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# Acknowledgements

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The California Foundation for Agriculture in the Classroom is dedicated to fostering a greater public knowledge of the agricultural industry. The Foundation works with K-12 teachers, community leaders, media representatives, and government executives to enhance education using agricultural examples. It offers school children the knowledge to make informed choices.

This unit was funded in 1995 by Calgene, Incorporated and the California Farm Bureau Federation. To meet the needs of California educators, From Genes to Jeans was revised to support the Curriculum Content Standards for California Public Schools. Funding from the California Farm Bureau Federation and private donations was used to make this revision possible.

The California Farm Bureau Federation actively represents, protects, and advances the social, economic and educational interests of the farmers in California.

Calgene is an agricultural biotechnology company developing improved varieties of plants and plant products for the fresh tomato, cotton seed and industrial and edible plant oils markets.

The Foundation would like to thank the people who helped create, write, revise, and edit this unit. Their comments and recommendations contributed significantly to the development of this unit. However, their participation does not necessarily imply endorsement of all statements in the document.

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Introduction

The *Science Framework for California Public Schools* emphasizes the need to make science education more meaningful to students so they can apply what they learn in the classroom to their daily lives. Since all students eat food and wear clothing, one natural connection between science and the real world is agriculture. Advances in agricultural technology, especially in biotechnology, are continually making headlines and are an excellent way for educators to connect current trends and issues in science to the lives of every student.

Agriculture is an important industry in the United States, especially in California. As more rural areas become urbanized and more challenges exist to maintain and improve the quality of the planet and feed the people of the world, it is extremely important to educate students about their environment, agriculture and the current technologies and research that continue to make the earth a viable planet.

*From Genes to Jeans*, a seventh through ninth grade unit, introduces the students to the world of agriculture and the genetic research and technologies associated with agriculture. This self-contained unit teaches students the basic concepts of genetics and provides activities that relate the concepts to current trends of genetics including genetic engineering. Students are provided with the scientific principles and tools associated with genetics and are encouraged to use their knowledge to think critically, creatively and freely about the viability and ethics associated with biotechnology, genetically modified organisms and agriculture. Students work independently and collaboratively with classmates and family members and ultimately design a genetically altered product.

This unit can be used to teach or reinforce specific subject matter Content Standards for California Public Schools. Those standards which are taught are mentioned by number in each lesson. A content standard matrix for the entire unit is located on pages 78-90.
Unit Overview

Unit Length

20-22 class periods, approximately 4-5 weeks.

Objectives

The students will:

• Compare observable genetic traits to the traits of classmates and family members, and interpret the differences in the two sets of data.

• Use Punnett squares as tools to predict potential offspring genotypes and phenotypes of parental crosses.

• Examine the relationships between mutations and/or environmental changes and the viability of a species.

• Construct a three-gene DNA model and genetically modify a hypothetical trait change.

• Design and defend a hypothetical genetically improved agricultural product to secure findings to market the new product.

• Conceptualize the complexity of the genetic makeup of living organisms and appreciate the benefits and challenges associated with the modifications of an organism’s genome.

Brief Description

This self-contained science unit allows students to move from the past, through the present, and toward the future with biotechnology. The students start with the basics of heredity by examining personal and family traits; they then use Punnett squares to predict possible phenotypic outcomes for a variety of plant breedings. The terms of dominance, co-dominance, and recessiveness are discussed. In the third lesson, students act as birds to demonstrate “survival of the fittest” in a changing environment. This activity illustrates that changes in a species may occur over time in “natural” circumstances. The fourth lesson has the students build a model of a portion of a DNA molecule and then genetically alter it to produce a trait change. Finally, working in teams, the students act as genetic engineers. They design and market a genetically improved product. In doing so, they address the viability and ethics of genetic engineering. Agricultural examples are used throughout the unit.

Curriculum Content Standards for California Public Schools

A concerted effort to improve student achievement in all academic areas has impacted education throughout California. The California Foundation for Agriculture in the Classroom provides educators with numerous resource materials and lessons that can be used to teach and reinforce the Curriculum Content Standards for California Public Schools. The goal of educators is to encourage students to think for themselves, ask questions, and learn problem-solving skills while learning the specific content needed to better understand the world in which they live.

This unit, From Genes to Jeans, includes lessons that teach or reinforce many of the educational content standards covered in grades seven through nine. It can be used as a self-contained unit, to enhance the lessons already in use, or provide technical information in the areas of genetics and agriculture.

The specific subject matter content standards covered in the lessons are listed on the sidebars of each lesson. A matrix chart showing how the entire unit is aligned with the Curriculum Content Standards for California Public Schools can be found on pages 78-90. This unit works well to teach genetics and evolution concepts in the seventh grade; investigation and experimentation concepts in grades seven and nine; and mathematical reasoning, technical reading, and oral reading and writing skills in grades seven through nine.
Unit Overview

Key Vocabulary

Appropriate vocabulary is discussed in each lesson. A glossary is located on pages 91-95.

- amino acid
- antibiotic
- antigen
- bacterium
- base
- base pair
- biotechnology
- chromosome
- clone
- co-dominance
- codon
- crossing over
- Darwin, Charles
- DNA
- dominant
- enzyme
- evolution
- expression
- gene
- gene expression
- genetic code
- genetic engineering
- genetics
- genome
- genotype
- heredity
- heterozygous
- homozygous
- hybridization
- ligase
- meiosis
- Mendel, Gregor
- mutant
- mutation
- natural selection
- nucleic acids
- nucleotides
- nucleus
- phenotype

Sequence of Events

- Review the enclosed background information, lessons, and student worksheets. Make appropriate changes to the unit to meet the needs of your students, facilities, time frame, and teaching style.

- Gather appropriate supplies and resource materials.

- Complete the activities in the following order:
  1. Just Like Me
  2. Let’s Get Square
  3. Bird Land
  4. Design Yer Genes
  5. Snappy Products, Inc.

Evaluation

This unit incorporates numerous activities and questions that can be used as evaluation tools, many of which can be included in student portfolios. The concluding activity, *Snappy Products, Inc.*, requires the students to apply what they have learned to a hypothetical, yet realistic, situation. Other evaluation factors may include active participation in class discussions and general knowledge acquired about the subject matter.

Visual Display Ideas

- Create a collage or free-standing display of products changed through biotechnology. Examples may include tomatoes, cotton, canola oil, papayas, soybeans, corn, and rice.

- Make a display of chromosomes, DNA molecules, genes, and proteins.

- Show the process of protein synthesis using a sequential flow chart.

- Create a display illustrating the sequence of events that occurs to produce a genetically modified plant product.

- Use pictures, graphs or charts to show the specific number of chromosomes in particular plants and animals.
Key Vocabulary (continued)

plasmid
polymerase
protein
recessive
recombination
RNA
selective breeding
tissue culture
trait
transcription
transformation
transgenic organism
translation
vector
virus
While the study of genetics and biotechnology is complicated, there are many simple components that can be incorporated into the classroom. The following information can help you better understand the subject matter and relay this information to your students.

**What is biotechnology?**

Biotechnology includes a number of technologies, which use living organisms (such as microbes, plants, fungi, or animals), to produce useful products, processes, and services. Production can be carried out by microorganisms such as yeast or bacteria or by chemicals produced from organisms, such as enzymes. The use of yeast in bread making is a form of biotechnology. The use of bacteria and molds in cheese making is another example of simple biotechnology. In the 1970s, a new type of biotechnology was developed: genetic engineering also known as recombinant DNA technology or transgenics.

**What is genetic engineering?**

Genetic engineering is a process in which genetic material (DNA) is taken from one organism and inserted into the cells of another organism, often of a different species. Genetic engineering can also be a rearrangement of the location of genes. The new “altered” organism then makes new substances or performs new functions based on its new DNA. For example, the protein insulin, used in the treatment of diabetes, can now be produced in large quantities in a laboratory by genetically modified bacteria and yeast. Insulin was formerly extracted from the pancreas of pigs.

**What can genetic engineering do?**

- It can **improve** the ability of an organism to do something it already does. For example, an adjustment in the amino acid balance in a particular corn variety improves its storage ability. A genetically enhanced rice variety is resistant to Bacterial Blight due to the insertion of an $Xa21$ gene that increases its resistance to the disease-causing microbes.

- It can **suppress** or stop an organism from doing something it already does. For example, the gene that codes for the softening of tomatoes is “turned-off” in a genetically modified tomato variety. This allows the tomato to stay on the vine longer, producing more flavorful fruit that is firm enough to easily transport.

- It can make an organism do something **new** that it has never done before. For example, bacteria and yeast have been genetically
modified to produce chymosin, an enzyme used to make the milk form curds in cheese production. A new genetically enhanced rice, called “Golden Rice,” has been modified to make beta-carotene, the precursor for Vitamin A. This advancement may end Vitamin A deficiency in children worldwide, one of the leading causes of blindness and other health problems.

**What is a gene?**

A gene is a sequence of DNA, which serves as a blueprint for the production of proteins in all living things. Thousands of genes make up chromosomes. DNA is found in the nuclei of cells with the exception of bacteria and viruses. Bacteria have their DNA in nuclear areas called nucleoids; viruses have their DNA coiled up in the cytoplasm of cells. DNA is made of sugars, phosphates, and four nitrogen-containing bases: adenosine, cytosine, guanine, and thymine. A gene codes for a specific protein or has an assigned function.

**What is a protein?**

Proteins are chains of amino acids that perform the necessary functions of living organisms. When a gene is “expressed” that means it is translated into protein. Proteins are essential chemicals for cell structure and activities such as reproduction, movement, and metabolism or defense (antibiotics). Some proteins perform specific functions themselves (such as insulin and muscle protein); others cause the production of cell components (such as enzyme proteins that assist in making carbohydrates and fats); and others are structural such as flagella and cilia.

**What are some examples of genetically modified products?**

- Human growth hormone, which is produced naturally in the pituitary gland, can now be produced through genetic engineering technology. There are now 84 genetically engineered biopharmaceuticals approved for use in the United States or Europe.

- A vaccine for wild animals that protects against the rabies virus.

- Oil-eating bacteria that efficiently clean up oil and gasoline spills.

- A genetically altered canola (rapeseed) plant, which produces healthier edible oils.
Background Information on Biotechnology

- A tomato that delays the onset of softening and rotting.
- Plants, such as cotton, that are resistant to herbicides allowing farmers to kill weeds without harming the crop.
- Varieties of fruits and vegetables that can be altered to resist plant viruses.
- A cheese that can be made using bacterial-fermented rennet (an enzyme formerly taken from calves’ stomachs).
- Plants that produce insecticidal proteins called Bt toxin thereby reducing the need for chemical pesticides.
- Rice that produces beta-carotene, the precursor of Vitamin A, can be used to reduce blindness and other diseases.
- It is estimated that in 1999, 57% of the soybeans, 38% of the cotton and 30% of the corn planted in the United States were modified by some form of biotechnology.

How do we know that genetically modified plant foods are safe?

The United States has the safest food supply in the world. Advanced technology, as well as standards and regulations set by food producers and governmental agencies, have allowed the United States to maintain its safe food record. The following information will help you better understand the genetic engineering food safety guidelines.

Before any plant food developed through biotechnology is made available to the public, it undergoes a safety evaluation. The United States Food and Drug Administration (FDA), in 1992, issued testing guidelines for genetically modified foods. The specific policies are under the title “Foods Derived From New Plant Varieties.” There are different policies for products other than plants. The genetically modified plant food product guidelines are summarized as follows:

- Genetically modified plant foods shall be regulated the same as traditionally produced foods.
- The food products will be judged on their individual safety, allergenicity, toxicity, etc., rather than on the methods used to produce them.
Background Information on Biotechnology

- Any new food additive produced via biotechnology will be evaluated for safety employing the same guidelines used for a traditional food additive (such as food coloring).

- Any food product that is found to contain material that could render it unsafe will not be allowed to enter commerce.

- If the introduced product contains an allergen or if the production of the food has altered its nutritional value, then the FDA may require informational labels.

In addition to the FDA, the United States Department of Agriculture (USDA) and the Environmental Protection Agency (EPA), are also committed to ensuring the safety of bio-engineered foods.

As is the case for any food product, genetically modified food found to contain substances not in keeping with the safety guidelines may be removed from the marketplace by the FDA. The United Nation’s World Health Organization continues to debate the policies revolving around genetically altered food products.

**How do we know if genetically modified plants are safe for the environment?**

In order to be sure that genetically modified crop plants are safe, the USDA oversees all field-testing of genetically modified products. Before a new crop can move into commercial production, the USDA reviews the field-testing results. Field-testing results and studies must demonstrate that plants altered using biotechnology react with ecosystems in the same ways as their traditionally produced plant counterparts. Detailed research in this area continues.

**What are some risks associated with genetically modified plants?**

As with any new technology, risks must be considered. Some criticisms of genetic engineering practices include the possibility that modifications in the genetic make-up of the plant could result in some type of unknown toxin. The odds of that occurring in normal plant breeding and selection are far greater than that occurring in genetic engineering. Genetic engineering involves only the movement of specific genes with specific functions. In traditional plant breeding, crosses between different varieties and wild relatives result in the transfer of many genes.
Background Information on Biotechnology

The potential of gene flow to closely-related plant species is a risk when the gene expressed is in the pollen. That could mean that herbicide resistance genes inserted into beneficial plants could be passed to closely related weed species. New methods are being developed to prevent this from occurring and detailed research continues.

The science of biotechnology is carefully monitored and the risks associated with any products and processes, such as allergens and ecological impacts are constantly addressed. Detailed papers and transcriptions from World Health Organization meetings can be viewed on several of the web sites listed on page 76.

How can genetic engineering benefit agriculture?

With increasing food and fiber needs around the world and the loss of farmland to urbanization, farmers must constantly find ways to increase yields. As farmers continue to look for renewable and safe ways to control pests and fertilize plants, geneticists continue their research to assist agriculture.

- Disease resistant plants are being developed through genetic modification. For example, mungbeans, a staple in Asia, can now be grown without the use of pesticides. Strawberry plants have been genetically altered to be resistant to root pests and fungi. The papaya industry in Hawaii was saved by a single gene insertion for viral coat protein. The papaya plants are now resistant to the papaya mosaic virus.

- Herbicide tolerant cotton has been developed through genetic engineering. The herbicide bromoxynil is degraded in the cotton plant. This allows the cotton field to be sprayed with bromoxynil to kill weeds without affecting the cotton plant itself. Roundup® resistant cotton has also been developed. These methods of weed control are very efficient and greatly reduce the total amount of herbicide used on cotton while increasing the yield of cotton per acre.

- Genetic engineering is helping farmers diversify their crops. For example, ethanol produced from plant oils such as canola and soybeans can be used as a fuel, and starches genetically added to potatoes can be used to produce biodegradable plastics. Uses such as these also reduce the nation’s dependence on fossil fuels.
Background Information on Biotechnology

What are the basic procedures for producing a genetically modified plant product?

The actual procedures for producing a genetically engineered product are very complex and vary from product to product. However, most genetically engineered products are produced using the basic steps described below:

1. **Trait Identification**: Traits of organisms are identified.
2. **Gene Discovery**: Genes with a desired function are identified.
3. **Gene Cloning**: The desired gene is placed into a bacterial cell (usually *Agrobacterium*) and, as the bacteria reproduce, the desired gene is also copied and reproduced.
4. **Gene Verification**: Researchers study the copies of the gene using molecular techniques to verify that the replicated gene is precisely what is wanted.
5. **Gene Implantation**: Using a bacterium or gene gun, the desired DNA (gene) is transferred into the chromosomes of plant cells in nature.
6. **Cell Regeneration**: Researchers select the plant cells that contain the new gene and regenerate whole plants from the selected plant cells.
7. **Testing New Plant**: Laboratory and field-testing occur to verify the function and safety of the new plants.
8. **Seed Production**: Seeds with the desired traits are produced using standards set for specific crop production.

Why is genetic engineering becoming such a popular science?

Genetic engineering offers new approaches to the solutions of problems caused by an increasing world population—the increase in demand for food, energy and healthcare. It allows the production of scarce biological substances, new and better pharmaceuticals and more nutritious foods. It can provide new sources of energy through the production of biofuels (fuels produced by plant oils) and improve crop yields. Genetic engineering is another tool available to meet challenges in these areas.
## Purpose

The purpose of this lesson is to introduce the concepts of dominant and recessive genes and the role genes play in inheritance patterns. The lesson includes homework activities that involve family members and integrates science concepts with math and writing.

## Time

3-4 forty-five minute sessions

## Materials

- Calculators *(optional)*
- Colored markers or pencils
- “Just Like Me” homework assignment *(1 per student)*
- “Just Like Me” student activity sheets *(1 per student)*
- Thiourea taste paper or PTC taste paper *(1 or 2 pieces per student)*

## Background Information

Prior to this lesson, your students should have a basic understanding that traits are carried on from one generation to the next, and that offspring obtain half of their genetic make-up from each parent. This activity is one of many that can be done to teach and reinforce the concepts of heredity, genetics, chromosomes, traits, phenotypes, genotypes, dominant genes, and recessive genes. Students may find it helpful to keep a self-made glossary of genetic terms used throughout the unit. Use activities of your own to complement this lesson.

This lesson includes questions that require students to look at traits of family members. Some students may not live with their biological parents; thus, remember to present this lesson in a non-threatening way. Encourage students to include half and step relatives when completing the *Just Like Me* homework assignment. This may show the students that they do have traits in common with non-biological or “half” family members.

