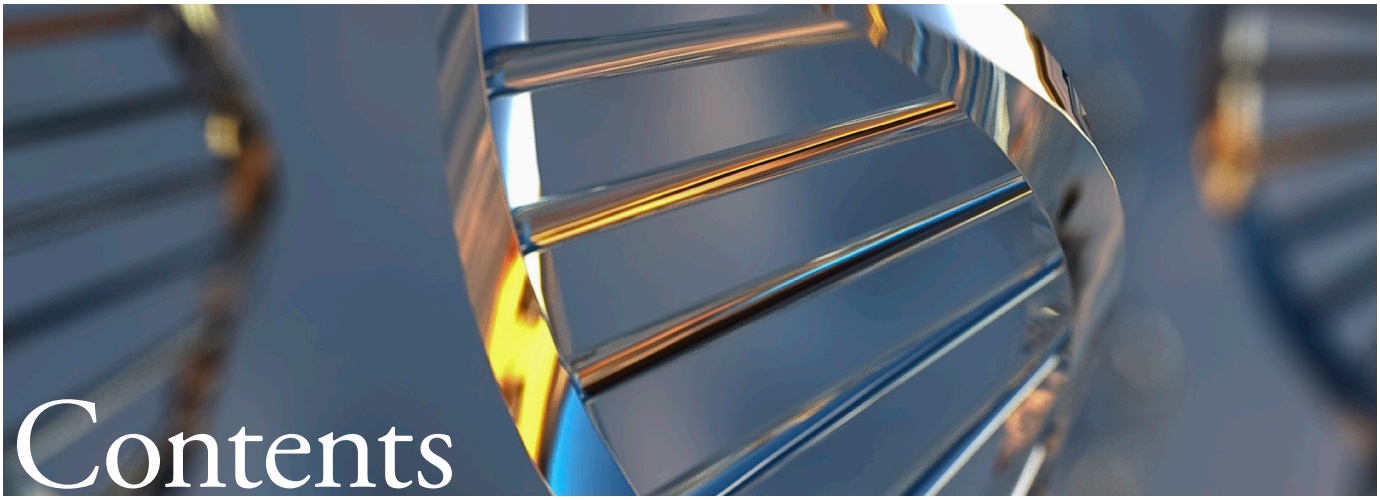
Key Partners:
Special thanks to **Heal the Bay,** sponsor of the EEI law, for their partnership and participation in reviewing portions of the EEI curriculum.

Valuable assistance with maps, photos, videos and design was provided by the **National Geographic Society** under a contract with the State of California.

Office of Education and the Environment
1001 I Street • Sacramento, California 95812 • (916) 341-6769
http://www.calepa.ca.gov/Education/EEI/

© Copyright 2010 by the State of California
All rights reserved.
This publication, or parts thereof, may not be used or reproduced without permission from the Office of Education and the Environment.

These materials may be reproduced by teachers for educational purposes.



Contents

Lesson 1 Super Rice in California

Key Unit Vocabulary 2

California Rice Pharming 3

Lesson 2 Taking Genes, Making Products

Taking Genes, Making Products 4

Lesson 3 Down on the Pharm

Influences of Genetically Engineered Products 5

Lesson 4 Going Beyond the Field

Going Beyond the Field 6

Lesson 5 Return to Super Rice

Genetically Engineered Rice in California 9

Lesson 6 Making Decisions about Genetic Engineering

Making Decisions about Genetic Engineering Chart 11

Pulling It All Together: Spectrum of Factors 12

Biofuel: An energy source derived from biomass, such as plants, or from metabolic byproducts, such as animal manure.

Biological diversity (biodiversity): A measure of the number of different species of organisms in a specific area, it is also used as a general description of species richness, ecosystem complexity, and genetic variation.

Biomedical: Referring to biological, medical, and physical sciences and related activities.

Bt gene: A gene inside bacterium, responsible for producing a toxin that kills common corn pests.

Components: The parts of something, such as a system.

Composition: The makeup of a system including the mixture of components and relative numbers of those components.

Cross-pollination: The transfer of pollen from the flower of one plant to flowers of a different plant.

Genetic contamination: The unintended transfer of genes from one population to another, in the case of genetic engineering (GE), from GE organisms to non-GE organisms.

Genetic engineering: The manipulation of genes within a species or the transfer of genes from one species to another using recombinant DNA technology.

Genetic resource: Naturally occurring genetic materials that can be used to modify the genetic makeup of an organism.

Ligase: An enzyme that can be used to join DNA segments together.

Marker gene: A gene that is inserted in a host organism for the purpose of determining if other genetic material has been successfully incorporated into host cells.

Microdiesel: A type of fuel produced by bacteria.

Monoculture: The cultivation of the same crop in the same field each year without any crop rotation.

Natural system: The interacting components, processes, and cycles within an environment, as well as the interactions among organisms and their environment.

