Where'd You Get Those Genes?

Grades 5-7

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Agriculture In The Classroom

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California Foundation for Agriculture in the Classroom

Vision: An appreciation of agriculture by all.

Mission: To increase awareness and understanding of agriculture among California's educators and students.

California Foundation For Agriculture In The Classroom

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California Foundation For Agriculture In The Classroom

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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 1996 by Calgene Incorporated and the California Farm Bureau Federation. To meet the needs of California educators, *Where'd You Get Those Genes?* 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.

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Introduction

What the future holds for agriculture will determine the quality of life for all . . .

- *farmers and ranchers*
- *suppliers*
- *food processors*
- *wholesalers*
- *retailers*
- *consumers!*

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 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 Earth a viable planet.

Where'd You Get Those Genes?, a fifth through seventh grade unit, introduces students to the world of agriculture and how the study of genetics and related technologies is used in the industry. Students work independently and collaboratively with classmates to learn more about heredity and biotechnology. Each lesson stands alone and can be used at different times throughout the year, or the unit can be used in its entirety as a common thread to teach the core curriculum. *Junior's Family Tree* can be taught at the beginning of the year when students are getting to know one another. This lesson is a good springboard for discussing family traits and heritage. The lesson *Rock, Paper, Scissors* has a statistical application and can be used as a math-science lesson that requires prediction and problem-solving skills. An art lesson about poster-making can be used to also teach about persuasive advertising in *Peanut Butter Broccoli*, while *The Geniacs* lesson can teach about biographies before the students write their own biographies or autobiographies. Finally, *Catch Up on Tomato Technology* has students perform research and practice public speaking.

This unit teaches or reinforces specific subject matter Content Standards for California Public Schools. The standards which may apply to each lesson are listed by grade level, subject matter, and number on the sidebars of each lesson. A content standard matrix for the entire unit, with specific standards described, is located on pages 69-77. *Where'd You Get Those Genes?* is one of many educational units provided by the California Foundation for Agriculture in the Classroom.

California Foundation For Agriculture In The Classroom

Unit Overview

Unit Length

Approximately 15 forty-minute sessions

Objectives

The students will:

- Read an interview with a horse breeder.
- Identify and record the known traits of a horse's family tree.
- Play a game and collect data regarding outcomes.
- Create an imaginary plant using the genetic concepts of dominant and recessive.
- Compare similarities and differences in traits.
- Create visual representations of data.
- Develop an advertisement for an imaginary produce item.
- Read biographies and gather key information.
- Become familiar with the history of tomato production.
- Practice oral presentation skills.

Brief Description

The students participate in a variety of lessons that examine the basic principles of heredity, as well as learn some specifics about genetics and how they are incorporated into today's agricultural industry. After reading an interview with a horse breeder, students will understand that certain traits are carried from one generation to the next. The *Rock, Paper, Scissors* activity helps students understand that some traits are dominant and others are recessive. Students are then asked to create a new produce item by combining existing traits with desirable traits. By reading biographies of scientists who have contributed to the study of genetics and biotechnology, students gain a better understanding of the history of genetic research. Finally, using tomatoes as an example, students learn how technological advances have affected tomato production.

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 lessons 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, *Where'd You Get Those Genes?*, includes lessons that can be used to teach or reinforce many of the educational content standards covered in grades five through seven. It can be used as a self-contained unit, each lesson can be incorporated into the curriculum at appropriate times, or can 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 69-77.

California Foundation For Agriculture In The Classroom

Unit Overview

Key Vocabulary

agriculture
biography
biotechnology
Burbank, Luther
Carver, George Washington
cell
chromosome
co-dominant
comparison
cross breed
deoxyribonucleic acid (DNA)
dominant
equestrian
express
family tree
Fox, Sally
gene
genetic code
genetic engineering
genetics
heredity
interview
McClintock, Barbara
Mendel, Gregor
natural selection
outcome
paint horse
produce
quarterhorse
recessive
selective breeding
technology
trait
variation

Evaluation

This unit incorporates numerous activities and questions that can be used as evaluation tools, many of which can be included in student portfolios. Embedded assessment includes oral and written responses to open-ended questions, drawing, group presentations, and other knowledge-application projects. Other evaluation factors may include active participation in class discussions and general knowledge of the subject matter.

Visual Display Ideas

- Display the student-designed diagrams of *Junior's Family Tree*.
- Display items obtained from the American Quarterhorse Association. See page 63 for ordering information.
- Have students bring in their favorite novels about horses. Display the books.
- Display the plant models developed in *Rock, Paper, Scissors*.
- In the classroom library, display the advertisements made in *Peanut Butter Broccoli*.
- Create a collage of products made from tomatoes and the technologies used in today's tomato industry.
- Make a collage or free-standing display of products changed through biotechnology.

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Junior's Family Tree

Tracing the Lineage and Traits of a Horse

Purpose

The purpose of this activity is to show that traits are passed on from one generation to the next.

Time

3 forty-minute sessions

Materials

For the teacher:

- *Meet Junior: A Quart of Paint* Interview (pages 10-13)
- *Junior's Relatives Fact Sheet* Teacher's Copy (page 17)

For each student:

- *Meet Junior: A Quart of Paint* Interview (pages 10-13)
- *Junior: A Quart of Paint Activity Sheet* (page 14)

For each team:

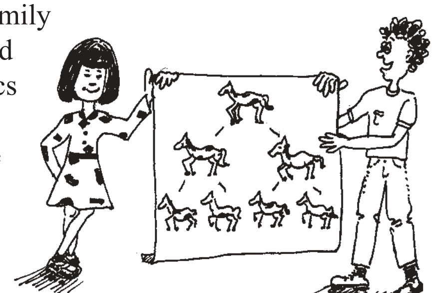
- *Junior's Family Tree Team Project* (pages 15-16)
- *Junior's Relatives Fact Sheet* (page 18)
- *Junior* (page 19)
- *Family Tree Horse Templates* (page 20)

Background Information

Throughout history, many animals and plants have been bred to perpetuate certain traits. Horses, cows, tomatoes, corn, and strawberries are just a few examples of living things that have been selectively bred by humans. Breeders of horses are very aware of horse family traits. The horse traits they breed can be visual, such as hair coloring and muscularity, or intangible, such as temperament and health characteristics.