The traits chosen for this activity are considered to be single gene traits. Students often ask about traits such as eye color and hair color. It is important to explain that most traits, including hair and eye color are not single gene traits—they are determined by multiple genes. The understanding of single gene and multiple gene traits is important when genetically modifying an organism. It is much easier to genetically alter a trait expressed by a single gene than it is to isolate and transfer a trait determined by several or hundreds of genes.

A farmer’s success depends greatly on the expression of the desired traits. Some agricultural dominant and recessive single gene traits are described:

- Russet and red potato skins are dominant over white potato skin.
- Red tomato skin is dominant over yellow tomato skin.
- Tomato stems either break off completely (non-jointed) or leave a small green stem when picked from the plant (jointed). The jointed variety is dominant over the non-jointed variety. The non-jointed variety has been selectively bred into processing tomatoes so mechanical harvesters only pick the portion of the plant that will be shipped to processing plants.
- In cattle, no horns is dominant over horns.
- Yellow kerneled corn is dominant over white kerneled corn.
Content Standards

Grade 7

Science
- Cell Biology • 1c
- Genetics • 2b, 2c, 2d, 2e
- Evolution • 3, 3a, 3e
- Investigation and Experimentation • 7a, 7c

Reading/Language Arts
- Reading • 1.0
- Writing • 1.7, 2.3b, 2.4a, 2.4b
- Written and Oral Language Conventions • 1.4, 1.6, 1.7

Mathematics
- Number Sense • 1.0, 1.3
- Statistics, Data Analysis and Probability • 1.0
- Mathematical Reasoning 1.0, 1.1, 1.3, 2.2, 2.5, 3.0, 3.3

Grade 8

Science
- Investigation and Experimentation • 9e

Reading/Language Arts
- Reading • 1.0, 1.3
- Writing • 1.6, 2.3d
- Written and Oral Conventions • 1.0, 1.4, 1.5, 1.6

Mathematics
- Algebra I • 24.2

Procedure

Day 1

1. Review the concepts of traits with the students. Use student volunteers to illustrate a specific trait such as hair color or eye color. Have the class guess what trait is being shown. Discuss that expressed traits are called phenotypes and the genes that make them up are called genotypes. Discuss the difference between single gene traits and multiple gene traits. Provide some agricultural examples.

2. Have the students read the “Problem” section of the Just Like Me activity sheet. Discuss any questions the students have about the “Problem” and then explain how to complete Part 2 of the activity sheet. Use the drawings provided to assist students in identifying their specific traits. It might be helpful to use student volunteers to show the various traits you are studying, such as thumb crossing, tongue rolling, and dimples. Have the students complete Part 2 of the lab sheet in class. At an appropriate time, distribute a piece of PTC test paper to each student so the PTC test paper section can be completed. Have water available for those students who have the trait of tasting this bitter paper.

3. Students are asked to predict how closely they match traits with their classmates. Model how to do this by asking one volunteer, “How many students do you think will match you on all of these traits?” Once the volunteer has predicted a number, explain to the class that this number goes into box number ten on the prediction table. Continue modeling as needed. Completion of the predictions chart may be given as homework.

Day 2

1. Refer to the “Investigation” section of the Just Like Me student worksheet. The idea is for each student to compare his/her phenotypes with every other student in the class! There are many ways of doing this. One procedure is described below:

   a. Place students into teams of four.

   b. Have students compare their traits with the traits of their team members and count how many traits they match.

   c. Have the teams move around to other teams to compare traits, gather data, and complete the tally column. If you have thirty-
five students, then each student should have thirty-four tallies.

2. Once students complete their tallies, demonstrate how to convert their results to percentages. Use calculators, if appropriate.

3. Using color markers or pencils, have students display their results on the visual bar graph. In a class of thirty-five, students should see a bell shaped curve with the high points around the sixes and sevens. Assign the completion of the bar graph as homework.

4. Assign the *Just Like Me* homework. A blank box is left for a trait you and your students would like to analyze. Some students may experience difficulty in gathering the information for this activity. Allowing students to use halves or steps or even family friends does not diminish this lesson, and in some ways enhances it. Use your discretion about assigning this homework to your students.

**Day 3**

1. Review the bar graphs your students completed on matching traits. Post some of the bar graphs around the room. Ask students to explain why they think the results came out as they did.

2. Ask students what they discovered while doing the homework assignment. Acknowledge all contributions. Writing entries into personal journals or notebooks may be appropriate.

3. Have the students look at the questions on the activity sheet. Discuss and clarify the intent of each question. Independently, have students complete questions 1-4. These questions can be used as individual assessment tools. Encourage students to use the vocabulary words discussed in this lesson.

4. Have students complete questions 5 and 6 of the *Just Like Me* activity sheet in small groups. Reinforce the idea that all living things have a genetic code that determines all traits.

5. As an assessment of this lesson, have students complete the *Think About This!* activity sheet.

6. Before continuing with this unit, be sure your students have the basic understanding of how traits are carried on from one generation to the next.

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**Content Standards**

*(continued)*

**Grade 9**

**Science**
- Genetics • 3, 3a, 6b
- Evolution • 7a, 7d, 8a
- 8b
- Investigation and Experimentation • 1d, 1g

**Reading/Language Arts**
- Reading • 1.0
- Writing • 1.9
- Written and Oral Language Conventions • 1.0, 1.3, 1.4

**Mathematics**
- Algebra I • 24.2

---

**Note**

Agriculturalists breed plants for certain traits. For example, corn farmers appreciate the trait of fungal resistance so less fungicide needs to be applied to their fields. Desired characteristics may vary from one region to the next. For example, California corn growers may want drought resistant corn while corn farmers in other regions of the United States may want a variety of corn that can tolerate wet soil or soil with high salinity.
1. **Problem**
   How many students in this room have the same phenotype as I do on 10 particular traits?

2. **Information**
   Following your teacher’s direction, determine whether your phenotype is dominant or recessive for each trait. Remember, the dominant traits are those with an upper case letter. Write the appropriate letters in the boxes provided.
Just Like Me

Prediction

Making predictions is an important science skill. With your teacher’s help, make predictions on how many of the ten traits you share with your classmates. For example, if you think there is not even one person who shares all ten traits with you, then your prediction for box ten is zero. If you think there might be two people who share nine out of ten traits with you, then your prediction for box nine is two. Your total number of predicted matches should equal the number of students in your class, minus yourself.

<table>
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<th>Number of Traits You Share with Classmates</th>
<th>10</th>
<th>9</th>
<th>8</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
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<td>Number of Classmates</td>
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Investigation

Follow your teacher’s directions to compare your phenotypes with the phenotypes of each student in the class. Put a tally mark on the tally sheet next to the number of matches you share with each student in your class. Then complete the rest of the chart.

<table>
<thead>
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<th>Number of Matched Traits</th>
<th>Tally</th>
<th>Ratio: ( \frac{\text{Matches}}{\text{Total Students}} )</th>
<th>Percent Who Match Me *</th>
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<tr>
<td>9</td>
<td></td>
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<tr>
<td>10</td>
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<td></td>
</tr>
</tbody>
</table>

* The sum of this column should add up to 100%.
Just Like Me

Questions

1. How many people in your class matched on all 10 traits? _______________________

2. How many people had zero traits shared? ___________________________________

3. Compare your prediction to the actual results. Were they similar or different?
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

4. In this investigation we compared ten traits. Over 100,000 traits contribute to the
make up of each human being. Based on this information and the results of your
investigation, discuss the following:

   a. What is the chance that there is another person in this school, in the United States,
or even in the world who has exactly the same traits as you? Why do you think
this? ______________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

Bar Graph of Matching Traits

Number of Students Who Matched Me

<table>
<thead>
<tr>
<th>Number of Traits Shared</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>3</td>
</tr>
</tbody>
</table>

Name ______________________________

Number of Students Who Matched Me
b. If two or more students shared all ten traits, would they look exactly alike?
   Explain. __________________________________________________________
   __________________________________________________________
   __________________________________________________________

5. As a team, make a two-sided list of human similarities and differences. On one side, list
   as many traits as you can that all humans share (two eyes, two ears, etc.). On the
   opposite side, list traits where differences occur (height, eye color, etc.). Are human
   beings more similar or dissimilar? Explain your response. ______________________
   __________________________________________________________
   __________________________________________________________
   __________________________________________________________

6. Genes are bits of DNA that control the traits of all living organisms—animals, plants,
   bacteria, viruses, etc.
   a. Just as in #5 above, make a two-sided list of the similarities and differences that can
      be found in corn. (For example, all corn kernels have a seed coat but the
      thickness of the seed coat varies. Popping corn has thick seed coats to retain
      moisture. Sweet corn, you eat off a cob, has a thin seed coat so it is tender.)

   b. Think of at least three genetic traits a farmer may want his/her corn crop to have.
      List these below. ______________________________________________________
      ______________________________________________________
      ______________________________________________________
      ______________________________________________________

   c. Think of at least three genetic traits a corn farmer may want to avoid. List these below.
      ______________________________________________________
      ______________________________________________________
      ______________________________________________________
      ______________________________________________________
**Think About This!**

Suppose a virus infected a tomato field in Yolo County and most of the tomato plants died. The few that survived had a trait that allowed them to fight off the virus. Suppose the seeds from the surviving ripened tomatoes were planted the following year. Assume that the rainfall, temperature levels, and other climatic factors remained the same.

a. If the same virus infested the new tomato plants the following year, what do you think would happen? ________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

b. What do you think would happen if a different virus infested the field? ____________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

b. What do you think would happen if all the tomatoes had exactly the same traits and a killer virus infected the field?
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

b. How does having many different traits within a population help that population survive? _____________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

Name ______________________________
Just Like Me
(Homework)

Compare your phenotypes to those of your family members. You may include your mother and father, sisters, brothers, aunts, uncles, grandmothers, grandfathers and “step” or “half” relatives.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Your Relative 1</th>
<th>Your Relative 2</th>
<th>Your Relative 3</th>
<th>Your Relative 4</th>
<th>Your Relative 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Widow’s Peak (i)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Widow’s Peak (I)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Dimples (D)</td>
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<tr>
<td>No Dimples (d)</td>
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<tr>
<td>Freckles (F)</td>
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<td></td>
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<tr>
<td>No Freckles (f)</td>
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<td></td>
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<tr>
<td>Hand Cross ‘R’ Top (R)</td>
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<tr>
<td>Hand Cross ‘L’ Top (r)</td>
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<td></td>
<td></td>
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<tr>
<td>Free Ear Lobe (E)</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Attached Ear Lobe (e)</td>
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<tr>
<td>Bent Fingers (B)</td>
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<tr>
<td>Parallel Fingers (b)</td>
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<tr>
<td>Tongue Roller (T)</td>
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<td></td>
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<tr>
<td>Non Tongue Roller (t)</td>
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</tr>
</tbody>
</table>

Relative’s Name

(Your Name)

In two or more well written paragraphs, on a separate sheet of paper, explain what you learned when you compared your phenotypes to your classmates’ phenotypes and then to your family’s phenotypes. After writing your summary, check it for accurate use of spelling, punctuation, clarity, and vocabulary. Rewrite your revised summary on the back of this page.
Let's Get Square

Purpose

This activity reviews the concept that some traits are dominant and others are recessive, and introduces Mendelian genetics. Students predict possible phenotypic and genotypic outcomes for a variety of common plant crosses. In the process, they learn that “mixing” parent genes produces a variety of possible outcomes in the offspring.

Time

2-3 forty-five minute sessions

Materials

- Brown and white construction paper
  (1 sheet of each color per group of two students)
- “Let’s Get Square” student activity sheets (1 per student)
- Paper bags (2 per group of two students)
- Scissors
- “The Blue Genes Challenge” activity sheets (1 per student)

Background Information

Students will need to review some common terms including genotype, phenotype, dominant traits, recessive traits, genes, and chromosomes. Students will learn about Gregor Mendel, incomplete dominance (or co-dominance), genotype, phenotype, homozygous genes, heterozygous genes, and Punnett squares. Spend as much or as little time as you deem necessary on the life and work of Gregor Mendel and other pioneers in genetic research. The history of Gregor Mendel and his work on peas and snapdragon flowers can be found in most middle and high school science textbooks. Several short biographies on people associated with genetics and biotechnology are included in the fourth through sixth grade genetics unit Where’d You Get Those Genes? available from the California Foundation for Agriculture in the Classroom.

Punnett squares are one tool scientists use to predict the outcome of potential crossings of two parents. This lesson provides the students with the basis for understanding how traits are passed on and expressed from one generation to the next. It is important for you and your students to realize that genetics is very complex and that the Punnett squares used in this activity are simplified so the basic concepts of genetic crossings are understood. Your students will continue to learn the complexity of genetics in the upcoming lessons as well as in high school and college courses.

Cotton is used as an example in this lesson. The following information about cotton may be useful when discussing the agriculture of cotton with your students.

- Cotton is grown in many states throughout the United States including Alabama, Arizona, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, Missouri, New Mexico, North Carolina, Oklahoma, South Dakota, Tennessee, Texas, and Virginia.

Cotton boll

leaf

stem

roots
Let’s Get Square

Content Standards

Grade 7

Science
- Genetics • 2, 2b, 2c, 2d
- Evolution • 3a
- Investigation and Experimentation • 7c, 7d

Reading/Language Arts
- Reading • 1.0, 1.2, 1.3
- Writing • 1.0, 1.2, 1.4, 2.3b, 2.4b
- Written and Oral Language Conventions • 1.0, 1.4, 1.6

Mathematics
- Number Sense • 1.0, 1.3
- Statistics, Data Analysis and Probability • 1.0
- Mathematical Reasoning • 1.0, 1.1, 1.2, 2.0, 2.1, 2.2, 2.5, 2.7, 3.0, 3.1, 3.2, 3.3

Grade 8

Science
- Investigation and Experimentation • 9a, 9b, 9e

Reading/Language Arts
- Reading • 1.0, 1.3
- Writing • 1.3, 2.3d, 2.4b
- Written and Oral Language Conventions • 1.0, 1.4, 1.5, 1.6

Procedure

1. Ask your students to predict the possible colors of offspring if a black cow were crossed with a white bull. Write all possibilities on the chalkboard. Discuss whether it would be possible for all of the calves to be white, grey, striped, spotted, etc. What kinds of information should they know to better predict the color of the offspring?

2. Review the work of Gregor Mendel, including his work with sugar peas and snapdragons. Explain how Punnett squares are tools used to predict the possible genotypes and phenotypes of offspring. Review the facts on dominant and recessive traits. The absence of a gene for a specific trait is represented by a (–). Discuss this and the importance of using upper case letters for dominant traits and lower
Content Standards (continued)

Grade 9

Science
Genetics • 2, 2e, 2g, 3, 3a, 3b, 3c, 4e
Evolution • 7b
Investigation and Experimentation • 1c, 1d, 1g

Reading/Language Arts
Reading • 1.0, 1.3
Writing • 1.0, 1.4, 1.9, 2.3a, 2.3b, 2.3d, 2.3f, 2.6a, 2.6b
Written and Oral Language Conventions • 1.0, 1.1, 1.2, 1.3, 1.4

History-Social Science
Chronological and Spatial Thinking • 1

Student Activity Sheet Answer Key

Part 1
1. 0/4, 0%
2. 0/4, 0%
3. 4/4 or all, 100%
4. no
5. 0, 0%

Part 2
1. 25
2. By looking at the Punnett square, one can see that approximately ¼ of the offspring would lack color genes (– –) and therefore would be white.
3. 1/2 white and 1/2 blue
4. Answers will vary.

case letters for recessive traits in upcoming activities. Discuss the meanings of some prefixes and suffixes used in genetics including “geno,” “pheno,” “type,” and “zygous.”

3. Prior to having the students complete the Let’s Get Square activity sheet, have students work with you on some basic Mendelian Punnett square examples. For example, tall peas (TT) can be crossed with short peas (tt); yellow corn (YY) can be crossed with white corn (yy), etc.

4. After students understand the mechanics of Punnett squares, have them complete the Let’s Get Square student investigation individually, in small groups, or as a class. You may wish to elaborate on the cotton scenario by bringing in examples of cotton, discussing the life cycle of cotton, or explaining how cotton is grown, harvested, and woven into fabric.

5. Discuss The Blue Genes Challenge activity with your students. Have them work in teams of two for the investigation and then individually complete the “What Do You Think?” learning assessment activity on red and white potatoes.

Variation

Instead of using brown and white pieces of construction paper, have students use poker chips or two different colors of centicubes.

Extensions

• Have students create Punnett squares for imaginary plants or animals, and show the possible variations of their creatures using illustrations or pictures from magazines.

• In most cases, herbicide resistant cotton (HH) is dominant over non-herbicide resistant cotton (hh). Develop some Punnett squares to do with your students.

• Have students research the work of Sally Fox and her production of naturally colored green and brown cotton.

• Have students report on the lives of Gregor Mendel and other geneticists.
Let’s Get Square

(Using Punnett Squares to Predict Future Offspring)

Part 1

You are a farmer who raises cotton. You’re also a student of scientific history and know about Gregor Mendel’s experiments with dominant and recessive traits. You’ve decided to cross two of your cotton plants, a pure homozygous dominant blue plant (BB) and a pure recessive white plant (– –), hoping to grow a light blue “acid wash” style fiber for denim jeans. If you are successful, you will produce a cotton fiber that will reduce the need for acid in the production of the jean fabric. Use the Punnett square below to show the types of offspring you would expect. Note: The white plant is designated (– –) because it lacks a gene for any color. A (bb) would represent a gene for the color white.