Pharm crop: An agricultural crop that is genetically engineered to produce a pharmaceutical product, such as a vaccine or drug.

Pharmaceutical: A medicinal drug.

Plasmid: A circular or linear strand of bacterial DNA often used by genetic engineers as a carrier of DNA.

Recombinant DNA technology (rDNA): The manipulation of DNA segments in the laboratory to form “new” (transgenic) organisms.

Restriction enzyme: An enzyme that is used to cut DNA.

Selective breeding: The process of breeding specific individual animals or plants to augment one or more desired traits.

Stakeholders: Individuals, groups, or organizations that have an interest in, or concern about, a particular action or decision.

System: A group of interacting components, processes, and cycles that form a complex whole, such as natural systems, political systems, and economic systems.

Transformation: The genetic alteration of a cell resulting from the introduction, uptake, and expression of foreign DNA.

Transgenic organism: An animal, plant, or bacterium that contains DNA from another species, based on rDNA technology.

Vaccine: A medical preparation given to produce or increase immunity to a particular disease.

Viable: Capable of living, developing, or germinating under favorable conditions.

Name: _____

Instructions: Write a brief response to each of the questions below. (10 points each)

1. How is the genetically engineered rice described in ***California Connections: Rice Pharming in California*, Part 1: Russ Greenwald and Ventria Bioscience** different from and similar to other rice?

   Different:

   Similar:

2. Why do scientists/farmers want to alter the genetic makeup of rice?

3. What advantages does this rice have over traditional rice? What disadvantages might it have?

   Advantages:

   Disadvantages:

Name: _____

Instructions: Answer the following questions in the spaces provided. (5 points each)

1. Where did the genetic resources necessary to make the modified corn come from and why did scientists want to add these genes to the corn?

2. What naturally occurring substances were used to change the DNA of the corn in order to make it resistant to the corn borer pest?

3. Imagine you are a genetic engineer. Think of a novel genetically engineered product (either agricultural or pharmaceutical) you would like to create. Describe your product, including the source of the gene you would splice in (what specific gene you would use and from what type of organism), what species you would splice it into, and what you would hope to accomplish with your modification.

Name: _____

Instructions: Read the articles on **Bt Corn** and **Malaria-Resistant Mosquitoes.** Then complete the appropriate rows on the chart below by describing how each genetically engineered product might influence: natural systems, biological diversity, and human health. (2 points per cell)

Genetically Engineered Product	Natural Systems	Biological Diversity	Human Health
Bt corn			
Malaria-resistant mosquitoes			

Name: _____

Instructions: As you listen to the group reports, complete the following table with information about how each of the genetically engineered products discussed today might influence: natural systems, biological diversity, and human health. (1 point per cell)

Genetically Engineered Product	Natural Systems	Biological Diversity	Human Health
Biofuels			
Toxic-avenger trees			

Name: _____

Genetically Engineered Product	Natural Systems	Biological Diversity	Human Health
Vaccines in food			
Anthrax vaccine from tobacco			

Name: _____

Genetically Engineered Product	Natural Systems	Biological Diversity	Human Health
Animals			
Golden rice			

Name: _____

Instructions: After reading ***California Connections: Rice Pharming in California, Part 2: From the "Flavr Savr" to the 2007 Rice Crop*** (Student Edition, pages 21–22), complete the following tasks in the spaces provided.

1. Describe the current status of genetically engineered rice in California. (3 points)

2. Why did Ventria Bioscience move its pharming operations to Kansas? (3 points)

3. In general, how can genetically engineered rice affect natural systems? (3 points)

Name: _____

4. Explain the beneficial and detrimental effects that genetically engineered rice had, or could have on natural systems and human health.

Beneficial (2 points):

Detrimental (2 points):

Making Decisions about Genetic Engineering Chart

Lesson 6

Name: _____

Instructions: As a group, review the case study you examined in Lesson 4 and the notes you took during that lesson. Using the table below, discuss with your group members the spectrum of factors that should be considered when deciding whether to introduce your genetically engineered product into natural systems. For each factor, identify the people or groups that may be most interested in this issue. In other words, identify who cares.

Our genetically engineered product _____.

Factor to be considered	Stakeholders

Name: _____

Instructions: As you hear from each of the groups in class, fill in the table below describing relevant factors that may influence decisions about each GE product.

Genetically Engineered Product: Biofuels	
Decision-making factors	**Stakeholders**

Genetically Engineered Product: Toxic Avenger Trees	
Decision-making factors	**Stakeholders**

Genetically Engineered Product: Vaccines in Food	
Decision-making factors	**Stakeholders**

Name: _____

Genetically Engineered Product: Anthrax Vaccine from Tobacco	
Decision-making factors	**Stakeholders**

Genetically Engineered Product: Animals	
Decision-making factors	**Stakeholders**

Genetically Engineered Product: Golden Rice	
Decision-making factors	**Stakeholders**

California Education and the Environment Initiative

Printed on post-consumer recycled paper