Traits are passed down through genes in cells. Genes are made of DNA molecules. Each parent contributes one half of the genetic make-up of offspring. Your students will learn more about cells, chromosomes, and the details of heredity as they learn about the cell.

This lesson includes an interview with a horse breeder and shows students that certain traits are passed on from one generation to the next. The students will trace the family history of a horse named Junior and learn why he has the characteristics he does. Feel free to extend this activity, and have students observe and review their own family traits.



Procedure

1. Explain to the students that they are about to read an interview with a horse breeder. Read aloud and discuss *Meet Junior: A Quart of Paint* with the class.
2. Distribute the *Junior: A Quart of Paint* activity sheet to each student. Individually, have the students review the interview and then complete the worksheet. Share and discuss the student worksheets.
3. Divide the students into groups of three or four. Review the *Junior's Family Tree Team Project* with your students and set guidelines for group work. The more organizational structure you provide at the onset, the more successful the students will be. Have the students complete the *Junior's Family Tree Team Project*.
4. At the completion of the activity, have student groups display Junior's family tree. Discuss the similarities and differences between the family tree diagrams. Keep in mind that the students should not be graded on "right" or "wrong" answers in this activity.

Junior's Family Tree

Tracing the Lineage and Traits of a Horse

Materials *(continued)*

- Butcher or chart paper
- Glue
- Markers
- Rulers

Content Standards

Grade 5

Science
Investigation and Experimentation • 6h

Reading/Language Arts
Reading • 1.1, 1.5, 2.1, 2.4
Writing • 1.0, 1.3
Written and Oral Language Conventions • 1.4, 1.5
Listening and Speaking 1.1, 1.2, 1.3, 2.2

Mathematics
Statistics, Data Analysis, and Probability • 1.0, 1.2
Mathematical Reasoning 1.1, 1.2

Grade 6

Science
Investigation and Experimentation • 7e

Reading/Language Arts
Reading • 1.0, 1.1, 1.2
Writing • 1.0, 1.3, 2.2
Written and Oral Language Conventions • 1.4, 1.5
Listening and Speaking 1.3, 1.6

They should be assessed on how well they thought about the "blue-eyed" question and how well they worked in their groups.

5. Discuss that Junior obtained half of his genes from each parent and that his parents obtained half of their genes from their parents. Since blue eyes are a recessive trait, blue eyed genes had to come from both sides of Junior's family. Discuss as much or as little of this as you feel appropriate.

6. Have the students complete a paragraph that starts with a sentence similar to the one written below:

   "I learned quite a bit about traits and heredity while charting Junior's family tree."

Variations

- Choose a different animal (steer, dog) and discuss its family tree.
- Have students do the activity individually rather than in groups.

Extensions

- Invite a horse trainer to class to discuss how certain characteristics affect a horse's ability to perform certain functions.
- Have students research the characteristics needed to be a good cutting horse, racehorse, riding horse, or a horse that is part of a transport team.
- Discuss that human traits are passed on from one generation to the next. Have students give examples of traits they have inherited from their ancestors. Remember that inherited traits are not always visual but may include traits such as health and temperament. Discuss how family members feel about the traits they have inherited. Have their feelings about their traits changed over time?
- Have students make a personal family tree by interviewing an older family member.
- Have the students research how certain plants and animals have been selectively bred for certain characteristics. Good examples include corn (maize), cows, figs, grapes, and cotton.

Content Standards

(continued)

Mathematics
Statistics, Data Analysis, and Probability• 2.0, 3.0
Mathematical Reasoning 1.0, 1.1, 1.3

Grade 7

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

Reading/Language Arts
Reading • 1.0, 1.1
Writing • 1.0, 1.4
Written and Oral Language Conventions • 1.4
Listening and Speaking 1.5

Mathematics
Mathematical Reasoning 1.0, 1.1, 1.3

- Invite a seed-manufacturing representative to class or take a field trip to a seed company. Discuss the processes used to produce seeds that have desirable traits.

- Collect seed packets of different varieties of the same item such as corn, beans, or radishes. In groups, have students read the packets and analyze what characteristics they think were selectively bred for home gardeners (for example, long beans, sweet corn, mild tasting radishes, etc.).

- Have the students read the story *Corn is Maize* by Aliki (see page 67). Discuss how corn was selectively bred over time to produce the corn we have in the marketplace today.

Meet Junior: A Quart of Paint

An Interview With a Horse Breeder

Narrator: *Horses are used in a variety of ways—for working on cattle ranches, for racing, for show, for strength, etc. In this interview, you will learn about a horse named Junior: A Quart of Paint! He is part quarterhorse and part paint horse. Can you figure out how he got his name? You will have another little mystery to solve as soon as this interview is over!*

Owner: Welcome to my family's ranch. My name is Karen.

Interviewer: How long have you lived here?

Owner: I have been breeding paint and quarterhorses since 1988; however, my family has been breeding horses since the early 1950s. We have owned this property since 1961.

Interviewer: Who is this interesting horse? *(Interviewer points at a horse.)*

Owner: He is part paint horse and part quarterhorse. Meet Junior: A Quart of Paint.

Interviewer: What beautiful eyes he has.

Owner: I know! It was a real surprise when he opened his eyes for the first time! Both of his parents have brown eyes!

Interviewer: Tell me a little bit about paint horses and quarterhorses.

Owner: Well, quarterhorses have a special build. *(She points to Junior as she talks.)* They generally have big hips, a short back, a nice long neck, and a small head. Quarterhorses are bred for these characteristics. Junior is also part paint horse. A paint horse is a special kind of quarter horse. Paint horses are known for their coloring. Junior's base coloring is bay *(a brownish color)* but he has lots of white hair. It looks as though he has been painted with white paint. When I breed for offspring, I want horses with "painted" coloring and the nice build of an attractive quarterhorse.