<table>
<thead>
<tr>
<th></th>
<th>Blue (B)</th>
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</thead>
<tbody>
<tr>
<td>Blue (B)</td>
<td></td>
<td>Blue (B)</td>
</tr>
<tr>
<td>White (–)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White (–)</td>
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</tbody>
</table>

1. What fraction of the offspring produces homozygous white cotton? _____ What percent? _____%

2. What fraction of the offspring would produce homozygous blue cotton? _____ What percent? _____%

3. What fraction of the offspring are heterozygous (B–)? _____ What percent? _____%

4. You find that regular blue cotton is produced by (BB) and (B–) genotypes. Co-dominance does not occur with these genes. Was your production of light blue fiber successful? _____

5. If the parents produced 100 offspring, predict how many would grow as white cotton. _____ What percent is this? _____%
Part 2

Your attempt to breed light blue cotton plants proved unsuccessful. However, you decide to try something else. You review Gregor Mendel’s work on peas and decide to cross two blue hybrid (B–) offspring cotton plants. Set up and complete an appropriate Punnett square in the space below.

1. If these parents produced 100 offspring, predict how many offspring would have white cotton. __________________________________________________________

2. Explain how two blue cotton plants could produce white cotton offspring.
   ___________________________________________________________________
   ___________________________________________________________________
   ___________________________________________________________________

3. What would the offspring look like from a cross between a heterozygous (B–) blue cotton plant and a homozygous (––) white cotton plant? Show the possible outcomes on the Punnett square below.

   Possible Cotton Colors:
   ________________
   ________________
   ________________

4. In actuality, scientists are still trying to genetically insert a blue colored gene from bacteria into cotton chromosomes so blue and white colored fiber cotton plants can be cross-pollinated. They are “dying” to find out if a pure blue cotton plant (BB) would be “bluer” than a hybrid blue cotton plant (B–). What do you think will happen?
   ___________________________________________________________________
Blue Genes Incorporated has just called you with a contract offer—big money for you if you can produce reasonably priced cotton plants that grow khaki colored (tan) cotton. You have just learned of a variety of cotton that is “off-white” in color and is controlled by a dominant (W) gene. You know that the (B) brown gene and the (W) off-white genes are equally strong, or co-dominant. A (BW) plant produces khaki colored cotton, so you begin your efforts to produce khaki colored cotton plants.

A. Using Punnett Squares to Predict Cotton Color

What will happen if you cross two cotton plants that produce khaki-colored cotton? Create a Punnett square that shows this cross and answer the questions below.

1. What fraction of the offspring should have off-white cotton? _____
   What percent? _____%

2. What fraction should have brown cotton? _____
   What percent? _____%

3. What fraction should have a hybrid khaki cotton? _____
   What percent? _____%

4. If 100 plants were produced, predict how many would be:
   _____ brown   _____ khaki   _____ off-white

B. Test Your Predictions!

You have told Blue Genes, Inc. that crossing two khaki colored (BW) cotton plants may not be the best way to produce the most khaki colored cotton. You suggest that brown and off-white colored cotton will also be produced. They want you to prove your theory. Instead of actually growing the plants, you decide to show them hypothetical data from an investigation including 40 offspring. Complete the following investigation outlined below to find the answer.

Problem

What are the potential colors of 40 offspring of two khaki colored parent cotton plants?
The Blue Genes Challenge (Page B)

Hypothesis

If 40 plants are produced, I predict there will be:
_____ brown _____ khaki, and _____ off-white cotton producing plants.

Materials

- 2 paper bags per group
- brown construction paper
- scissors
- white construction paper

Procedure

1. Label each parent bag “Khaki Parent (BW).”
2. Cut out 40 brown paper squares and 40 white paper squares of equal size.
3. Place 20 white squares and 20 brown squares in each bag. Mix thoroughly.
4. Pull a single square from each bag and record that genotype pair on your data table: BB, WW, or BW. **Note:** This pair of genes represents the cotton color of one baby cotton plant.
5. Repeat #4 until all 40 offspring plants have been produced and the data is recorded.
6. Using your data table, complete the bar graph and answer the conclusion questions.

Results

<table>
<thead>
<tr>
<th>Cotton Offspring Data Table</th>
<th>Cotton Color Bar Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  2  3  4  5  6  7  8  9  10</td>
<td>![Bar Graph]</td>
</tr>
<tr>
<td>11 12 13 14 15 16 17 18 19 20</td>
<td></td>
</tr>
<tr>
<td>21 22 23 24 25 26 27 28 29 30</td>
<td></td>
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<tr>
<td>31 32 33 34 35 36 37 38 39 40</td>
<td></td>
</tr>
</tbody>
</table>

Total number of cotton plants of each color: _____ brown _____ khaki _____ off-white
The Blue Genes Challenge

Conclusion

1. Did your actual data match your hypothesis exactly? Explain your answer.

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

2. Blue Genes, Inc. now wants to produce 100 cotton plants from two (BW) khaki parent plants. Based on your knowledge, predict how many should be:

_____ brown   _____ khaki   _____ off-white

3. Suppose you could produce khaki cotton plants by crossing any variety of plants — homozygous off-white (WW), homozygous brown (BB) and/or heterozygous khaki (BW). What would be the most effective way of producing khaki colored cotton? Write three or four sentences to explain your thinking. Use Punnett squares to help you predict and support your thoughts.

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

What Do You Think?

Using what you have learned so far, explain how two potato plants that are red-skinned could produce offspring with the recessive white-skinned trait. Use (R) to show the dominant, red-skinned trait and (r) to show the recessive white-skinned trait. Draw a Punnett square to support your explanation. You will be graded on grammar, spelling and punctuation as well as your reasoning. Do your best work!
Bird Land
(How Changes in Plant Life Can Affect Animal Life)

Purpose

This lesson uses role-playing and kinesthetic activities to introduce the concept of evolution through naturally occurring mutations. Students learn that some genetic mutations produce traits that are not advantageous while other mutations allow one species to survive while others become extinct. The students will examine how the environment can determine whether or not a genetic change is beneficial.

Time

2-3 forty-five minute sessions

Materials

- “Bird Land” activity sheets (1 per student)
- Brass fasteners (100)
- Paper Clips (100)
- Plastic spoons (25-30)
- Rubber bands (100)
- Small paper cups (1 per student)
- Toothpicks (10-15)
- Tweezers (10-15)

Background Information

This activity is based on Darwinian evolutionary theory. It would be helpful for the students to have a solid background on Darwin and his findings in the Galapagos Islands. The concept of “survival of the fitter/fittest” and the knowledge that genes can mutate (thereby changing phenotypes) are also important to this lesson.

The case of the peppered moth from Northern England can be used to show how a subtle mutation of a gene might result in a species-saving trait or phenotype. There were two varieties of peppered moths in pre-industrial Northern England. The dark-colored moth (ww) was a genetic variation of the light-colored moth (WW) or (Ww). The dark moths were barely surviving, as they were easily seen by predators. They were dark food items on light-colored tree trunks. As factory soot darkened the tree trunks, the white moths became more visible and were eaten in considerably larger numbers. The dark moths now had a sizable population advantage over the white moths of Northern England. In this case a genetic variation, which seemed nearly disastrous, became beneficial due to an environmental change.

It is important for students to understand that a mutation is an accidental change in the DNA of an organism and that most mutations occur naturally. Whether a mutation is beneficial is determined by the relative survivability of the species over time—or “naturally selected” over time. It might be appropriate to discuss several topical issues involving genetics and mutations. Some examples include:

- solar radiation and skin cell carcinomas
- dentists’ lead blankets and x-rays
- tanning booths and skin mutations
- viral resistance in grape root stock
- nematode resistance in peach root stock
- ability of dogs to smell certain items such as mushrooms
- ability of plants to grow in high salt or acidic soils
- humans who carry the sickle-cell gene are resistant to malaria
- some strains of field corn are resistant to the corn smut fungus
Bird Land

Content Standards

Grade 7

Science
- Evolution • 3, 3a, 3b, 3c, 3e
- Earth and Life History • 4g
- Investigation and Experimentation • 7a, 7c

Reading/Language Arts
- Reading • 1.0
- Written and Oral Language Conventions • 1.0

Mathematics
- Number Sense • 1.0
- Statistics Data Analysis and Probability • 1.0
- Mathematical Reasoning 2.1, 2.5, 2.8, 3.3

Grade 8

Science
- Investigation and Experimentation • 9a, 9b, 9c

Reading/Language Arts
- Reading • 1.0, 1.3
- Writing • 1.3, 1.5, 2.4b
- Written and Oral Language Conventions • 1.0

Procedure

Day 1

1. Have the students read the “Problem” posed on their student worksheets. Explain to the students that they will soon be transformed into three sub-species of birds: Tweezertweeters, Spoonbills and Woodpickers. Illustrate the three types of beaks—tweezers, spoons and toothpicks. Continue by explaining that these three bird groups have all evolved from one bird species over the course of several hundred thousand years. They have evolved three distinct beaks, tailored to the specific type of food found in the environment. Refer to Darwins’ travels and his findings regarding the finches of the Galapagos Islands and/or the peppered moths of England.

2. Explain that each bird group has a beak that “fits” a particular food item. Show the students the food items (rubber band “worms,” brass brad “bugs,” and paper clip “silver slugs”). Ask the students to predict which of the foods might be eaten most easily by the Woodpickers and why. Discuss the other birds as well.

3. Once you have discussed the different types of food found in this environment, consider “hooking” the students into this role-play by creating a story. The following story is one of many that can be used. Alter the story to meet the needs of your students and classroom.

Long ago, in a faraway land lived three unique bird groups: the Tweezertweeters, who used their tweezers-shaped beaks to pick up food; the Spoonbills, who collected food by scooping it up; and the Woodpickers who ate by piercing their food items. [At this point, you might want to ask volunteers to demonstrate their food collecting abilities. Have students hold a paper cup in one hand. The paper cup will represent the “mouth.” The other hand will hold the appropriate item (tweezer, spoon, or toothpick) to represent the “beak.” Pinching the food between the “beak” and “mouth” is unacceptable.]
These three bird groups successfully lived together in the same area, for a long time. They had each evolved a different beak to capture a different type of food. To see how these groups live and eat together, we’re going to have “lunch.” [At this point assign the students roles to play, remembering that each bird group should be represented by about 1/3 of the class. Have volunteers spread out the food items (100 paper clips, 100 rubber bands and 100 brads), in random fashion, throughout the room. If appropriate, you may choose to complete this lesson outside.]

The birds feed in a very short period of time. This is because they are quite wary of predator cats. The birds are also extremely wary of each other. So . . . if one bird has its beak on a piece of food, the others will leave it alone (this will avoid unsafe “competition” for food!). All types of birds are able to eat all types of foods even though their beaks might be able to obtain a particular type of food easier than others.

4. Distribute the bird “beaks” (toothpicks, tweezers, and spoons) and “mouths” (paper cups) to the students and let them “forage” for food for 2-3 minutes. Watch out for unfriendly competition and for unfair eating practices. At the end of the designated time, send the “birds” and their cups of food back to their “nests” (seats).

5. Have the three types of bird teams tally up their total numbers of gathered food items. Then as a class, tally up those numbers so you now know how many pieces of food each type of bird was able to eat. For example, the Tweezertweeters might have 10 members who, together, “ate” a total of 34 worms, 26 bugs and 35 slugs—for a grand total of 95 food items. Have students complete the Eating Like a Bird Data Table, Part 1.

6. After depositing their food in a collection bin, have the students discuss/answer the questions following the data table. Then, discuss aloud why even though some birds didn’t compete for food as well as others, they still survived as a species. This is because there was plenty of food, and the birds were generally eating different food items.
The story continues. . . *The area became infested with a variety of parasites which completely destroyed two of the three food sources—the paper clip slugs and brass brad bugs. Additionally, the rubber band worms had their numbers reduced by about 50%.*

Ask the students to refer to their last question from the previous feeding. What do they think will happen, now that this environmental change has occurred? What bird species is best able to deal with this change?

**Day 2**

1. Have the feeding process repeat, only this time have the birds compete for about 50 rubber band worms, spread throughout the environment.

2. Have the students complete the *Eating Like A Bird* Data Table, Part 2, then discuss and answer the conclusion questions. You may choose to assign this as homework or as an independent assessment of student knowledge.

   NOTE: Students should discover that the Tweezertweeters are the only survivors. The other groups, because of their beak structures, could not obtain enough food to survive. This lesson reinforces the concept of evolution as a naturally-occurring process and that some species cannot survive in a changed environment. Also discuss that, in reality, this process would occur over a long period of time.

3. Discuss that parasites affect agricultural crops. Relate the role-play scenario to the phylloxera calamity that has destroyed huge areas of California grape acreage. The pest, the phylloxera parasite, attacks the root systems of grape vines and destroys the plants. Vintners have somewhat successfully combated the problem by breeding for pest-resistant root stock and then grafting premium grape varieties to the improved root stock. The original phylloxera virus resistant root stock was a natural mutation that researchers and farmers are
taking advantage of. Also discuss that viruses are decomposers and that decomposers return nutrients back to the soil. If an environmental change killed all decomposers except phylloxera and all plants were resistant to phylloxera, then nutrients would not be able to be returned to the soil. The students should see that ecosystems are very sensitive and complex and are affected by many environmental and genetic factors.

Other agricultural discussions may include the threat of Pierce’s disease to California’s grape industry as well as other crops. Students can follow in the newspapers how researchers are working to develop reasonable control methods for this disease. The most likely methods may include developing plants that are resistant to the bacterium, *Xylella fastidiosa*, which causes the disease. Other possible control methods may include controlling the insect vector for this bacterium, the Glassy-Winged Sharpshooter.

**Variations**

- Use various colored items as “food.” Have one group of animals be color-blind (wear safety goggles covered with colored cellophane) while another group of the same species possess color vision due to a natural mutation.

- Use items that are grass/lawn appropriate and do the activity outside.

- In part of the lesson, keep in a few brass bugs and silver slugs. This can show how some individuals in a population might have a genetic built-in tolerance of parasitic diseases. Relate this to penicillin-resistant strains of bacteria.

**Extensions**

- Have the students perform research on the common garden snail and find out why they are such persistent home garden and agricultural pests. Find out how this pest is controlled.

- Continue your story by telling the students that you were mistaken about the parasite. It was actually a rare fungus that attacked all of the lower forms of animal life and killed them off. As nature would have it, another species evolved—the Moldy Mushrooms (marshmallows). If this were the only food source to the birds, which species would have the advantage? Discuss how natural selection works in favoring one species over others. Those that are
better adapted to their new surroundings are better able to pass their genes on to future generations.

- Discuss real cases of potential or actual species extinction due to altered environments (peppered moths, carrier pigeons, spotted owls, etc.)

- Discuss the tomato as an agricultural example of natural selection and selective breeding. The tomato is the most common home garden plant and has an interesting history. Some interesting facts about tomatoes are described below:

  - Tomatoes were brought to Europe from South America by Spanish explorers.
  - Through cross-breeding programs, hundreds of different tomato shapes, sizes, colors and flavors are now available.
  - Tomatoes were once considered poisonous.
  - Joseph Campbell and his partner were the first to “can” a tomato and also the first to condense this fruit into a rehydratable soup.
  - Thomas Jefferson grew several varieties of tomatoes in his Monticello gardens.

- The tomato is a good example of natural selection. The many varieties of tomato allow it to survive in a wide range of habitats. Some naturally selected tomato mutations are described below:

  - A naturally selected Siberian tomato sets fruit at 38°F and ripens in 48 days.
  - A spontaneous mutation, in 1914, produced the bushy-type plant most gardeners seek.
  - Many wild tomato varieties have developed resistance to as many as 27 different tomato diseases. These traits are being bred into domestic varieties.
  - In the Galapagos Islands, a variety of wild tomato grows less than five yards from the ocean. It has the ability to survive in sea water.
  - In Peru, a drought-resistant tomato obtains all the water it needs from fog.
Bird Land

(A Model of Natural Selection)

**Problem**

How will a mutation (or environmental change) affect a group of birds and their ability to obtain food?

**Procedure**

Follow your teacher’s directions to become one of three types of birds and work to obtain “food.” Fill out the Data Table and answer the questions.

“Eating Like A Bird” Data Tables

**Part 1**

**Directions**: Write the number of food items “eaten” in the boxes below.

<table>
<thead>
<tr>
<th>Bird Species</th>
<th>Rubber Worms</th>
<th>Brass Bugs</th>
<th>Silver Slugs</th>
<th>Total Eaten</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tweezertweeters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spoonbills</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woodpickers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Conclusion**

1. If each species needs at least 30 food items to survive, tell which species stayed alive.

_____________________________________________________________________

2. Did one species of bird eat more than the others? ______ If so, which one?

_____________________________________________________________________

What advantage did this bird have over the others? _____________________________

_____________________________________________________________________

_____________________________________________________________________
Bird Land

3. Predict what might happen to these bird sub-species if the amount of food available were drastically reduced because of a disastrous environmental change. Explain your thoughts.