Interviewer: Tell me what quarterhorses and paint horses are used for.

Owner: There are many breeds of horses. Quarterhorses are generally used for riding and cutting cattle. Cutting cattle means to remove a particular steer or cow from a herd of cattle and make it go where you want it to. Paint horses are also often used for pleasure riding and showing. Junior, here, would be a good horse for a young person to own. He could be a real good show horse some day. He has a real sparkle in his eye and has a lot of personality. He also has great lines.

Interviewer: Tell me a little more about his coloring.

Owner: He has brown markings on his head up to his ears. We call this a "medicine hat." Since his face is all white, we call it a "bald face." See here *(she points toward the mane and tail)* . . . he has black markings on the tip of his tail and on the part of his mane that hangs down on his forehead. All of these things are markings that an owner may or may not want on a paint horse.

Interviewer: Tell me about his parents.

Owner: Junior's mother is a mare named Heart's Delight. She is bay colored (brownish) and has a white tail with a black tip. Her legs are white and her neck and back are somewhat short. She has brown eyes. She is a very gentle horse but is very lively. In fact, I think she is more lively than Junior. By the way, she is called a dam because she is a mom.

Interviewer: What about Junior's father?

Owner: Well, we call the father of a horse a sire. His name is Triple Feature. He is a sorrel colored *(a light reddish brown)* quarterhorse. His hair, mane, and tail are all sorrel colored. He is a beautiful horse. I especially like his blaze face. A blaze face is one like this horse has here. *(She points to a horse that has a white strip that runs between his eyes and down to his nose.)* Junior's father is not quite as big as Heart's Delight. He's very calm and pleasant with good athletic ability. Junior has great athletic ability too!

Interviewer: What color are Triple Feature's eyes?

Owner: His eyes are brown! That is why I was quite surprised to see that Junior's eyes are blue.

Interviewer: Where did he get his blue eyes then?

Meet Junior: A Quart of Paint

(continued)

Owner: Well, I can tell you a little about Junior's grandparents. That may help!

Interviewer: Great! But I only have a few minutes before I have to head back to the office. Let's go for it! This is getting interesting.

Owner: Junior's mother's mother, known as a second dam, was named Pretty Papoose. She was a paint horse with brown and white body hair. She had four white legs and a blaze face. She was owned by some children. Junior's grandfather on his mother's side *(known as a "dam sire")* is named Dixie Wardrum. He is part paint and part quarterhorse and lives on our ranch. He is very gentle and docile. He is bay and white with four white socks, which are white markings on his lower legs–like socks! He has sparkling brown eyes.

Interviewer: Wow! You certainly know a lot about Junior's relatives. Can you quickly tell me about his other two grandparents?

Owner: Certainly. I know all of this information because in the horse breeding industry it's very important to know the history of your horse . We register our horses. Junior's father's mother, I guess I can call her the sire's dam, is named Welcome Home. She has an elegant long neck, is bay colored with a black mane and tail. She has four white socks. Welcome Home is a very gentle horse.

Interviewer: I am enjoying hearing the horse's names. Someday you will have to tell me how horse breeders name their horses. Anyway . . . I think you have to tell me about one more grandfather.

Owner: Yes! Junior's father's father, known as a sire's sire, is called Triple Tough and is a quarterhorse. He has two white socks on his hind legs and brown eyes. He was one of my first horses. He's a bit wild and difficult to work with. But he certainly is a beautiful horse!

Narrator: *As the owner and interviewer walk back to the ranch entrance, they stop and look at Junior one more time. He is eating grass in the pasture. He looks up at the two.*

Meet Junior: A Quart of Paint

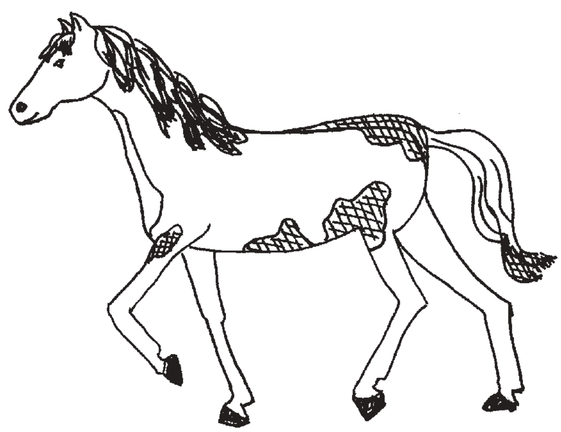
(continued)

Owner: Junior likes to eat hay and grain with rice bran in it. But he also loves spending his days in the pasture. I hope Junior will make a good show horse or a good working cattle horse. We'll just have to wait and see how well he does as he grows and gets trained.

Interviewer: Look! Junior's looking right at me. His eyes are so sparkling! Well, you never did tell me how Junior got those beautiful blue eyes! I guess I will have to figure that out on my own!

Owner: Thank you for stopping by. Come back anytime to see Junior.

Narrator: *So, how did Junior get those blue eyes?*



Special thanks to Karen Hendricks and Jennifer Harrison for providing information for this lesson.

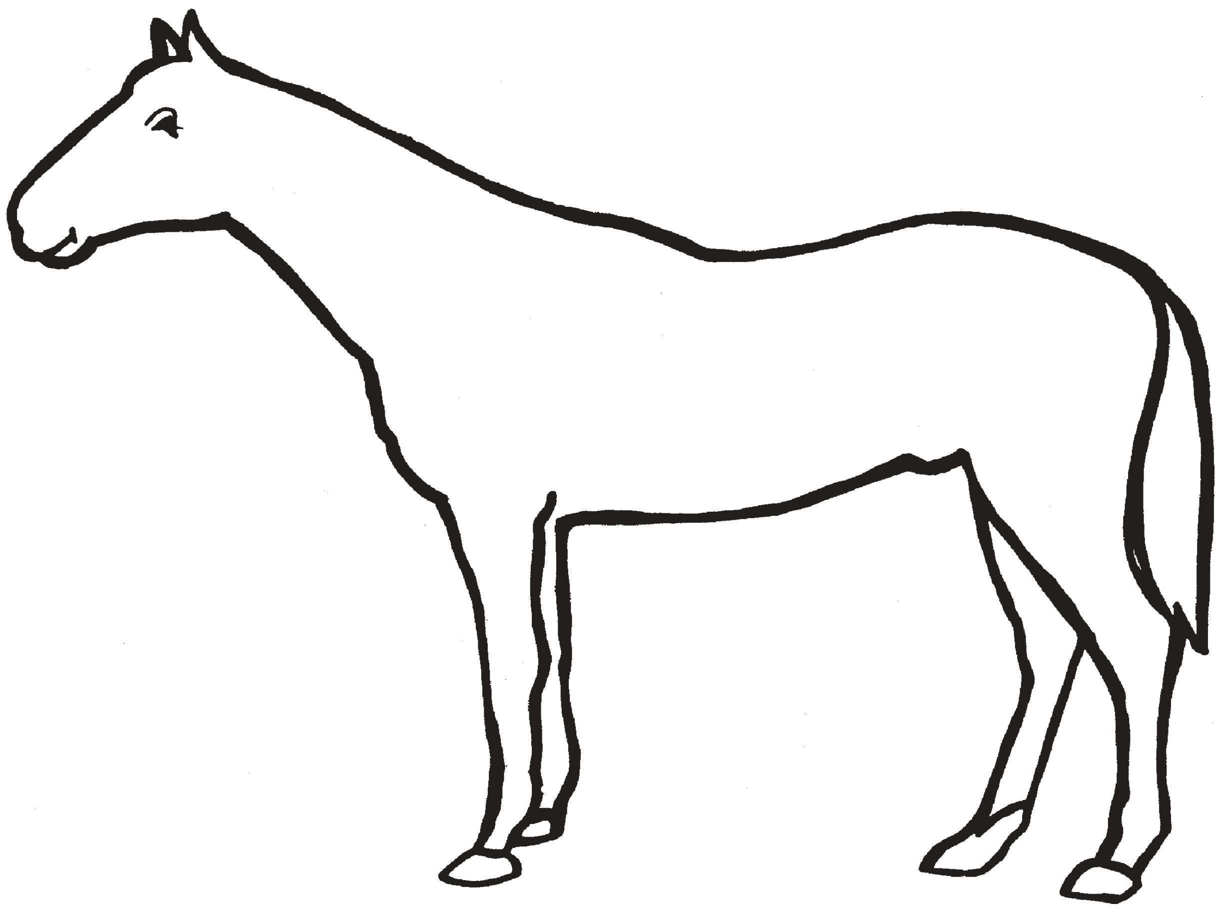
Junior: A Quart of Paint

Activity Sheet

Name ___________________

Date ___________________

After listening to the interview about Junior, color the picture as realistically as possible.



1. What are some characteristics of Junior that you were unable to show by coloring?

____

____

2. After discussing your drawing with your classmates, are there any changes you would make to the picture you colored of Junior? If so, what would they be?

____

____

____

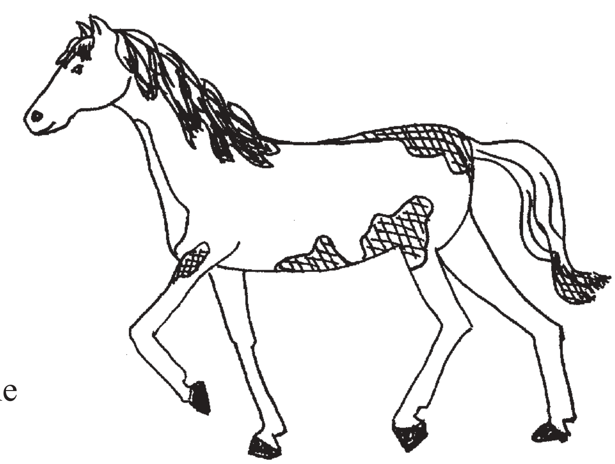
Junior's Family Tree Team Project

Horses are necessary on many farms in the United States today. Cattle ranchers use horses to round-up cattle. Certain horses are preferred for this job because they require particular characteristics. Can you imagine a rancher riding a horse that was not fast enough to help rope a calf, or a horse whose legs were too wobbly to climb a rocky mountain? Horse owners not only choose their horses for strength and agility, but they also choose horses for their temperament, strength, and appearance. You will see that horse breeding is a very complex science as you complete this activity.

You and your team will create a model of Junior's family tree using facts that you obtained from his breeder and by making assumptions of your own. Junior has a combination of his mother's and father's genes. Junior's mother and father got their genes from each of their parents. Complete the following procedure to make Junior's family tree and determine how Junior *really* got his blue eyes!

Materials

- *Junior* picture (page 19)
- Six Family Tree Horse Templates (page 20)
- Large sheet of butcher paper or construction paper
- Markers, crayons, or colored pencils
- Black marker
- Ruler
- Glue/glue stick
- *Meet Junior: A Quart of Paint* Interview
- *Junior's Relatives Fact Sheet*
- Other supplies your group brings from home



Junior's Family Tree
Team Project *(continued)*

Procedure

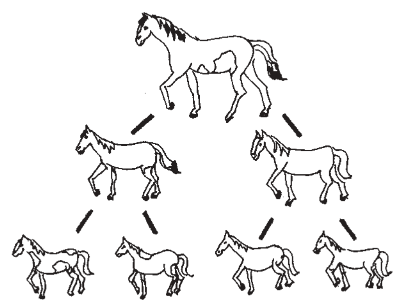
1. Establish a neat and organized work place for your team.

2. Organize the materials provided by your teacher. Listen to clean-up procedures and other rules your teacher has about the project.