______________________________________________________________
______________________________________________________________
______________________________________________________________

Part 2

Directions: Write the number of food items “eaten” in the boxes below.

<table>
<thead>
<tr>
<th>Bird Species</th>
<th>Rubber Worms</th>
<th>Brass Bugs</th>
<th>Silver Slugs</th>
<th>Total Eaten</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tweezertweeters</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spoonbills</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woodpickers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Conclusion

1. Each species needs 30 food items to stay alive. Which birds survived?

______________________________________________________________

2. Give at least two reasons for the survival of one species over the others.

a. __________________________________________________________________

b. __________________________________________________________________

3. The human population continues to grow in astounding numbers. Think of one natural mutation that might assist the world with this challenge. Discuss its advantages and disadvantages. Be creative—there are no right or wrong answers.

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
## Purpose

This lesson introduces students to the relationships between chromosomes, genes, and DNA molecules. It also provides activities that clearly show how changes in the DNA of an organism, either naturally or artificially, can cause changes in an organism.

## Background Information

Start this activity with some review of basic terms and definitions: sugar groups, phosphate groups, adenine, guanine, cytosine, thymine, gene, chromosome, and DNA. The students should remember that their traits (and the traits of all organisms) are controlled by genes on chromosomes. These genes are made up of a set of molecules that are the same for all living things — sugars, phosphates, and bases. The order in which the molecules are arranged and their numbers, however, are what make the students human and a slug something entirely different. The 23 pairs of human chromosomes contain over 100,000 genes.

If appropriate, review with the students that codons are specific three-nucleotide sequences of bases that specify the cell to make particular amino acids. These amino acids then combine in specific ways to create different proteins.

This activity is hypothetical and very simplistic. The goals are for students to understand the general structure of DNA, the natural changes that occur in a DNA strand, and then the concept of genetic engineering. The lab activity itself is broken into three parts. Part 1 has the students create a model of a small portion of a strawberry chromosome, complete with 3 genes. Part 2 requires the students to model a naturally occurring mutation. They will remove a segment of their DNA model (four base pairs) and replace it with a new piece (gene) inserted where the old one had been. This change will cause a different trait to appear in the strawberry’s phenotype. (Real genes can be hundreds of base pairs in length, but for the sake of model size, the genes here will be four base pairs.) In Part 3, students work as “genetic engineers” and alter the strawberry’s DNA.

The following background information on strawberries can be shared with your students at appropriate times during the activity.

- California produces 80% of the U.S. strawberry crop annually and is the world’s largest producer of strawberries.
- Agriculture is California’s biggest business and strawberry revenues rank in the top 10 of all cash crops.
- Eight medium-sized strawberries contain 140% of the U.S. RDA for Vitamin C.

## Time

5-6 forty-five minute sessions

## Materials

For each team of two students:

- Colored markers or pencils
- DNA Gene Cut-Out Models (one set per team)
- “Design Yer Genes” Lab Sheets Parts 1, 2 & 3 (one set per team)
- Envelopes or plastic bags
- Fresh strawberries (2)
- Glue or tape
- Phosphate, Sugar and Base Pair cut-out sheets (one set per team)
- Scissors

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### Background Information

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Design Yer Genes

Content Standards

Grade 7
Science
Genetics • 2, 2c, 2e
Investigation and Experimentation • 7d, 7e

Reading/Language Arts
Reading • 1.0, 1.3, 2.2
Writing • 1.0, 1.1, 1.2, 1.3, 1.7
Written and Oral Language Conventions • 1.0, 1.4, 1.6, 1.7

Mathematics
Mathematical Reasoning
1.0, 1.1, 1.3, 2.2, 2.4, 2.5, 3.1, 3.2, 3.3

Grade 8
Science
Chemistry of Living Systems • 6c

Reading /Language Arts
Reading • 1.0
Writing • 1.0, 1.2, 1.3
Written and Oral Language Conventions • 1.0, 1.4, 1.5, 1.6

Grade 9
Science
Organic and Biochemistry 10a, 10c
Genetics • 5a, 5b, 5c, 5d, 5e
Investigation and Experimentation • 1d, 1g, 1m

• Breeding programs using traditional hybridization methods continue to keep California at the forefront of strawberry production.

• Strawberries have 8 chromosomes, each containing thousands of genes.

• Many research articles have been written about the origin of the name for the fruit, but none seem clearly definitive. Here are some theories on how the strawberry got its name:
  - Historically, straw was placed under the fruit to prevent bruising.
  - Early cultivators noticed the vines grew all over the place or were “strewed” or “strawed.”
  - English children threaded the berries onto straw and offered them for sale.
  - Strawberry runners resembled straw.
  - The ancient Latin word “stragum” means fragrant.

Procedure

Design Yer Genes — Part I

This activity illustrates the components of DNA molecules and shows how they hook together to make genes and chromosomes. The students will use this model to develop their understanding of DNA mutations and genetic engineering.

1. Review and complete the entire lesson yourself so you can get a feel for the concepts and sequence. Jot down notes that will help the lesson flow smoothly with your students. Save your completed model of the strawberry DNA to use as a visual example for your students.

2. Begin this activity by referring to Darwin’s finch experiences or the peppered moths of England. Let the students know that this lesson will shed light on how a living species, such as the birds in the Galapagos, can evolve into a different species due to the changes in their genetic blueprint.

3. Distribute a fresh strawberry to each student. As they enjoy eating it, discuss some interesting facts about strawberries. (As always, be aware of student food allergies before having a student eat the fruit.) Brainstorm a list of observations about the berries.

4. Distribute the student Design Yer Genes—Part 1 lab sheets to your students. Discuss and clarify the problem the students are trying to
solve. Explain to your students that they are going to build a simple model of a strawberry DNA molecule to better understand genetics.

5. Review the procedure for building the strawberry DNA with your students. Pair your students together into working teams of two.

Monitor their work continuously. Provide plastic bags or envelopes for your students to organize and store their work. Allow the students to figure out how the base pairs should match with the sugar units by trial and error. Display your DNA model. Remind students that sugar units alternate with phosphate units and that base pairings must be A-T and C-G. Do not have your students tape or glue their models together until they “dry-fit” their model and get it approved by you! Refer the students to the strawberry “Gene Key” at the appropriate time.

Note: As the students complete their models, check them for accuracy. You want your students to be successful in this portion of the activity so they will be encouraged to learn the science concepts rather than get bogged down with the coloring and cutting activity. Coloring only the left or right side of the sugar-phosphate links may be an option for student groups who are having difficulty.

6. Discuss the meanings of the Part 1 questions. Assign these questions for homework if they do not finish them in class.

7. During and after DNA model completion, check your students for understanding regarding traits and genes. Have the students twist
Design Yer Genes

their completed models into the classic double helix and discuss how X-ray diffraction led Watson and Crick to the discovery of DNA’s shape. Stress that DNA and the manipulations of DNA done by geneticists are much more complicated than their models suggest.

8. Prepare the students for Part 2 of this lesson by asking for their opinions on how the strawberry could be improved. You might also want to inquire about their knowledge regarding gene splicing or genetic engineering. Consider having students do research on how farmers have “changed” certain produce items through selective crossing or hybridization. Examples include the production of seedless watermelons and grapes, strains of corn and wheat that are disease resistant, dwarf trees, and the production of tangelos and broccoflowers. The chart *Where Do Genes Come From?* on page 46 may be useful in this discussion.

Design Yer Genes — Part 2

Part 2 of this activity shows students how a change in the genetic code (mutation) can result in an altered phenotype of the organism. The strawberry will be used as an example. Students will remove one of their strawberry genes and replace it with another. In nature, this is a random event and rarely provides an immediate benefit to the organism.

1. Explain to your students that the DNA model they developed in Part 1 of this lesson is just that—a model. Briefly discuss how DNA molecules are reproduced and how easy it is to make a slight error during DNA replication. You might even discuss how errors were made in the production of the student DNA models. An error in DNA replication is called a mutation. Genetic engineering is when a DNA molecule is purposely altered. Explain to the students that they will act as geneticists and purposely alter a strawberry DNA molecule by removing a gene and inserting another.

2. Review the problem and procedure of “Design Yer Genes — Part 2.” Working in the same groups as they did in Part 1, have students carefully follow the described procedure. Extra cut-out sheets may be needed. Again, your prepared model will help students visualize what it is they are to do. As with Part 1 of this activity, remind students that they are modeling a very complex procedure—DNA (genetic) replication. It is much more complicated than can be represented by this model.

3. After the students have completed altering their strawberry DNA model, have each group explain to the class (or in writing) what characteristic they altered.
Design Yer Genes

4. Have the students answer the “Design Yer Genes — Part 2 Questions.” These questions can be an in-class assessment or a homework assignment. Previewing and discussing the questions will be helpful to the students. Here are some points to discuss with your students prior to their work on the questions:

- Question 4 could benefit from references to the Galapagos finches and the peppered moths. Negative effects of DNA mutation can be discussed by referring to the many human genetic disorders such as Huntington’s Disease, Cystic Fibrosis and Sickle Cell Anemia. It is important to stress that there may also be positive effects to what we call negative genetic disorders. For example, people who carry the Sickle Cell gene (Ss) but do not express the trait (ss) are resistant to Malaria.

- You might wish to assign question 6 as a research paper rather than as one of the regular questions. Again, the students will gain more insight for this question if you guide them in a discussion of the positive and potentially negative implications of genetic engineering. Refer to the Background Information on Biotechnology at the beginning of this unit. Enlighten your students as to how the scientific and political communities are dealing with public concerns.

Design Yer Genes — Part 3

This part of the unit provides students with a basic understanding of “real” genetic engineering that occurs in the laboratory. Your students will need some basic information on how genes are taken from one organism and then inserted into the genetic code of another organism. The Background Information on Biotechnology section at the beginning of this unit provides some information. Some other facts you may find useful are listed below.

- In part 2 of this lab, students created a natural mutation by removing one gene and replacing it with another. Until recently, this could not be done purposely in the laboratory. These “removal and insertion” changes occur most often in natural situations.

- The desired gene can come from any organism—a dog, cat, tree, bacterium, etc. The trick is to make the organism accept the gene from another organism.
Design Yer Genes

- Genes are genes. For example, a gene for the production of a protein like insulin is the same for all organisms and can theoretically be inserted to make insulin in any organism if the gene is accepted into the DNA molecule.

- In most commonly used genetic modification processes, genes are added, not removed or replaced. It is technically much easier to insert genes into a chromosome than it is to remove or replace them.

- Inserting a gene does not guarantee that the desired trait will be expressed in the new organism. There are many factors controlling gene expression, and in many cases successful gene transfer is a process of trial and error.

1. Review the problem and procedure of “Design Yer Genes—Part 3” with your students. Discuss that what makes this lab more like genetic engineering than the Part 2 activity is that one gene is not removed or altered from the DNA; rather a new gene is added.

2. The students will need four gene cut-out sheets to choose from—Gene A, Gene B, Gene C and Gene D. Explain that each gene codes for or controls a specific trait, which you will reveal after the students have chosen and added one or more of the traits to their strawberry DNA model.

3. Have the students complete the activity. Remind the students that, when adding their new gene, they can insert the new gene anywhere in the molecule as long as the three previous genes are not destroyed. They can insert the new gene between two other genes, at the end of one gene, etc.

4. After the students have completed their genetic manipulations, reveal what the hypothetical new genes do:

   - **Gene A comes from a bacterium and causes an increase in sugar production in the strawberry for a super sweet berry.**

   - **Gene B comes from red algae and causes an increase in beta-carotene pigment production for very red berries.**

   - **Gene C comes from a banana and causes the strawberry to have a banana taste.**
**Design Yer Genes**

- Gene D comes from a virus and causes the strawberry to become resistant to a certain bacteria that makes strawberries rot. Therefore, this altered strawberry resists rotting.

5. Have the students complete the “Questions” section of this lab.

6. Discuss the implications of some of the hypothetical genes mentioned above. For example, if a strawberry plant does not produce sweet berries, Gene A might do wonders for the strawberry industry. If Gene B is added to a light pink strawberry, it might make the berry more appealing to the consumer. However, if Gene B is added to an already red strawberry, the increase in red color may cause the berry to be so red it could appear brown or black. Gene C may or may not affect the saleability of the strawberries while Gene D could reduce the need for pesticides.

7. Discuss that some unwanted side affects may result from genetically modifying the strawberry plant. For example, a gene may insert itself into the blooming mechanism of the plant and produce sterile flowers or no flowers at all. If this is the case, the redder color or change in taste may not work because strawberries could not be produced to show the new trait. This is one reason why the process of transgenics is so complex and time consuming.

8. Review the fact that the students’ models are only simplified versions. A strawberry plant has eight chromosomes, each made of thousands of genes. Each gene is made of thousands of base pairs!

9. Emphasize that the study of genetics is very complex and that if the students like this activity they may want to pursue taking more classes in genetics.

**Variations**

- Have students create “edible” DNA models out of marshmallows, gum drops, etc., and then have an “Eat Your Genes” party in class.

- Make “Gene D” a funny or unusual trait, such as a “skunky” smell. This may add humor as well as show that genetic engineering does not always produce desired results.
Design Yer Genes

Extensions

- Have your students complete the following research and writing assignment. In-class reference books and the Internet may be good resources for students. Refer to the Teacher Resources and References section of this unit for reference articles, books, organizations, and useful web sites.

- As you have learned, genetic engineering is in some ways, similar to changes that occur naturally. However, geneticists are not always successful in getting a new gene to function in a different chromosome. It is very time consuming and expensive to take DNA from one organism and put it into another. So, why do scientists do it? Assume the role of a genetic engineer who must convince the public of the value of genetic engineering. Write a short newspaper editorial stating what genetic engineering is and how it can benefit people. Your editorial should have some examples of genetically engineered plants and/or animals. You will have to do a little research for this assignment. Discuss possible reference sources with your teacher.

- Invite a geneticist into your classroom to discuss his/her occupation.

- Invite a farmer or agri-business representative into your classroom to explain how their commodities have changed from biotechnology and/or scientific research.

- Vegetatively reproduce strawberry plants in class by rooting the vines that grow off a parent strawberry plant. Discuss the genetics of the new plants and the benefits and risks of vegetative reproduction.

- Research and report on the newest developments in genetically modified agricultural products.
## Where Do Genes Come From?

<table>
<thead>
<tr>
<th>Crop</th>
<th>Source of Genes</th>
<th>Name of Gene</th>
<th>New Trait</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canola</td>
<td>Various plants</td>
<td>Enzymes for oil (lipid) synthesis</td>
<td>Lower saturated oils</td>
</tr>
<tr>
<td></td>
<td>Various plants</td>
<td>Synthesis</td>
<td>Special oil compositions like building blocks for shampoo, synthetic lubricants, shortenings</td>
</tr>
<tr>
<td>Chrysanthemum</td>
<td>Bacteria</td>
<td>Antisense pigment genes</td>
<td>Pure white petal color</td>
</tr>
<tr>
<td>Cotton</td>
<td>Soil microbe</td>
<td>Enzymes that degrade herbicides</td>
<td>Provides resistance to herbicides</td>
</tr>
<tr>
<td></td>
<td>Bacteria</td>
<td>Bt</td>
<td>Insect control</td>
</tr>
<tr>
<td></td>
<td>Bacteria and plants</td>
<td>Pigment genes</td>
<td>Genetically colored fiber</td>
</tr>
<tr>
<td>Papaya</td>
<td>Plants</td>
<td>Ripening genes</td>
<td>Increased flavor and firmness</td>
</tr>
<tr>
<td></td>
<td>Virus</td>
<td>Viral coat protein</td>
<td>Viral resistance</td>
</tr>
<tr>
<td>Potato</td>
<td>Bacteria</td>
<td>Starch</td>
<td>Increased starch content</td>
</tr>
<tr>
<td>Rice</td>
<td>Bacteria</td>
<td>Enzymes involved in pathway to make $\alpha$-carotene</td>
<td>Rice rich in Vitamin A known as “Golden Rice”</td>
</tr>
<tr>
<td>Soybean, Sunflower, Canola</td>
<td>Legumes and nuts</td>
<td>Storage proteins</td>
<td>Makes the plant by-products have more protein so it can be used for nutritious animal feed</td>
</tr>
<tr>
<td>Squash, Cantaloupe</td>
<td>Virus</td>
<td>Viral coat protein</td>
<td>Viral resistance</td>
</tr>
<tr>
<td>Strawberry, Raspberry</td>
<td>Plants</td>
<td>Ripening genes</td>
<td>Increase firmness and size</td>
</tr>
<tr>
<td>Tomato</td>
<td>Tomato</td>
<td>Antisense enzyme(s)</td>
<td>To soften more slowly; allows tomato to remain on the vine longer</td>
</tr>
<tr>
<td></td>
<td>Virus</td>
<td>Viral coat protein</td>
<td>Viral resistance</td>
</tr>
<tr>
<td></td>
<td>Bacteria</td>
<td>Enzyme to make sugar</td>
<td>Extra sweet</td>
</tr>
<tr>
<td></td>
<td>Bacteria</td>
<td>Enzymes involved in pathway to make $\alpha$-carotene</td>
<td>Increase in Vitamin A content</td>
</tr>
</tbody>
</table>
Design Yer Genes

Part 1

Problem

How is a DNA molecule put together? What are genes?