3. Fill in the facts you know about Junior and his relatives on the *Junior's Relatives Fact Sheet*.

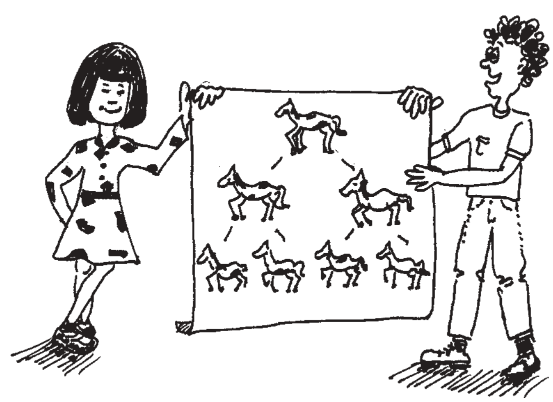
4. As a group, review what Junior really must look like. Have someone in the group color the group's picture of Junior.

5. Make a rough sketch of Junior's family tree using the diagram shown as a guide. Your rough sketch should include descriptions of each relative in the family tree. The descriptions should include appearance as well as characteristics you cannot see. Have your teacher approve your rough sketch.



6. Make your final display of Junior's Family Tree on large paper. Your family tree must include the following:

   - The names of your group members.
   - Accurately colored picture of each relative.
   - Written description of characteristics one cannot see for each relative.
   - Lines that accurately connect one horse to the next.
   - A written explanation describing where Junior got his blue eyes.
   - Any facts your group would like to add or details that add to the appearance of your display.



Junior's Relatives Fact Sheet

Teacher's Copy

Junior

Quarterhorse/Paint Horse

Bay colored *(brownish)*

Lots of white hair

Medicine hat *(brown markings on his head up to his ears)*

Bald face *(white face)*

Black markings on tail tip and on forehead mane

Blue eyes

Big hips

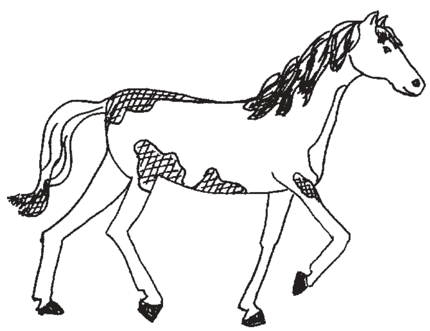
Short back

Long neck

Small head

Good, lively personality

Great athletic ability



Heart's Delight—Mother *(dam)*

Brown eyes

Bay colored *(brownish)*

White tail with black tip

White legs

Short neck and back

Lively

Triple Feature—Father *(sire)*

Quarterhorse

Brown eyes

Hair, mane and tail are sorrel *(light reddish brown)*

Blaze face

Calm and pleasant

Good athletic ability

Pretty Papoose
Mother's Mother
(second dam)

Bay colored

White legs

Paint horse

Blaze face

Gentle

Dixie Wardrum
Father's Father
(dam's sire)

Bay colored

White socks

Brown eyes

Paint and quarterhorse

Gentle and docile

Welcome Home
Father's Mother
(sire's dam)

Bay colored

Black mane and tail

White socks

Long neck

Gentle

Triple Tough
Father's Father
(sire's sire)

Quarterhorse

Two white socks

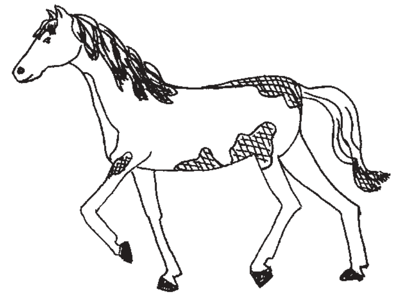
Brown eyes

Wild

Junior's Relatives Fact Sheet

Name ___________________________

Fill in the chart below with as many facts as you can about Junior and his relatives. Use this chart to help create Junior's family tree display. You may choose to make some hypotheses about some traits–if you do this, somehow mark that these are guesses and not actually proven facts.



Heart's Delight—**Mother** *(dam)*

Junior

Father—**Father** *(sire)*

Pretty Papoose
Mother's Mother
(second dam)

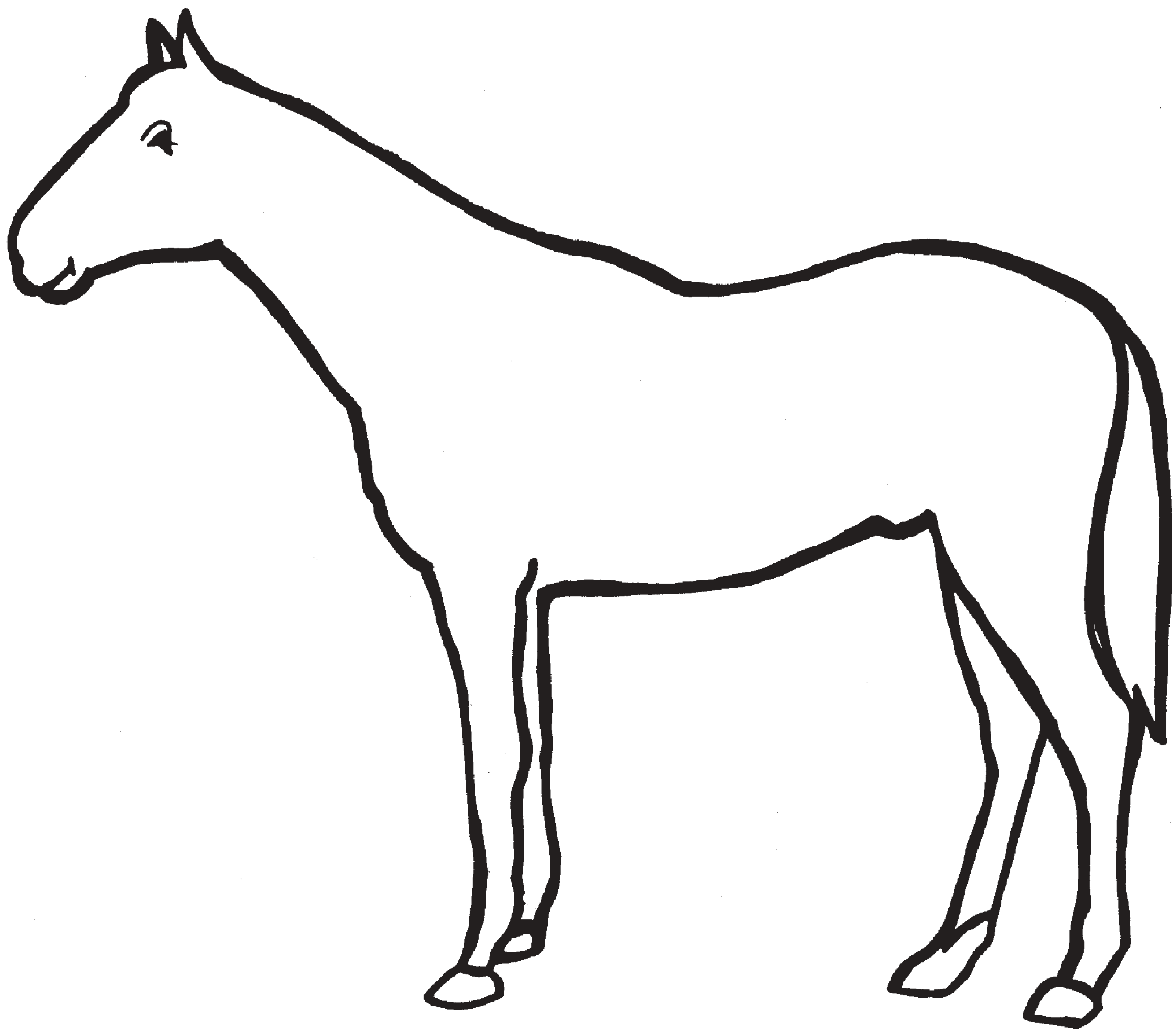
Dixie Wardrum
Mother's Father
(dam's sire)