Materials

- Colored markers
- **Design Yer Genes — Part 1** lab sheets
- Envelopes or bags to hold cut pieces
- Glue or tape
- Phosphate, sugar and base pair cut-out sheets
- Scissors

Procedure

1. Color the sugar units, phosphate units and base units. All of the sugar units must be the same color, all of the phosphates must be the same color, and each of the four different base units must be their own color. **You will use six different colors.**

2. Cut out the pieces you have just colored. **Be careful not to cut off the tabs; they will be needed to attach the model together.**

3. Figure out how these pieces fit together. Hints: the tabs must match; the phosphate molecules must attach to sugar molecules.

4. Using the **Gene Key for Strawberries**, choose which three traits you will put on your model.
Design Yer Genes

Name ______________________________

Write the following information on your own paper.

My strawberry will have the following base pair sequences:

Gene 1 = _________________________
Gene 2 = _________________________
Gene 3 = _________________________

In one sentence, describe how your strawberry will appear (its phenotype):

__________________________________________________________________________________
__________________________________________________________________________________

5. Put together the four base pairs that match the traits you have chosen above. Each group of four bases represents one gene.

6. Dry fit your model. Make sure you have followed your teacher’s directions about alternating sugars and phosphates and have matched base pairs correctly. Your model should look like a ladder and have three genes. Have your unglued model approved by your teacher. As soon as you are sure your model is correct, glue or tape it together at the tabs.

<table>
<thead>
<tr>
<th>Gene Number</th>
<th>Base Pairs in Gene</th>
<th>Trait in Gene</th>
<th>Base Pairs in Gene</th>
<th>Trait</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>T-A A-T A-T A-T</td>
<td>Fruit has seeds in normal pattern</td>
<td>CG CG GC CG</td>
<td>Fruit has no seeds</td>
</tr>
<tr>
<td>2</td>
<td>A-T CG CG A-T</td>
<td>Fruit is sweet, has high sugar content</td>
<td>CG A-T CG A-T</td>
<td>Fruit is tart, has low sugar content</td>
</tr>
<tr>
<td>3</td>
<td>A-T A-T CG CG</td>
<td>Fragile skin</td>
<td>A-T CG GC GC</td>
<td>Tough skin</td>
</tr>
</tbody>
</table>

A-T = Adenine & Thymine base pair    C-G = Cytosine & Guanine base pair
**Questions**

Answer the following questions on your own paper. Title your paper *Design Yer Genes — Part I Questions*.

1. The bases only fit together in certain pairings. What are these pairings?

2. The sides of the DNA ladder are made up of what two units?

3. Where is the only place for the base pairs to connect to the ladder?

4. If a “gene” were really a distinct segment of four base pairs along the DNA molecule, how many “genes” have you created in your model?

5. Look back at the Gene Key for Strawberries. Explain why it might be beneficial to have some strawberries with seeds and other strawberries without seeds. Why might it be beneficial to have some varieties of strawberries with fragile skins and other varieties with tougher skins?

6. Describe at least two things you have learned about DNA and genes that you did not know before.

**Extension**

**Extra! Extra!** We know genes control our traits or phenotypes. How many genes are on a typical human chromosome?
Phosphaté Units for the DNA Model

P

P

P

P
Sugar Units for the DNA Model

S

S

S

S

S

S

S

S

S

S

S

S

S

S

S

S

S

S
Base Pairs for the DNA Model
Design Yer Genes

Part 2

Problem

How does a geneticist change a strawberry’s trait?

Introduction

You are about to alter your strawberry DNA model. You must remember that the science of genetics is very complex and that changes in DNA occur naturally in nature as well as artificially in a laboratory. You can pretend that the changes you make in your model are occurring naturally (called a mutation) or artificially (called genetic engineering or transgenics).

Materials

- Colored markers or pencils
- Design Yer Genes — Part 2 lab sheet
- DNA models from Part 1
- Gene Key for Strawberries
- Glue or tape
- Phosphate, sugar, and base pair cut-out sheets
- Scissors

Procedure

1. Refer to the Gene Key for Strawberries in Part 1 of this lab. You chose three traits from this list to put on your strawberry DNA molecule. Recall what three genes you chose. You will change one of these three traits. Pick the one you would like to alter and locate it on your DNA model.

2. Remove the trait you wish to change by cutting out the four base pairs (gene) from the sugar units. In nature, genes are changed at random. In the laboratory, genetic engineers try to control which genes are altered.

3. Referring to the Gene Key for Strawberries in Part 1, make a new gene to replace the one you just removed. Remember, this new gene must consist of four base pairs and must be different than the other two genes that are already on your DNA molecule. For
example, you may not add a fragile skinned gene if there is a fragile skinned or tough skinned gene already on the chromosome. After you are certain that the change you are making is compatible with the rest of your DNA, color the base pairs, cut them out and insert this gene at the sugar units.

3. Tape or glue the new gene in place.

**Questions**

Answer the following questions on your own paper. Label your answers “Design Yer Genes — Part 2.”

1. What trait (gene) did you remove from your model of strawberry DNA?

2. What trait (gene) did you insert into your model of strawberry DNA?

3. Compare the traits of your old strawberry plant to your new strawberry plant.

4. Explain why you chose to insert the new trait into your strawberry DNA. In your answer, discuss how this new trait might benefit the strawberry, the environment and/or humans. Discuss any problems that may arise.

5. When a real section of DNA changes, it is called a mutation:
   - How could a naturally occurring mutation help a species? List at least two examples.
   - How could a natural mutation hurt a species? List at least two examples.

6. Some people are uncertain or even fearful of genetically altering an organism. Write a short essay on:
   - What you think people might be worried about.
   - What you think the problems and/or benefits are in changing the genes in an organism.
Part 3

Problem

How do real geneticists change or “engineer” the DNA of a strawberry?

Introduction

In real recombinant genetics technology, the scientists cannot yet easily remove one unwanted gene and stick in another, as you did in your last activity. However, they are able to add genes to a DNA molecule. Your teacher will provide more information on this. Using the materials provided, find out what kind of strawberry you can produce.

Materials

- Colored pencils or markers
- DNA models (from Part 2)
- Design Yer Genes — Part 3 lab sheets
- Glue or tape
- Part 3 Gene Cut-out sheets
- Scissors

Procedure

1. Review the three genes (and the traits they control) on your strawberry DNA model from Part 2.

2. Observe the four new gene cut-out sheets and choose one that you will attempt to insert into your DNA model.

3. Color (using the same colors as in Parts 1 and 2) and cut out the chosen gene.

4. Tape or glue your new gene onto:
   - Either end of your model, or
   - Into the middle of your model without destroying one of the other genes.
Remember: In real DNA, the genes “fit” themselves onto the chromosome wherever they can. Scientists cannot control where they attach.

5. Find out what trait your new DNA model produces in your strawberry. Your teacher will help you with this.

Questions

Answer the questions on your own paper. Title your answers “Design Yer Genes — Part 3.”

1. What were the four base pairs in the gene you added to your model?

2. What trait does this new gene control?

3. Do you believe this new trait will help or hurt the strawberry species? Explain your answer.

4. In one to three well written paragraphs, explain what you have learned about all of the following:

   • The DNA molecule
   • Mutations
   • Genetic engineering
   • How agriculture and/or consumers are affected by genetic engineering
   • Any other information you found interesting
Part 3
Gene Cut-out Sheet

Gene A
Part 3
Gene Cut-out Sheet

Gene B
Part 3
Gene Cut-out Sheet

Gene C
Part 3
Gene Cut-out Sheet

Gene D
Purpose

This project requires the students to take concepts and information learned from prior lessons, and apply them to a “new” situation. Working in a collaborative, interdependent “bio-tech company,” students will genetically modify a plant and then promote their product at a bio-technology funding fair.

Time

5-6 forty-five minute sessions

Materials

For each team of 4 students:

- 3-way display board
- Articles on biotechnology
- Assignment Packet (see procedure)
- Colored markers or pencils
- Computer with printer (optional)
- Construction paper
- DNA model cut-outs (pp. 50-52 and/or pp. 57-60)
- Glue or tape
- Other items supplied by the students
- Scissors

Background Information

At this point in the unit, the students should be well versed in the vocabulary of genetics and the basics of biotechnology. However, before this final project begins (or even as it progresses) you might want to assign outside reading or research on genetically altered products. Possible resources are listed in the Teacher Resources and References section on pages 73-75 or may be found on the web sites listed on page 76.

Before you have the students begin this project, spend some time organizing student teams. Each team will need a visionary, a creator, a mechanic, and skilled writer. Team students so there are students of a variety of skills in each group.

Procedure

1. Personally review the Student Assignment Packet. Make changes to the packet to meet the needs of your students, time frame and classroom. The student packet you choose may include some or all of the following:

   - Student Assignment Packet
   - Possible Products List
   - Company Positions
   - Daily Work Log
   - Display Tool
   - Project Planning Sheet
   - Quality Criteria List
   - Reading assignments and other handouts of your choosing

2. Organize students into pre-determined teams. Distribute the student packets to each team. Read “The Scenario” aloud to the class. Explain how small companies are often funded by larger corporations.

3. Have students complete Part 1 of the lesson. Focus the students’ ideas on plant products that may be beneficial to society. Encourage students to look at the Possible Products List if they are having difficulty in choosing a plant or product.
4. After a product is chosen, have the students complete Part 2 of the lesson “What’s Your Job?” Have students refer to the *Company Positions* descriptions. Some teams will need more guidance in assigning roles than others. Remind students that each job carries its own grade. It is best if students know they will be graded individually, based on their performance.

5. Have students complete Part 3 of the lesson. Remind students that their daily work logs will be checked. This helps promote steady work during this project. At the very least, the daily work log has the students review what they have accomplished. During the last few minutes of class, you can “spot check” certain groups and discuss their progress. Whether or not you wish to “review” this daily log is your option. However, if the students know you are reviewing it, they will be more inclined to complete it with good effort.

Some guidance will be needed as students proceed through this project.

- Give directions as needed, but let the students struggle within their teams, too. Learning how to resolve issues is part of the learning process.
- Guide students in making the DNA model or drawing. This may be difficult for some groups; they can refer to their DNA models from the previous lab activities.
- Check the written materials occasionally for clarity and content accuracy.

6. Assign biotechnology readings as appropriate.

7. Have students complete Part 4 of the lesson. As students head toward the “finish line,” check their daily logs and their actual work. Review the *Quality Criteria List* with each group before they paste-up their display boards. Remind students of the plus and minus system on the list and encourage them to do their best work.

8. Have students complete Part 5 of the lesson. Since public speaking is a great fear of many students, it is important that you develop a non-threatening classroom environment. Treat this part of the project as a fun, play-acting effort. It is important that each student takes ownership of his/her part of the project, however. Make sure each student on the team is responsible for at least some of the prepared speaking and participates in the answering of the questions.
Content Standards (continued)

Grade 9

Science
- Genetics • 5a, 5b, 5c
- Investigation and Experimentation • 1a, 1d, 1g, 1m

Reading/Language Arts
- Writing • 1.0, 1.1, 1.3, 1.4, 1.5, 1.9, 2.3a, 2.3b, 2.3c, 2.3d, 2.3f, 2.4a, 2.4c, 2.4d
- Written and Oral Language Conventions • 1.0, 1.3, 1.4
- Listening and Speaking • 1.0, 1.1, 1.3, 1.4, 1.5, 1.6, 1.7, 1.12, 2.5

History/Social Science
- Chronological and Spacial Thinking • 1

Sometimes you might also want to “funding” to exceptional projects, or simply grade these projects in the traditional sense. Traditional grading might include individual grades for individual work and group grades for the whole project. However, try not to make competition between companies the prime focus of your grading. In fact, if all the companies follow the criteria they should all receive funding, and have a sense of goal achievement. During this project the students use new scientific information in a way that benefits society. This is a valuable and honorable use of scientific endeavors. Consider having the students grade themselves in conjunction with your input.

Variations

- Have a set of “alternative” assignments for students who miss large parts of this activity.
- Set up a “town hall” meeting of the various company spokespeople and the citizens of Anytown where the companies promote their product’s benefits and safety to the townspeople.
- If appropriate, permit a group of students to prepare a display that opposes the production of genetically modified plants.

Extensions

- Assign independent research projects on genetically modified products that currently exist in medicine or agriculture.
- Invite a geneticist to your class to discuss his/her work in biotechnology.
Snappy Products, Inc.  Name ______________________________
(Student Assignment Packet)

The Scenario

You are a design and production team for a small biotechnology company. Your company has come up with a genetically altered agricultural product, obviously not listed here due to security reasons. Your company is too small to pay for full production and marketing of your product to the public. You are sure that you can convince a funding source to fund your product because you believe that consumers everywhere will want to buy it. Its benefits to society and the environment are worthwhile. Ultimately, both the funding company and your company will make lots of money.

This coming week, there is an Agricultural Technology Fair in Sacramento, California. The purpose of this fair is to give small companies like yours a chance to sell their product ideas to large funding companies. The Agricultural Technology Fair Committee has sent you the dimensions of the display board for your booth and is expecting your company to be a part of this event.

Before the fair begins, your company must complete the following tasks:

Part 1 - Company Name and Product

• Create a catchy, fun company name and write it on your Project Planning Sheet.

• Brainstorm a list of plants your company may want to genetically change.

• Analyze the various plants’ potential benefits to society.

• Choose a plant to change and determine its benefits. Write this information on the Project Planning Sheet.

HELP . . . If your company is having trouble deciding on a product, refer to the Possible Products List for ideas.

Part 2 - What’s Your Job?

• Review the four job positions within your biotech company.

• Discuss which jobs would be best for which team members.

• Choose a job for each person. Write the names next to the job titles on the Project Planning Sheet.
Snappy Products, Inc.  Name ______________________________

Part 3 - Getting To Work

- **Begin work** by organizing yourself and helping your company get organized; begin working on the tasks at hand; work steadily and consult with your group as necessary; it is crucial that each of you knows what the others are doing.

- **Record** each day’s efforts and accomplishments on the *Daily Work Log*; each member of the group must contribute to this log every day.

- **Discuss** what each person will do the next class period.

**HELP . . .** If getting started is a problem, refer to the *Daily Work Log* example. Your team’s *Daily Work Log* will be different, of course, but this example may give you some ideas.

<table>
<thead>
<tr>
<th>Date</th>
<th>Your Name &amp; Company Position</th>
<th>Summary of Efforts &amp; Accomplishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-18</td>
<td><strong>Joe Smith</strong> Product Design Manager</td>
<td>Today I discussed with Jamal the size of a 3-way display. I started a list of materials we need for the board.</td>
</tr>
<tr>
<td>10-18</td>
<td><strong>Jamal Johnson</strong> Graphic Artist</td>
<td>Today Joe and I discussed how to make the display board and I decided where to put pictures and models. Also, I talked to Maria and Sara about their writing ideas and where the written parts should go. I asked if they would need any art work to go along with their writing.</td>
</tr>
<tr>
<td>10-18</td>
<td><strong>Maria Hernandez</strong> Science Copy Writer</td>
<td>Today Sara and I talked about how we were going to genetically change our product. We drew rough drafts with Jamal of our plant’s DNA, both before and after altering it.</td>
</tr>
<tr>
<td>10-18</td>
<td><strong>Sarah Cunningham</strong> Ad Copy Writer</td>
<td>I created a list of catchy slogans and asked Joe if he could think of some rhyming words tonight.</td>
</tr>
</tbody>
</table>
Part 4 - Nearing the Finish Line

• Design your display and “pencil in” where each item will go on the project planning sheet.

• Compare your work with the Quality Criteria List and have your teacher check your work when you think your drafts are ready to become final versions.

• Make any changes necessary to match the criteria on the Quality Criteria List.

• Glue or tape the finished drawings and text on the display board according to the plan devised by the Product Design Manager and the Graphic Artist.

Part 5 - Speaking Out

Congratulations! Your company has been selected as one of the finalists for funding. However, the BIG company wants your team to give an oral review of your product. You are to discuss its benefits and how your company changed the product genetically. Each company member is expected to give a brief (1-3 minutes) summary of his/her job and what he/she did to accomplish the tasks. Further, the BIG company may ask questions of your company members.

To prepare for this part of the fair, members should:

• Review job descriptions and what each person did to complete the project.

• Determine how the presentation will be given and the order in which each member will speak.

• Predict what questions may be asked and how to answer them.

• Practice your presentation, speaking clearly and loudly.

• Present your product to the company—your classmates.
Snappy Products, Inc.

Possible Products List

- bananas that don’t get too mushy
- carnivorous crops
- chocolate flavored fruits or vegetables
- cold-tolerant fruits and vegetables
- cotton that grows already colored
- crops that can grow in salty water
- crops that produce more oxygen
- pickle-flavored cucumbers
- drought-tolerant fruits and vegetables
- faster growing trees
- flowers that glow in the dark (bio-luminance)
- fruits with the nutritional benefits of vegetables
- medicine producing plants
- pest-resistant crops
- plants that grow lots of food on one tree or vine
- plants with high levels of nutrients such as calcium or iron
- plants where every part is useful
- plants that are distasteful to bugs
- “pollution-eating” plants
- popcorn with unique flavors (butter, caramel, etc.)
Company Positions

Product Design Manager

Gathers materials, designs, and puts together a 3-way backboard for display; works with Graphic Artist and Copy Editors; organizes and stores materials for later use; verifies the accuracy of material through research.

Graphic Artist

Designs (with Product Design Manager) the “look” of the 3-way display board; designs and draws “before and after” drawings of the product; works with Science Copy Editor to design and create a drawing or model of the “before” and “after” DNA; designs and draws advertisements for marketing the product to the public (with the assistance of the Advertisement Copy Editor).

Science Copy Editor

 Writes the background information on what the product’s gene sequence is, produces a chart showing the “before” and “after” gene sequence for the trait; explains how the product was changed; works with the graphic artist on the DNA model or drawing; verifies the accuracy of material through research.

Advertisement Copy Editor

 Writes the advertisement for the public; explains in common language how biotechnology works and how their product has been safely changed; discusses why the public will like this product better than the old one; works with the Graphic Artist to produce a draft advertisement poster showing benefits of the product.
# Daily Work Log

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>
Display Tool

Note: Use your creativity to create your own display. This is just an idea of what one may look like.
Project Planning Sheet

Company Name

Product Before

Product After

Product Benefits Explanation

Product Design Manager ________________________________________
Graphic Artist ________________________________________________
Science Copy Editor ___________________________________________
Ad Copy Editor ________________________________________________

Display Board Dimensions

22” 22”
24” 24”
36”
Snappy Products, Inc.  Name ______________________________

Quality Criteria List

In order to be successful in your funding quest for your fantastic new product, your project should meet the criteria described below. This is something your team should do together, using your teacher as a consultant. Place a “+” next to any criteria you meet or exceed, and a “–” next to any you need to improve on. Help one another to improve your product and display board. Once you have made the necessary improvements, you can change the minus signs into plus signs.

(+ or –)

___ Does the display board fit the size requirements?

___ Is the display board eye-catching and attractive to potential viewers?

___ Are the names of the company, the company members and the genetically-changed product clearly visible?

___ Are the “before” and “after” drawings or models effective in showing the benefits of the modified plant?

___ Are the models or drawings of the genetically engineered DNA labeled clearly?

___ Is the advertisement poster eye-catching to potential customers?

___ Is the written scientific background information clear and correct?

___ Is the written consumer background information clear and informative to the general public?

___ Is the poster text informative? Will the public be convinced of your product’s benefits?

___ Is the final display board neatly put together and legible?

___ Have all company members agreed that the display board is complete?
Teacher Resources
and References

Ag Experience
Teaching kits providing materials and activities for hands-on lessons about agriculture. Kits are available for cotton and strawberries. Request a brochure.

Ag Experience
3144 North G Street, #125-141
Merced, CA 94340
(209) 358-9057
Fax: (209) 384-1378
E-Mail: agexper@cyberlynk.com

Agricultural Research Service Magazine
Published monthly by the Agricultural Research Service, United States Department of Agriculture, this magazine reports on current research in the agricultural industry. Free one-year subscription to schools and libraries.

Agricultural Research Magazine
5601 Sunnyside Avenue, 1-2232C
Beltsville, MD 20705-5130
(301) 504-1660
Fax: (301) 504-1641
Web Site: www.ars.usda.gov/is/AR

Bio-Rad Laboratories
This company provides many biotechnological classroom kits and supplies. Request a free catalog.

Bio-Rad Laboratories
2000 Alfred Nobel Drive
Hercules, CA 94547
(800) 424-6723
Fax: (800) 879-2289
Web Site: www.bio-rad.com

Biotechnology—Careers for the 21st Century Video
This video shares interviews of people who have a career in biotechnology.

National Association of Biology Teachers
11250 Roger Bacon Drive #19
Reston, VA 22090
(703) 264-9696
Fax: (703) 264-7778
Web Site: www.nabt.org

Biotechnology Industry Organization
A variety of basic and detailed information on biotechnology including genetic engineering is available.

Biotechnology Industry Organization
1625 K Street NW, Suite 1100
Washington, DC 20006
(202) 857-0244
Fax: (202) 857-0237
Web Site: www.bio.org

California Foundation for Agriculture in the Classroom
Provides a variety of programs and resources, which can increase the understanding of agriculture and its impact in today’s world. Commodity and natural resource fact and activity sheets, lesson plans, and teacher and student programs are available. Request a free Teacher Packet.

California Foundation for Agriculture in the Classroom
2300 River Plaza Drive
Sacramento, CA 95833
(800) 700-2482
Fax: (916) 361-5697
Web Site: www.cfaitec.org

California Science Teachers Association
This association provides newsletters, journals, and conferences for California science educators about ideas, issues, and trends in science education.

CSTA
3550 Watt Avenue, #120
Sacramento, CA 95821-2666
(916) 979-7004
Fax: (916) 979-7023
Web Site: www.cascience.org

California Strawberry Commission
Free strawberry lessons and fact sheets are available.

California Strawberry Commission
Post Office Box 269
Watsonville, CA 95077-0269
(831) 724-1301
Fax: (831) 724-5973
Web Site: calstrawberry.com
Teacher Resources and References

CDE Press
The Content Standards for California Public Schools and subject matter frameworks are available through this company. They are also available on the listed California Department of Education Web site.

CDE Press, Sales Office
California Department of Education
Post Office Box 271
Sacramento, CA 95812-0271
(916) 445-1260
Fax: (916) 323-0823
Web Site: www.cde.ca.gov

Center for Consumer Research
This organization has a free video and brochures available on food biotechnology. They educate consumers about food biotechnology and address current issues.

Center for Consumer Research
University of California
One Shields Avenue
Davis, CA 95616
(530) 752-2774
Fax: (530) 752-6523

Center for Engineering Plants for Resistance Against Pathogens
This organization has a variety of free resources and programs for educators including those described below.

Germ Wars is a sixth through ninth grade interactive computer program that describes how people and plants defend themselves against microbes and how biotechnology can help prevent and treat disease.

The Virtual DNA Fingerprinting Lab is software that involves high school students in solving a forensic mystery. Over the course of seven episodes, students collect evidence, extract DNA, perform a southern blot, use PCR, and finally solve a crime.

Center for Engineering Plants for Resistance Against Pathogens
University of California, Davis
One Shields Avenue
Davis, CA 95616
(530) 752-6552
Fax: (530) 752-6523
Web Site: ceprap.ucdavis.edu

Cotton’s Journey—A Field Trip in a Box
This kit contains a booklet, teaching guide, student manual, 23-minute video, poster, planting seeds, cotton bolls, and cotton swatches. Price of kit varies depending on funding.

The Alaca Company
Post Office Box 55
Tranquillity, CA 93668
Fax: (559) 698-5190
E-Mail: ALACA@juno.com

Cottonseed and Its Products
This free 24-page pamphlet describes the history of cotton and cottonseed production as well as its many products.

National Cottonseed Products Association, Inc.
Post Office Box 172267
Memphis, TN 38187-2267
(901) 682-0800
Fax: (901) 682-2856
Web Site: www.cottonseed.com

Council for Biotechnology Information
This organization’s purpose is to share information about biotechnology, relying on scientific research, expert opinion, and published reports. Free information is available including a brochure, Biotechnology: Good Ideas Are Growing.

Council for Biotechnology Information
Post Office Box 34380
Washington, DC 20043-0380
(202) 467-6565
Fax: (202) 467-5777
Web Site: www.whybiotech.com
Teacher Resources and References

Field of Genes: Making Sense of Biotechnology in Agriculture
Experimental activities show how genetically engineered products are created and the impact that these products may have on agricultural production and the environment. A hard copy or compact disc of this unit may be purchased for $5 plus shipping and handling.

National 4-H Council
7100 Connecticut Avenue
Chevy Chase, MD 20815-4999
(301) 961-2934
Fax: (301) 961-2937
Web Site: www.fourhcouncil.org
Catalog Web Site: www.4hbookstore.org

Lab-Aids, Inc.
Numerous genetics and heredity hands-on modules are available. Request a free catalog.

Lab-Aids, Inc.
17 Colt Court
Ronkonkoma, NY 11779
(631) 737-1133
Fax: (631) 737-1286
Web Site: www.sepup.com

National Cotton Council
A variety of resources including brochures, stories, teaching packets and posters are available. Request a free catalog.

National Cotton Council
Communications Service Department
Post Office Box 820285
Memphis, TN 38182
(901) 274-9030
Fax: (901) 725-0510
Web Site: cotton.org

National FFA Organization
This organization has a variety of biotechnology materials available in their catalog. Most relate to careers in biotechnology.

National FFA Center
6060 FFA Drive
Post Office Box 68960
Indianapolis, IN 46268-0960
(317) 802-4334
Fax: (317) 802-5334
Web Site: wwwffa.org
### Biotechnology and Related Web Sites

This list is offered as an information resource only. It contains Web sites established by various entities and, at the time of printing, included information on biotechnology or a subject matter related to the instructional materials unit *From Genes to Jeans*. The list is not considered to be all-inclusive. The entities or contents of the sites on this list are not necessarily endorsed by the California Foundation for Agriculture or by the authors or editors of *From Genes to Jeans*.

<table>
<thead>
<tr>
<th>Web Site</th>
<th>URL</th>
</tr>
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<tbody>
<tr>
<td>Ag-West Biotech Inc.</td>
<td><a href="http://www.agwest.sk.ca">www.agwest.sk.ca</a></td>
</tr>
<tr>
<td>American Crop Protection Association</td>
<td><a href="http://www.acpa.org">www.acpa.org</a></td>
</tr>
<tr>
<td>American Farm Bureau Federation</td>
<td><a href="http://www.fb.org/issues/biotech">www.fb.org/issues/biotech</a></td>
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<tr>
<td>Biotechnology Industry Organization</td>
<td><a href="http://www.bio.org/food&amp;ag/foodwelcome.html">www.bio.org/food&amp;ag/foodwelcome.html</a></td>
</tr>
<tr>
<td>Biotechnology Information Center, National Agricultural Library</td>
<td>warp.nal.usda.gov/bic</td>
</tr>
<tr>
<td>California Farm Bureau Federation</td>
<td><a href="http://www.cfbf.com">www.cfbf.com</a></td>
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<tr>
<td>California Foundation for Agriculture in the Classroom</td>
<td><a href="http://www.cfaitc.org">www.cfaitc.org</a></td>
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<tr>
<td>Center for Engineering Plants for Resistance Against Pathogens</td>
<td>ceprap.ucdavis.edu</td>
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<tr>
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<td><a href="http://www.whybiotech.com">www.whybiotech.com</a></td>
</tr>
<tr>
<td>Food and Drug Administration</td>
<td></td>
</tr>
<tr>
<td>Center for Food Safety and Applied Nutrition</td>
<td>vm.cfsan.fda.gov/~lrd/biotechm.html</td>
</tr>
<tr>
<td>The Alliance for Better Foods</td>
<td><a href="http://www.betterfoods.org">www.betterfoods.org</a></td>
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<tr>
<td>University of California Biotechnology Program</td>
<td><a href="http://www.biotech.ucdavis.edu">www.biotech.ucdavis.edu</a></td>
</tr>
<tr>
<td>University of California Center for Consumer Research</td>
<td>ccr.ucdavis.edu/biot</td>
</tr>
</tbody>
</table>
Related Literature


Fine, Edith Hope. *Barbara McClintock: Nobel Geneticist*. Enslow Publishers, Inc., 1998. Presents the life and career of the geneticist who spent many years studying cells of maize and, in 1983, was awarded the Nobel Prize in physiology and medicine.

Fussell, Betty. *The Story of Corn*. Alfred A. Knopf, 1992. The story of corn: the myths and history, the culture and agriculture, the art and science of this crop.


Viola, Herman J. and Carolyn Margolis. *Seeds of Change*. Smithsonian, 1991. Words and photographs explain the encounter and exchange of plants and animals between the Old and New Worlds and the transformation of people and land in the 500 years since Columbus.

## Content Standards for California Public Schools

**Addressed in *From Genes to Jeans***

Obtained from the California Department of Education

### Grade 7

<table>
<thead>
<tr>
<th>Standard</th>
<th>Lesson(s) in which Standard is Taught or Reinforced</th>
<th>Standard Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cell Biology 1c:</td>
<td>Just Like Me</td>
<td>The nucleus is the repository for genetic information in plant and animal cells.</td>
</tr>
<tr>
<td>Genetics 2:</td>
<td>Let’s Get Square Design Yer Genes</td>
<td>A typical cell of any organism contains genetic instructions that specify its traits. Those traits may be modified by environmental influences.</td>
</tr>
<tr>
<td>Genetics 2b:</td>
<td>Just Like Me Let’s Get Square</td>
<td>Sexual reproduction produces offspring that inherit half their genes from each parent.</td>
</tr>
<tr>
<td>Genetics 2c:</td>
<td>Just Like Me Let’s Get Square Design Yer Genes Snappy Products</td>
<td>An inherited trait can be determined by one or more genes.</td>
</tr>
<tr>
<td>Genetics 2d:</td>
<td>Just Like Me Let’s Get Square Snappy Products</td>
<td>Plant and animals cells contain thousands of different genes, and typically have two copies of every gene. The two copies of every gene may or may not be identical, and one may be dominant in determining the phenotype while the other is recessive.</td>
</tr>
<tr>
<td>Genetics 2e:</td>
<td>Just Like Me Design Yer Genes Snappy Products</td>
<td>DNA is the genetic material of living organisms, and is located in the chromosomes of each cell.</td>
</tr>
<tr>
<td>Evolution 3:</td>
<td>Just Like Me Bird Land</td>
<td>Biological evolution accounts for the diversity of species developed through gradual processes, over many generations.</td>
</tr>
<tr>
<td>Evolution 3a:</td>
<td>Just Like Me Let’s Get Square Bird Land</td>
<td>Both genetic variation and environmental factors are causes of evolution and diversity of organisms.</td>
</tr>
<tr>
<td>Evolution 3b:</td>
<td>Bird Land</td>
<td>Understanding the reasoning Darwin used in making his conclusion that natural selection is the mechanism of evolution.</td>
</tr>
<tr>
<td>Evolution 3c:</td>
<td>Bird Land</td>
<td>Independent lines of evidence from geology, fossils, and comparative anatomy provide a basis for the theory of evolution.</td>
</tr>
<tr>
<td>Evolution 3e:</td>
<td>Just Like Me Bird Land</td>
<td>Extinction of a species occurs when the environment changes and the adaptive characteristics of a species are insufficient for its survival.</td>
</tr>
<tr>
<td>Earth and Life History 4g:</td>
<td>Bird Land</td>
<td>Explain significant developments and extinctions of plant and animal life on the geologic time scale.</td>
</tr>
</tbody>
</table>
## Content Standard Details

### Grade 7 (continued)

<table>
<thead>
<tr>
<th>Standard</th>
<th>Lesson(s) in which Standard is Taught or Reinforced</th>
<th>Standard Description</th>
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</thead>
<tbody>
<tr>
<td><strong>Science</strong></td>
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</tr>
<tr>
<td>Investigation and Experimentation 7a:</td>
<td>Just Like Me Bird Land Snappy Products</td>
<td>Select and use appropriate tools and technology to perform tests, collect data, and display data.</td>
</tr>
<tr>
<td>Investigation and Experimentation 7b:</td>
<td>Snappy Products</td>
<td>Utilize a variety of print and electronic resources to collect information as evidence as part of a research project.</td>
</tr>
<tr>
<td>Investigation and Experimentation 7c:</td>
<td>Just Like Me Let’s Get Square Bird Land Snappy Products</td>
<td>Communicate the logical connection among hypothesis, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.</td>
</tr>
<tr>
<td>Investigation and Experimentation 7d:</td>
<td>Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Construct scale models, maps and appropriately labeled diagrams to communicate scientific knowledge.</td>
</tr>
<tr>
<td>Investigation and Experimentation 7e:</td>
<td>Design Yer Genes Snappy Products</td>
<td>Communicate the steps and results from an investigation in written reports and verbal presentations.</td>
</tr>
<tr>
<td><strong>Reading/Language Arts</strong></td>
<td></td>
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</tr>
<tr>
<td>Reading 1.0</td>
<td>Just Like Me Let’s Get Square Bird Land Design Yer Genes</td>
<td>Use knowledge of words and word origins and word relationships to determine the meaning of specialized vocabulary.</td>
</tr>
<tr>
<td>Reading 1.2</td>
<td>Let’s Get Square</td>
<td>Use knowledge of Greek, Latin, and Anglo-Saxon roots and affixes to understand content-areas vocabulary.</td>
</tr>
<tr>
<td>Reading 1.3</td>
<td>Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Clarify word meanings through the use of definition, example, restatement, or contrast.</td>
</tr>
<tr>
<td>Reading 2.2</td>
<td>Design Yer Genes Snappy Products</td>
<td>Locate information by using a variety of consumer, workplace, and public documents.</td>
</tr>
<tr>
<td>Writing 1.0</td>
<td>Let’s Get Square Design Yer Genes</td>
<td>Write clear, coherent, and focused essays. The writing exhibits awareness of audience and purpose.</td>
</tr>
<tr>
<td>Writing 1.1</td>
<td>Design Yer Genes Snappy Products</td>
<td>Create an organizational structure that balances all aspects of a composition and uses effective transitions between sentences to unify important ideas.</td>
</tr>
<tr>
<td>Writing 1.2</td>
<td>Let’s Get Square Design Yer Genes Snappy Products</td>
<td>In writing, support statements and claims with anecdotes, descriptions, facts and statistics, and specific examples.</td>
</tr>
</tbody>
</table>
### Grade 7 (continued)