Welcome Home
Father's Mother
(sire's dam)

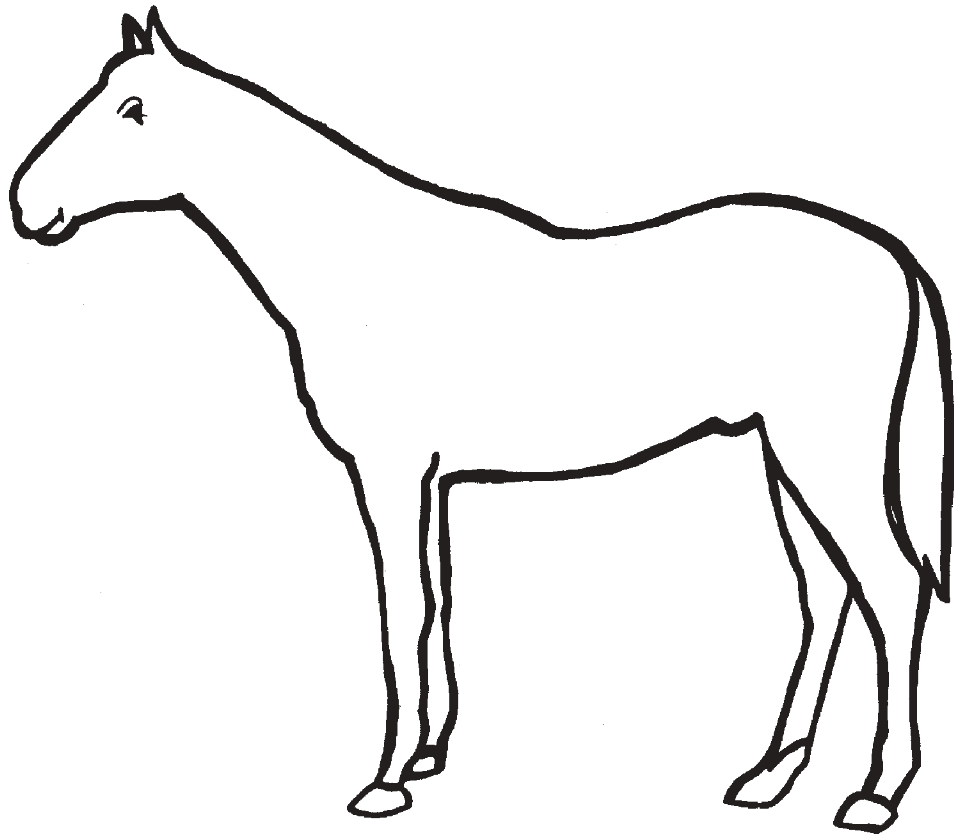
Triple Tough
Father's Father
(sire's sire)