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<tr>
<th>Standard</th>
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</thead>
<tbody>
<tr>
<td>Writing 1.3</td>
<td>Design Yer Genes Snappy Products</td>
<td>Uses strategies of notetaking, outlining, and summarizing to impose structure in compositions.</td>
</tr>
<tr>
<td>Writing 1.4</td>
<td>Let’s Get Square Snappy Products</td>
<td>Identify topics, ask and evaluate questions, and develop ideas leading to inquiry, investigation, and research.</td>
</tr>
<tr>
<td>Writing 1.7</td>
<td>Just Like Me Design Yer Genes</td>
<td>Revise writing to improve organization and word choice after checking the logic of the ideas and the precision of the vocabulary.</td>
</tr>
<tr>
<td>Writing 2.3a</td>
<td>Snappy Products</td>
<td>Write research reports that pose relevant tightly drawn questions about the topic.</td>
</tr>
<tr>
<td>Writing 2.3b</td>
<td>Just Like Me Let’s Get Square Snappy Products</td>
<td>Convey clear and accurate perspectives on the subject.</td>
</tr>
<tr>
<td>Writing 2.3c</td>
<td>Snappy Products</td>
<td>Include evidence compiled through the formal research process.</td>
</tr>
<tr>
<td>Writing 2.4a</td>
<td>Just Like Me Snappy Products</td>
<td>State a clear position or perspective in support of a proposition or proposal.</td>
</tr>
<tr>
<td>Writing 2.4b</td>
<td>Just Like Me Let’s Get Square Snappy Products</td>
<td>Describe the points in support of the proposition, employing well-articulated evidence.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.0</td>
<td>Let’s Get Square Bird Land Design Yer Genes Snappy Products</td>
<td>Write and speak with a command of standard English conventions appropriate to the grade level.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.4</td>
<td>Just Like Me Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Demonstrate the mechanics of writing and appropriate English usage.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.6</td>
<td>Just Like Me Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Use correct capitalization.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.7</td>
<td>Just Like Me Design Yer Genes Snappy Products</td>
<td>Spell derivatives correctly applying the spellings of bases and affixes.</td>
</tr>
<tr>
<td>Listening and Speaking 1.0</td>
<td>Snappy Products</td>
<td>Deliver focused coherent presentations that convey clearly and relate to the background and interests of the audience.</td>
</tr>
</tbody>
</table>
## Content Standard Details

### Grade 7 (continued)

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</thead>
<tbody>
<tr>
<td>Listening and Speaking 1.1</td>
<td>Snappy Products</td>
<td>Ask probing questions to elicit information, including evidence to support the speaker’s claims and conclusions.</td>
</tr>
<tr>
<td>Listening and Speaking 1.2</td>
<td>Snappy Products</td>
<td>Determine the speaker’s attitude toward the subject.</td>
</tr>
<tr>
<td>Listening and Speaking 1.3</td>
<td>Snappy Products</td>
<td>Respond to persuasive messages with questions, challenges, or affirmations.</td>
</tr>
<tr>
<td>Listening and Speaking 1.4</td>
<td>Snappy Products</td>
<td>In an oral delivery, organize information to achieve particular purposes and to appeal to the background and interests of the audience.</td>
</tr>
<tr>
<td>Listening and Speaking 1.5</td>
<td>Snappy Products</td>
<td>In an oral delivery, arrange supporting details, reasons, descriptions, and examples effectively and persuasively in relation to the audience.</td>
</tr>
<tr>
<td>Listening and Speaking 2.4a</td>
<td>Snappy Products</td>
<td>When speaking, state a clear position or perspective in support of an argument or proposal.</td>
</tr>
<tr>
<td>Listening and Speaking 2.4b</td>
<td>Snappy Products</td>
<td>When speaking, describe the points in support of an argument and employ well-articulated evidence.</td>
</tr>
</tbody>
</table>

### Mathematics

<table>
<thead>
<tr>
<th>Standard</th>
<th>Lesson(s) in which Standard is Taught or Reinforced</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Number Sense 1.0</td>
<td>Just Like Me Let’s Get Square Bird Land Snappy Products</td>
<td>Know the properties of, and compute with, rational numbers expressed in a variety of forms.</td>
</tr>
<tr>
<td>Number Sense 1.3</td>
<td>Just Like Me Let’s Get Square</td>
<td>Convert fractions to decimals and percents and use these representations in estimations, computations, and applications.</td>
</tr>
<tr>
<td>Statistics, Data Analysis and Probability 1.0</td>
<td>Just Like Me Let’s Get Square Bird Land</td>
<td>Collect, organize, and represent data sets that have one or more variables and identify relationships among variables within a data set.</td>
</tr>
<tr>
<td>Mathematical Reasoning 1.0</td>
<td>Just Like Me Let’s Get Square Design Yer Genes</td>
<td>Students make decisions about how to approach problems.</td>
</tr>
<tr>
<td>Mathematical Reasoning 1.1</td>
<td>Just Like Me Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, identifying missing information, sequencing and prioritizing information, and observing patterns.</td>
</tr>
<tr>
<td>Mathematical Reasoning 1.3</td>
<td>Just Like Me Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Determine when and how to break a problem into simpler parts.</td>
</tr>
</tbody>
</table>
## Content Standard Details

### Grade 7 (continued)

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<tr>
<th>Standard</th>
<th>Lesson(s) in which Standard is Taught or Reinforced</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Mathematical Reasoning 2.0</td>
<td>Let’s Get Square</td>
<td>Use strategies, skills, and concepts in finding solutions.</td>
</tr>
<tr>
<td>Mathematical Reasoning 2.1</td>
<td>Let’s Get Square Bird Land</td>
<td>Use estimation to verify the reasonableness of calculated results.</td>
</tr>
<tr>
<td>Mathematical Reasoning 2.2</td>
<td>Just Like Me Let’s Get Square Design Yer Genes</td>
<td>Apply strategies and results from simpler problems to more complex problems.</td>
</tr>
<tr>
<td>Mathematical Reasoning 2.2</td>
<td>Design Yer Genes</td>
<td>Make and test conjectures by using both inductive and deductive reasoning.</td>
</tr>
<tr>
<td>Mathematical Reasoning 2.5</td>
<td>Just Like Me Let’s Get Square Bird Land Design Yer Genes</td>
<td>Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.</td>
</tr>
<tr>
<td>Mathematical Reasoning 2.7</td>
<td>Bird Land</td>
<td>Indicate the relative advantages of exact and approximate solutions to problems and give answers to a specified degree of accuracy.</td>
</tr>
<tr>
<td>Mathematical Reasoning 2.8</td>
<td>Bird Land</td>
<td>Make precise calculations and check the validity of the results from the context of the problem.</td>
</tr>
<tr>
<td>Mathematical Reasoning 3.0</td>
<td>Just Like Me Let’s Get Square</td>
<td>Determine a solution is complete and move beyond a particular problem by generalizing to other situations.</td>
</tr>
<tr>
<td>Mathematical Reasoning 3.1</td>
<td>Let’s Get Square Design Yer Genes</td>
<td>Evaluate the reasonableness of the solution in the context of the original situation.</td>
</tr>
<tr>
<td>Mathematical Reasoning 3.2</td>
<td>Let’s Get Square Design Yer Genes</td>
<td>Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving similar problems.</td>
</tr>
<tr>
<td>Mathematical Reasoning 3.3</td>
<td>Just Like Me Let’s Get Square Bird Land Design Yer Genes Snappy Products</td>
<td>Develop generalizations of the results obtained and the strategies used and apply them to new problem situations.</td>
</tr>
</tbody>
</table>
## Content Standard Details

### Grade 8

<table>
<thead>
<tr>
<th>Standard</th>
<th>Lesson(s) in which Standard is Taught or Reinforced</th>
<th>Standard Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Science</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemistry of Living Systems 6c</td>
<td>Design Yer Genes Snappy Products</td>
<td>Living organisms have many different kinds of molecules including small ones such as water and salt, and very large ones such as carbohydrates, fats, proteins, and DNA.</td>
</tr>
<tr>
<td>Investigation and Experimentation 9a</td>
<td>Let’s Get Square Bird Land</td>
<td>Plan and conduct a scientific investigation to test a hypothesis.</td>
</tr>
<tr>
<td>Investigation and Experimentation 9b</td>
<td>Let’s Get Square Bird Land</td>
<td>Evaluate the accuracy and reproducibility of data.</td>
</tr>
<tr>
<td>Investigation and Experimentation 9c</td>
<td>Bird Land</td>
<td>Distinguish between variable and controlled parameters in a test.</td>
</tr>
<tr>
<td>Investigation and Experimentation 9e</td>
<td>Just Like Me Let’s Get Square</td>
<td>Construct appropriate graphs from data and develop quantitative statements about the relationships between variables.</td>
</tr>
</tbody>
</table>

| **Reading/Language Arts** | | |
| Reading 1.0 | Just Like Me Let’s Get Square Bird Land Design Yer Genes Snappy Products | Use knowledge of word origins and word relationships, as well as historical and literacy context clues, to determine the meaning of specialized vocabulary and understand the precise meaning of words. |
| Reading 1.3 | Just Like Me Let’s Get Square Bird Land Snappy Products | Use word meanings within the appropriate context and show ability to verify those meanings by definition, restatement, example, comparison, or contrast. |
| Reading 2.6 | Snappy Products | Use information from a variety of consumer, workplace, and public documents to explain a situation or decision and to solve a problem. |
| Writing 1.0 | Design Yer Genes | Write clear, coherent, and focused essays. |
| Writing 1.1 | Snappy Products | Create compositions that establish a controlling impression, have a coherent thesis, and end with a clear and well-supported conclusion. |
| Writing 1.2 | Design Yer Genes Snappy Products | Establish coherence within and among paragraphs through effective transitions, parallel structures, and similar writing techniques. |
| Writing 1.3 | Let’s Get Square Bird Land Design Yer Genes | Support theses or conclusions with analogies, paraphrases, quotations, opinions from authorities, comparisons, and similar devices. |
# Content Standard Details

## Grade 8 (continued)

<table>
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<tr>
<th>Standard</th>
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<th>Standard Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Writing 1.5</td>
<td>Bird Land Snappy Products</td>
<td>Achieve an effective balance between researched information and original ideas.</td>
</tr>
<tr>
<td>Writing 1.6</td>
<td>Just Like Me Snappy Products</td>
<td>Revise writing for word choice, appropriate organization; consistent viewpoint; and transitions between paragraphs, passages, and ideas.</td>
</tr>
<tr>
<td>Writing 2.3a</td>
<td>Snappy Products</td>
<td>Define a thesis in a research report.</td>
</tr>
<tr>
<td>Writing 2.3b</td>
<td>Snappy Products</td>
<td>Record important ideas, concepts and direct quotations from significant information sources and paraphrase and summarize all perspectives on the topic.</td>
</tr>
<tr>
<td>Writing 2.3d</td>
<td>Just Like Me Let’s Get Square Snappy Products</td>
<td>Organize and display information on charts, maps, and graphs.</td>
</tr>
<tr>
<td>Writing 2.4a</td>
<td>Snappy Products</td>
<td>Include a well-defined thesis in a persuasive composition.</td>
</tr>
<tr>
<td>Writing 2.4b</td>
<td>Let’s Get Square Bird Land Snappy Products</td>
<td>Present detailed evidence, examples, and reasoning to support arguments, differentiating between facts and opinion.</td>
</tr>
<tr>
<td>Writing 2.4c</td>
<td>Snappy Products</td>
<td>Provide details, reasons, and examples, arranging them effectively by anticipating and answering reader concerns and counterarguments.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.0</td>
<td>Just Like Me Let’s Get Square Bird Land Design Yer Genes Snappy Products</td>
<td>Write and speak with a command of standard English conventions appropriate to eighth grade.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.1</td>
<td>Snappy Products</td>
<td>Use correct and varied sentence types and sentence openings to present a lively and effective personal style.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.4</td>
<td>Just Like Me Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Edit written manuscripts to ensure that correct grammar is used.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.5</td>
<td>Just Like Me Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Use correct punctuation and capitalization.</td>
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</table>
### Content Standard Details

#### Grade 8 (continued)

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<th>Standard</th>
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<tbody>
<tr>
<td>Written and Oral Language Conventions 1.6</td>
<td>Just Like Me</td>
<td>Use correct spelling conventions.</td>
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<tr>
<td></td>
<td>Let’s Get Square</td>
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<td>Design Yer Genes</td>
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<td></td>
<td>Snappy Products</td>
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<tr>
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<td></td>
<td>Use correct spelling conventions.</td>
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<tr>
<td>Listening and Speaking 1.3</td>
<td>Snappy Products</td>
<td>Use correct spelling conventions.</td>
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<tr>
<td>Listening and Speaking 1.4</td>
<td>Snappy Products</td>
<td>Use correct spelling conventions.</td>
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<td>Listening and Speaking 1.5</td>
<td>Snappy Products</td>
<td>Use correct spelling conventions.</td>
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<tr>
<td>Listening and Speaking 1.6</td>
<td>Snappy Products</td>
<td>Use correct spelling conventions.</td>
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</tr>
<tr>
<td>Listening and Speaking 2.3a</td>
<td>Snappy Products</td>
<td>Use correct spelling conventions.</td>
</tr>
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<tr>
<td>Listening and Speaking 2.3b</td>
<td>Snappy Products</td>
<td>Use correct spelling conventions.</td>
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<tr>
<td>Listening and Speaking 2.3d</td>
<td>Snappy Products</td>
<td>Use correct spelling conventions.</td>
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<tr>
<td>Listening and Speaking 2.4a</td>
<td>Snappy Products</td>
<td>Use correct spelling conventions.</td>
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<tr>
<td>Listening and Speaking 2.4b</td>
<td>Snappy Products</td>
<td>Use correct spelling conventions.</td>
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</tr>
<tr>
<td>Listening and Speaking 2.4c</td>
<td>Snappy Products</td>
<td>Use correct spelling conventions.</td>
</tr>
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</tr>
<tr>
<td><strong>Mathematics</strong></td>
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</tr>
<tr>
<td>Algebra I 24.2</td>
<td>Just Like Me</td>
<td>Identify the hypothesized conclusion in logical deduction.</td>
</tr>
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</tr>
<tr>
<td><strong>Science</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic and Biochemistry 10a</td>
<td>Design Yer Genes</td>
<td>Large molecules such as proteins, nucleic acids, and starch are formed by repetitive combinations of simple sub-units.</td>
</tr>
<tr>
<td>Organic and Biochemistry 10c</td>
<td>Design Yer Genes</td>
<td>Amino acids are the building blocks of proteins.</td>
</tr>
<tr>
<td>Genetics 2</td>
<td>Let's Get Square Bird Land</td>
<td>Mutation and sexual reproduction lead to genetic variation in a population.</td>
</tr>
<tr>
<td>Genetics 2e</td>
<td>Let's Get Square</td>
<td>Approximately half of an individual’s DNA sequence comes from each parent.</td>
</tr>
<tr>
<td>Genetics 2g</td>
<td>Let's Get Square</td>
<td>Predict possible combinations of alleles in a zygote from the genetic make-up of the parents.</td>
</tr>
<tr>
<td>Genetics 3</td>
<td>Just Like Me Let's Get Square</td>
<td>A multicellular organism develops from a single zygote, and its phenotype depends on its genotype, which is established at fertilization.</td>
</tr>
<tr>
<td>Genetics 3a</td>
<td>Just Like Me Let's Get Square</td>
<td>Predict the probable outcome of phenotypes in a genetic cross from the genotypes of the parents and mode of inheritance.</td>
</tr>
<tr>
<td>Genetics 3b</td>
<td>Let's Get Square</td>
<td>Understand the genetic basis for Mendel’s laws of segregation and independent assortment.</td>
</tr>
<tr>
<td>Genetics 3c</td>
<td>Let's Get Square</td>
<td>How to predict the probable mode of inheritance from a pedigree diagram showing phenotypes.</td>
</tr>
<tr>
<td>Genetics 4c</td>
<td>Let's Get Square</td>
<td>Mutations in the DNA sequence of a gene may or may not affect the expression of the gene, or the sequence of amino acids in an encoded protein.</td>
</tr>
<tr>
<td>Genetics 5a</td>
<td>Design Yer Genes Snappy Products</td>
<td>Understand the general structures and functions of DNA, RNA, and protein.</td>
</tr>
<tr>
<td>Genetics 5b</td>
<td>Design Yer Genes Snappy Products</td>
<td>Apply base-pair rules to explain precise copying of DNA during semi-conservative replication, and transcription of information from DNA into mRNA.</td>
</tr>
<tr>
<td>Genetics 5c</td>
<td>Design Yer Genes Snappy Products</td>
<td>Genetic engineering (biotechnology) is used to produce novel biomedical and agricultural products.</td>
</tr>
<tr>
<td>Genetics 5d</td>
<td>Design Yer Genes</td>
<td>Basic technology is used to construct recombinant DNA molecules.</td>
</tr>
<tr>
<td>Genetics 5e</td>
<td>Design Yer Genes</td>
<td>Exogenous DNA can be inserted into bacterial cells in order to alter their genetic make-up and support expression of new protein products.</td>
</tr>
</tbody>
</table>
## Grade 9 (continued)

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<thead>
<tr>
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<tbody>
<tr>
<td>Genetics 6a</td>
<td>Bird Land</td>
<td>Biodiversity is the sum total of different kinds of organisms, and is affected by alterations of habitats.</td>
</tr>
<tr>
<td>Genetics 6b</td>
<td>Just Like Me Bird Land</td>
<td>Analyze changes in an ecosystem resulting from changes in climate, human activity, introduction of non-native species, or changes in population size.</td>
</tr>
<tr>
<td>Evolution 7a</td>
<td>Just Like Me Bird Land</td>
<td>Natural selection acts on the phenotype rather than the genotype of an organism.</td>
</tr>
<tr>
<td>Evolution 7b</td>
<td>Let’s Get Square</td>
<td>Alleles that are lethal in a homozygous individual may be carried in a heterozygote, and thus maintained in a gene pool.</td>
</tr>
<tr>
<td>Evolution 7c</td>
<td>Bird Land</td>
<td>New mutations are constantly generated in a gene pool.</td>
</tr>
<tr>
<td>Evolution 7d</td>
<td>Just Like Me Bird Land</td>
<td>Variation within a species increases the likelihood that at least some members of a species will survive under changed environmental conditions.</td>
</tr>
<tr>
<td>Evolution 8a</td>
<td>Just Like Me Bird Land</td>
<td>Natural selection determines the differential survival of groups of organisms.</td>
</tr>
<tr>
<td>Evolution 8b</td>
<td>Just Like Me Bird Land</td>
<td>A great diversity of species increases the chance that at least some organisms survive large changes in the environment.</td>
</tr>
<tr>
<td>Evolution 8d</td>
<td>Bird Land</td>
<td>Reproductive or geographic isolation affects speciation.</td>
</tr>
<tr>
<td>Investigation and Experimentation 1a</td>
<td>Snappy Products</td>
<td>Select and use appropriate tools and technology to perform tests, collect data, analyze relationships, and display data.</td>
</tr>
<tr>
<td>Investigation and Experimentation 1c</td>
<td>Let’s Get Square</td>
<td>Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.</td>
</tr>
<tr>
<td>Investigation and Experimentation 1d</td>
<td>Just Like Me Bird Land Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Formulate explanations using logic and evidence.</td>
</tr>
<tr>
<td>Investigation and Experimentation 1g</td>
<td>Just Like Me Bird Land Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Recognize the use and limitations of models and theories as scientific representations of reality.</td>
</tr>
<tr>
<td>Investigation and Experimentation 1m</td>
<td>Design Yer Genes Snappy Products</td>
<td>Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings.</td>
</tr>
</tbody>
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## Content Standard Details

### Grade 9 (continued)

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<tr>
<td><strong>Reading/Language Arts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading 1.0</td>
<td>Just Like Me Let’s Get Square Design Yer Genes</td>
<td>Apply knowledge of word origins to determine the meaning of new words encountered in reading materials and use those words accurately.</td>
</tr>
<tr>
<td>Reading 1.3</td>
<td>Let’s Get Square</td>
<td>Identify Greek, Roman, and Norse mythology and use the knowledge to understand the origin and meaning of new words.</td>
</tr>
<tr>
<td>Reading 2.3</td>
<td>Snappy Products</td>
<td>Generate relevant questions about readings on issues that can be researched.</td>
</tr>
<tr>
<td>Reading 2.6</td>
<td>Design Yer Genes</td>
<td>Demonstrate use of sophisticated learning tools by following technical directions.</td>
</tr>
<tr>
<td>Writing 1.0</td>
<td>Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Write coherent and focused essays that convey a well-defined perspective and tightly reasoned argument. The writing demonstrates students’ awareness of the audience and purpose.</td>
</tr>
<tr>
<td>Writing 1.1</td>
<td>Snappy Products</td>
<td>Establish controlling impression or coherent thesis that conveys a clear and distinctive perspective on the subject and maintain a consistent tone and focus throughout the piece of writing.</td>
</tr>
<tr>
<td>Writing 1.3</td>
<td>Snappy Products</td>
<td>Use clear research questions and suitable research methods to elicit and present evidence from primary and secondary sources.</td>
</tr>
<tr>
<td>Writing 1.4</td>
<td>Let’s Get Square Bird Land Snappy Products</td>
<td>Develop the main ideas within the body of the composition through supporting evidence.</td>
</tr>
<tr>
<td>Writing 1.5</td>
<td>Design Yer Genes Snappy Products</td>
<td>Synthesize information from multiple sources and identify complexities and discrepancies in the information and the different perspectives found in each medium.</td>
</tr>
<tr>
<td>Writing 1.9</td>
<td>Just Like Me Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Revise writing to improve logic and coherence of the organization and controlling perspective, the precision of word choice, and the tone by taking into consideration the audience, purpose, and formality of the context.</td>
</tr>
<tr>
<td>Writing 2.3a</td>
<td>Let’s Get Square Snappy Products</td>
<td>Marshal evidence in support of a thesis and related claims, including information on all relevant perspectives.</td>
</tr>
<tr>
<td>Writing 2.3b</td>
<td>Let’s Get Square Snappy Products</td>
<td>Convey information and ideas from primary and secondary sources accurately and coherently.</td>
</tr>
<tr>
<td>Writing 2.3c</td>
<td>Snappy Products</td>
<td>Make distinctions between the relative value and significance of specific data, facts and ideas.</td>
</tr>
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<tr>
<td>Writing 2.3d</td>
<td>Let’s Get Square Snappy Products</td>
<td>Include visual aids by employing appropriate technology to organize and record information on charts, maps, and graphs.</td>
</tr>
<tr>
<td>Writing 2.3f</td>
<td>Let’s Get Square Snappy Products</td>
<td>Use technical terms and notations accurately.</td>
</tr>
<tr>
<td>Writing 2.4a</td>
<td>Bird Land Snappy Products</td>
<td>In persuasive writing, structure ideas and arguments in a sustained and logical fashion.</td>
</tr>
<tr>
<td>Writing 2.4c</td>
<td>Design Yer Genes Snappy Products</td>
<td>Clarify and defend positions with precise and relevant evidence, including facts, expert opinions, quotations, and expressions of commonly accepted beliefs and logical reasoning.</td>
</tr>
<tr>
<td>Writing 2.4d</td>
<td>Snappy Products</td>
<td>Address readers’ concerns, counter-claims, biases, and expectations.</td>
</tr>
<tr>
<td>Writing 2.6a</td>
<td>Let’s Get Square</td>
<td>In technical documents, report information and convey ideas logically and correctly.</td>
</tr>
<tr>
<td>Writing 2.6b</td>
<td>Let’s Get Square</td>
<td>Offer detailed and accurate specifications.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.0</td>
<td>Just Like Me Let’s Get Square Bird Land Design Yer Genes Snappy Products</td>
<td>Write and speak with a command of standard English conventions.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.1</td>
<td>Let’s Get Square Design Yer Genes</td>
<td>Identify and correctly use clauses, phrases, and mechanics of punctuation.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.2</td>
<td>Let’s Get Square Design Yer Genes</td>
<td>Understand sentence construction and proper English usage.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.3</td>
<td>Just Like Me Let’s Get Square Bird Land Design Yer Genes Snappy Products</td>
<td>Demonstrate an understanding of proper English usage and control of grammar, paragraph and sentence structure, diction, and syntax.</td>
</tr>
<tr>
<td>Written and Oral Language Conventions 1.4</td>
<td>Just Like Me Let’s Get Square Design Yer Genes Snappy Products</td>
<td>Produce legible work that shows accurate spelling and correct use of the conventions of punctuation and capitalization.</td>
</tr>
<tr>
<td>Listening and Speaking 1.0</td>
<td>Snappy Products</td>
<td>Formulate adroit judgments about oral communication. Deliver focused and coherent presentations of their own that convey clear and distinct perspectives and solid reasoning. Use gestures, tone, and vocabulary tailored to the audience and purpose.</td>
</tr>
</tbody>
</table>
## Content Standard Details

**Grade 9 (continued)**

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<tbody>
<tr>
<td>Listening and Speaking 1.1</td>
<td>Snappy Products</td>
<td>Formulate judgements about the ideas under discussion and support those judgements with convincing evidence.</td>
</tr>
<tr>
<td>Listening and Speaking 1.3</td>
<td>Snappy Products</td>
<td>When speaking, choose logical patterns of organization to inform and to persuade the audience.</td>
</tr>
<tr>
<td>Listening and Speaking 1.4</td>
<td>Snappy Products</td>
<td>When speaking, choose appropriate techniques for developing the introduction and conclusion.</td>
</tr>
<tr>
<td>Listening and Speaking 1.5</td>
<td>Snappy Products</td>
<td>When speaking, recognize and use elements of classical speech forms in formulating rational arguments and applying the art of persuasion and debate.</td>
</tr>
<tr>
<td>Listening and Speaking 1.6</td>
<td>Snappy Products</td>
<td>When speaking, present and advance a clear thesis statement and choose appropriate types of proof that meet standard tests for evidence, including credibility, validity, and relevance.</td>
</tr>
<tr>
<td>Listening and Speaking 1.7</td>
<td>Snappy Products</td>
<td>Use props, visual aids, graphs, and electronic media to enhance the appeal and accuracy of presentations.</td>
</tr>
<tr>
<td>Listening and Speaking 1.12</td>
<td>Snappy Products</td>
<td>Evaluate the clarity, quality, effectiveness, and general coherence of a speaker’s important points, arguments, evidence, organization of ideas, delivery, diction, and syntax.</td>
</tr>
<tr>
<td>Listening and Speaking 2.5</td>
<td>Snappy Products</td>
<td>Deliver persuasive arguments that structure ideas in a coherent, logical fashion.</td>
</tr>
</tbody>
</table>

**Mathematics**

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<tr>
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<tbody>
<tr>
<td>Algebra I 24.2</td>
<td>Just Like Me</td>
<td>Identify a hypothesis and conclusion in logical deduction.</td>
</tr>
</tbody>
</table>

**History/Social Science**

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<tbody>
<tr>
<td>Chronological and Spatial Thinking 1</td>
<td>Let’s Get Square</td>
<td>Compare the present with the past, evaluating consequences of past events and decisions and determining the lessons that were learned.</td>
</tr>
<tr>
<td>Chronological and Spatial Thinking 2</td>
<td>Design Yer Genes</td>
<td>Analyze how change happens at different rates at different times; understand that some aspects can change while others remain the same; and understand that change is complicated and affects not only technology and politics but also values and beliefs.</td>
</tr>
</tbody>
</table>

**Amino Acid**: The biochemical units from which all proteins are made. There are twenty different amino acids that occur most commonly in the proteins of all life forms.

**Antibiotic**: A substance that kills or prevents the growth of microorganisms; often produced by other microbes.

**Antigen**: A substance (often a protein) which triggers the production of antibodies.

**Bacterium**: A simple organism consisting of one cell or short chain of cells in which there is no nucleus. The chromosomal DNA is free within the cytoplasm as a singular circular strand.

**Base**: One of four different chemical units comprise DNA or RNA. The sequence of DNA bases codes for the amino acid sequence of proteins. These four bases are adenine, cytosine, guanine, and thymine. In RNA, uracil substitutes for thymine.

**Base Pair**: Two complementary bases on opposing strands of the sugar-phosphate ladder structure of DNA. These bases can form hydrogen bonds in only one way: adenine with thymine and cytosine with guanine. In RNA, adenine pairs with uracil.

**Biotechnology**: The development of a product or products using biological agents. In the past, these agents have been yeasts, molds, enzymes and bacteria used in such processes as wine-making and in bread and cheese production. Recently, biotechnology is identified with techniques that collectively allow the precise identification, isolation, alteration, and re-introduction of heritable traits to living organisms for specific purposes.

**Chromosome**: Rod or thread-like structures found in cell nuclei; contains the DNA molecules that make up the chromosome’s genes.

**Clone**: A group of cells or an entire organism generated from one ancestor; all cloned cells or organisms are genetically identical to the parent.

**Co-dominance**: A circumstance where the two alleles (or genes) for a specific trait are equally strong; a mixture of the two phenotypes results; e.g. pink snapdragons from a red and white cross.
**Glossary**

**Codon:** A three-nucleotide sequence of bases on RNA that specifies an amino acid. ACG would be a codon on RNA; its counterpart along the DNA strand would be TGC and is called an anti-codon. The three-base group may also act as a signal to stop or start gene translation (protein synthesis) or perform some other function of gene regulation.

**Crossing Over:** A natural process occurring during meiosis in sexually-reproducing organisms in which sections of similar chromosome pairs are exchanged, often resulting in new traits.

**Darwin, Charles:** Co-credited with the theory of evolution.

**Deoxyribonucleic Acid (DNA):** The chemical that makes up genes (the information molecules for the cell); looks like a spiral ladder, with sugar and phosphate groups the ladder sides and the four bases (adenine, cytosine, guanine and thymine) as the rungs.

**Dominant:** A gene or allele that is expressed or “shown” in the phenotype regardless of the nature of the other gene or allele.

**Enzyme:** A protein catalyst, which speeds up a specific chemical reaction.

**Evolution:** Theory that life forms change over long periods of time; the mechanism of change in natural selection.

**Expression:** The manifestation of a particular characteristic specified by a gene.

**Gene:** The basic unit of informational inheritance consisting of a sequence of DNA and generally occupying a specific position within a genome. Genes may be structural, which encode for particular proteins; regulatory, which control the expression of the other genes; or genes for transfer RNA.

**Gene Expression:** The physical manifestation of a genetic trait (phenotype). The DNA message is translated to make a protein, which ultimately gives rise to the phenotype of the cell.

**Genetic Code:** The groups of three nucleotide bases (codons) which specify a particular amino acid.

**Genetic Engineering:** The process whereby the DNA of living organisms is altered so that new traits are produced in the organism.
Glossary

Genetics: The study of DNA and heredity.

Genome: The total hereditary material of a cell’s nucleus.

Genotype: The kinds of genes an individual carries for a trait or traits.

Heredity: The passing of genetic traits, based on the DNA code, from parents to offspring.

Heterozygous: Two different genes for the same trait [for example (Ww)].

Homozygous: Two identical genes for the same trait [for example (ww) or (WW)].

Hybridization: Used in cross-breeding to produce offspring from genetically different parents; in plant production, two genetically dissimilar parents are crossed to produce a hybrid offspring.

Ligase: An enzyme used to join segments of DNA together.

Meiosis: Reproduction in sex cells where the daughter cells produced have half the number of parent chromosomes.

Mendel, Gregor: So-called “father of modern genetics”; Austrian monk who discovered how genetic “factors” were passed down; his experiments with pea plants are well-documented.

Mitosis: The process of division of the nucleus of a cell in which the chromosomes duplicate and divide to yield two identical nuclei. Nuclear division is usually followed by cell division.

Mutant: A cell or an organism that expresses traits due to a change in its genetic material.

Mutation: A random or directed change in the structure of DNA or the chromosomes.

Natural Selection: The mechanism by which evolution operates; says that individuals who are best adapted to their environment will have a better chance to pass on their genes to their offspring; “survival of the fittest.”

Nucleic Acids: DNA and RNA; large molecules made up of nucleotides in base pairings.
Glossary

**Nucleotides:** The basic units of nucleic acids; each nucleotide consists of a base, a sugar and a phosphate group. The order in which the nucleotides are arranged determines what proteins are made by the cell.

**Nucleus:** The control center of a cell; the membrane-bound structure within eukaryotic cells that contains the chromosomes.

**Phenotype:** The physical expression of a genotype.

**Plasmid:** A small ring of DNA found in many bacteria and some yeast. Plasmids are able to replicate independently of the chromosome and may pass from one cell to another. They are principal agents used in genetic engineering for cloning and transformation.

**Polymerase:** An enzyme which catalyses the synthesis of nucleic acid molecules.

**Protein:** A molecule composed of a chain of many amino acids that acquires a particular folded shape due to the amino acid sequence; both the amino acid sequences and the pattern of folding are involved in the specific functions of the protein.

**Recessive:** An allele or gene that is not expressed or “shown” in the phenotypes. This is usually “hidden” by a dominant gene.

**Recombination:** Inserting new genetic information into another living organism.

**Restriction Enzyme:** An enzyme that will cut DNA molecules only at sites where particular sequences of base pairs occur.

**Ribonucleic Acid (RNA):** Similar to DNA, but with the sugar ribose instead of deoxyribose in its structure, and with the base uracil in place of thymine; there are several forms of RNA.

**Selective Breeding:** Continuous breeding of particular organisms to obtain a desired trait or traits.

**Tissue Culture** (in plant biotechnology): The process of regeneration of a plant from single cells, isolated embryos, or small bits of plant tissue on liquid or solid media. The media is supplemented with a customized balance of nutrients and plant hormones known to induce the formulation of roots, shoots, or both from plant tissue, called callus.
Glossary

**Trait**: A specific inherited characteristic.

**Transcription**: The synthesis of a strand of RNA by cellular enzymes using the sequence of bases present in a single strand of the DNA molecule as a template.

**Transformation**: A change in the genetic composition of a cell or organism brought about by the integration and expression of purified DNA.

**Transgenic Organism**: The living thing that results from inserting foreign genetic material into another living organism.

**Translation**: Synthesis of a protein directed by the DNA sequence information encoded in a mRNA molecule.

**Vector**: The vehicle by which external genetic information is spliced into another living organism.

**Virus**: A submicroscopic infectious agent that contains genetic material but must invade a cell in order to replicate itself.