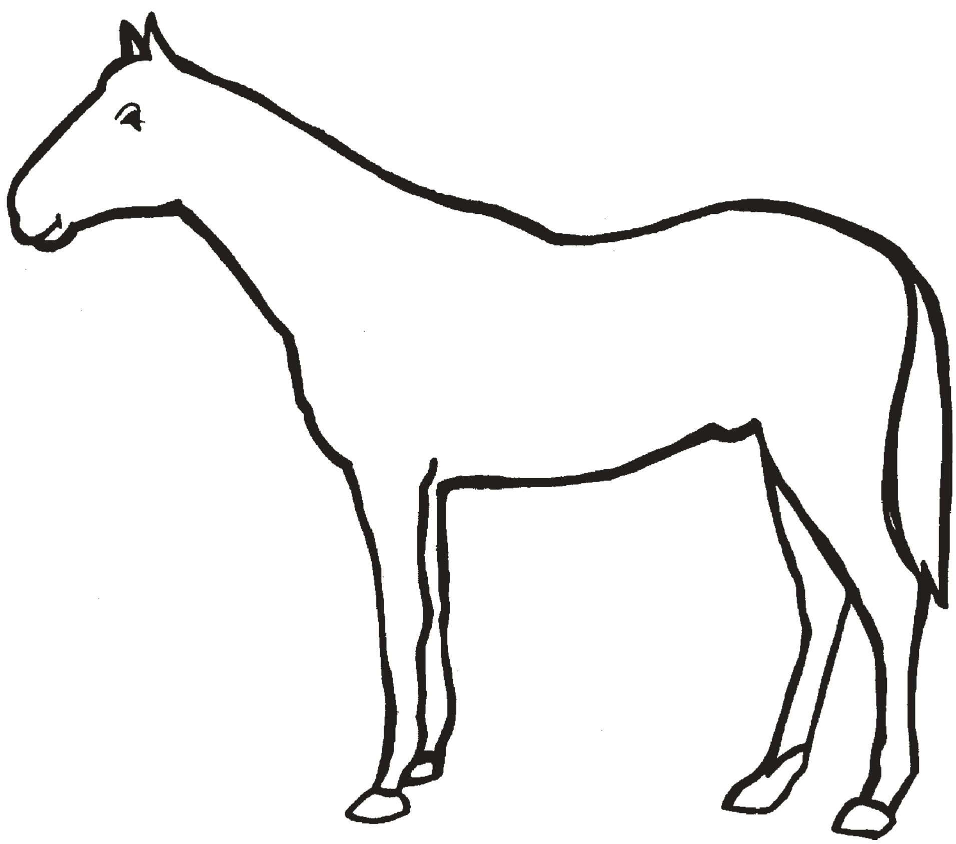
Junior

After discussing what Junior looks like with your team members, color this picture accurately and use it to begin your family tree project.



Family Tree Horse Templates





California Foundation For Agriculture In The Classroom

Rock, Paper, Scissors

Dominant and Recessive Traits

Purpose

The purpose of this activity is to understand the meaning of dominant and recessive genes and the concept of how genes determine the characteristics of offspring.

Time

2 forty-minute sessions

Materials

For each partnership:

- *Plant Features* Activity Sheet (page 25)
- *Rock, Paper, Scissors Recording Chart* (page 24)

For each student:

- *What Does It Look Like?* Activity Sheet (page 26)
- Crayons and scissors

For the class:

- Five "gene pool" containers made from shoe boxes or baskets

Background Information

When an offspring is formed, its traits are determined by a combination of genes from each parent. Each parent contributes one half of the genes for each trait. In the simplest cases, genes are either dominant or recessive. When a dominant gene combines with a recessive gene, the dominant gene's characteristics are expressed in the offspring. When two recessive genes are combined, the recessive characteristic is expressed in the offspring. Co-dominance occurs when the genes for a particular trait are equally strong. In this case, the two variations of the gene are expressed in equal strength.

In agriculture there are many examples of dominant, recessive and co-dominant traits. Some examples are listed below:

- Red potato skin is dominant over white potato skin.
- Russet colored potato skin is dominant over white potato skin.
- Green peas are dominant over yellow peas.
- Red cherry tomatoes are dominant over yellow cherry tomatoes.
- Red and white snapdragon flowers are co-dominant and produce pink flowers.
- Short and tall corn plants are co-dominant and produce medium height corn plants.
- Tall sunflower plants are dominant over short sunflower plants.
- Yellow kerneled corn is dominant over white kerneled corn.

Procedure

1. Have students list words that are associated with the words "dominant" (dominated, dominating, dominate, domain, dominance, predominant, dominator, etc.) and "recessive" (recessively, recede, recess, receded, receding, recessional, recession, etc.). Then discuss the differences between the concept of dominating a situation and receding in the same situation. For instance, if two people wanted to climb up a ladder of a slide at the same time, one person might dominate the situation by yelling it was his turn or pushing someone out of the way. Someone else might recede by walking away and playing something else. The receding person

California Foundation For
Agriculture In The Classroom

Rock, Paper, Scissors

Dominant and Recessive Traits

Content Standards

Grade 5

Science
Investigation and Experimentation • 6

Reading/Language Arts
Reading • 1.2

Mathematics
Mathematical Reasoning 1.0, 1.1, 1.2, 2.3

Grade 6

Science
Investigation and Experimentation • 7, 7c

Reading/Language Arts
Reading • 1.2

Mathematics
Statistics, Data Analysis, and Probability • 2.3, 2.4, 2.5
Mathematical Reasoning 1.1

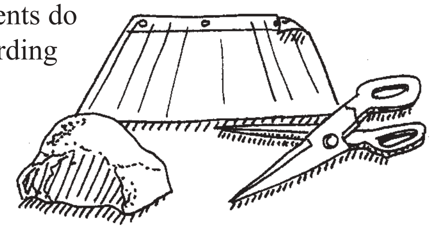
Grade 7

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

Reading/Language Arts
Reading • 1.2, 1,3

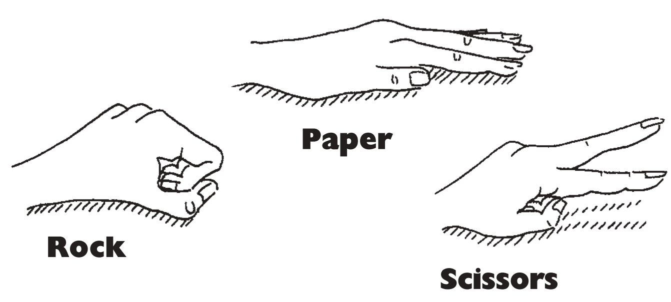
may play at the slide later when there is less competition (similar to genes). Role-play a few situations such as lining up after recess or participating in class discussions.

2. Describe the activity *Rock, Paper, Scissors*, using the words "dominant" and "recessive." Discuss that rock dominates scissors, scissors dominate paper, and paper dominates rock. Have the students do the activity with a partner, recording on a chart (provided) each partner's contribution and each outcome for several rounds. The outcome column will say either "Rock," "Paper," or "Scissors." If both people choose the same item, then it is a tie and the item that both people chose will be written in the outcome box. The procedure for the activity is described below.



How to Play Rock, Paper, Scissors

After a count of "1-2-3," each player must symbolize a rock, paper, or scissors with one hand on a desk or tabletop. The hand symbol for rock is a fist. The hand symbol for paper is a flat hand on the desk or tabletop. The hand symbol for scissors is the first two fingers cutting the air in a scissors motion. It is important that both partners reveal their chosen hand symbols at exactly the same time.



3. Discuss the outcome of the game. Are there ways of making certain one person will always dominate (win)?

4. Discuss "dominant" and "recessive" in terms of genes and heredity.

5. Have each partnership color and cut out the items on the *Plant Features* page. Place the features into the prepared "gene pool" containers (boxes, envelopes, etc.) labeled "Leaves," "Fruit,"

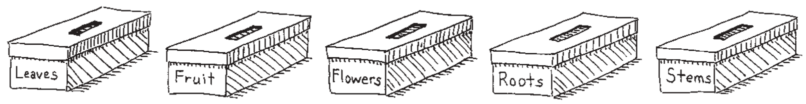
Rock, Paper, Scissors

Dominant and Recessive Traits

Content Standards
(continued)

Mathematics
Statistics, Data Analysis, and Probability • 1.0
Mathematical Reasoning 1.0, 1.1, 2.0, 2.1, 2.4, 2.5, 3.0, 3.1, 3.2, 3.3

"Flowers," "Roots," and "Stems." Each partnership will contribute a dominant and recessive trait for each feature. Place the five different boxes in different locations throughout the room.



6. Hand out to each pair of students *What Does It Look Like?* (page 26). From five separate "gene pool" containers, have each student randomly select one feature. Have the students fill in the gene chart of the features chosen. The partners then need to determine what their plant looks like. For example, if one partner chooses a dominant round fruit and the other partner chooses a recessive oval fruit, the plant will have round fruit. Have the students draw their plant showing the appropriate feature.

7. Have the students display their plants. Discuss how many dominant traits were expressed compared to recessive traits. Discuss the wide variety of plants produced from the same gene pool and how this activity shows that it would be highly unlikely for two brothers or sisters to be exactly the same.

Variations

- Have the class design their own dominant and recessive features for the gene pool.
- Rather than working in pairs, have the class create one plant on a flannel board by randomly selecting from the gene pool.
- When discussing traits that are dominant, co-dominant, and recessive, use colored chalk and a chalkboard to illustrate. Two colors can be blended for co-dominance and a recessive color can be erased.

Extensions

- Have two pairs of students cross their plants to produce offspring. The offspring would be created by a random selection of one trait from each plant's gene pool. Students could hold their traits behind their back while the other pair chose right or left hand to arrive at a trait. This process could continue through several generations. The plant's family tree could be displayed on a bulletin board.
- Based on features in an offspring, discuss what the parent plants may have looked like.

Rock, Paper, Scissors Recording Chart

Name ________________________

Date __________________________

Round	Partner A	Partner B	Outcome (Paper, Rock, Scissors)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Possible Outcomes

- Rock dominates scissors
- Scissors dominate paper
- Paper dominates rock

Conclusion

1. Which outcome was most common in your partnership? ________________________
2. Which outcome was the least common? ____________________________________
3. Were your results similar to the results of the class? __________________________
4. Describe one thing you learned about genetics by doing this activity. _______________

____

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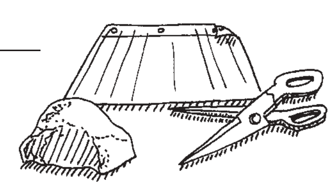
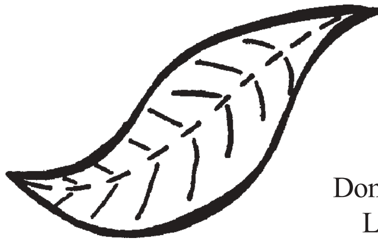
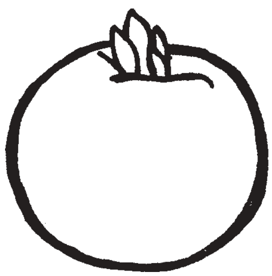
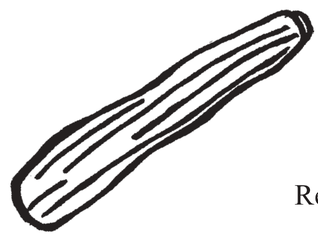
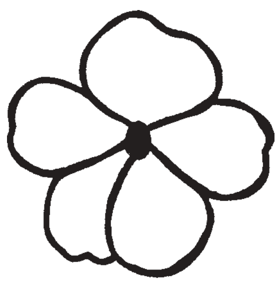
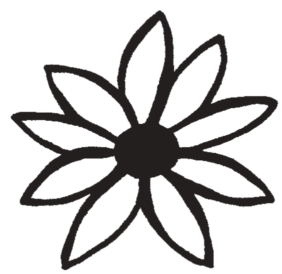
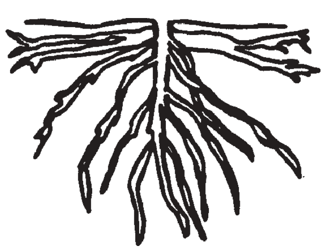
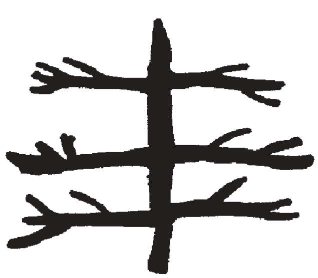
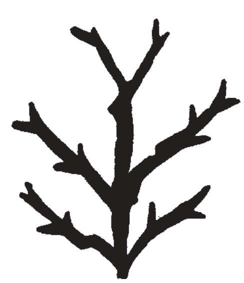


Plant Features

Color and cut out the dominant and recessive features and place them in the appropriate boxes as explained by your teacher.

	Dominant	Recessive
Leaf	 Dominant Leaf	 Recessive Leaf
Fruit	 Dominant Fruit	 Recessive Fruit
Flower	 Dominant Flower	 Recessive Flower
Root	 Dominant Root	 Recessive Root
Stem	 Dominant Stem	 Recessive Stem

What Does It Look Like?

Name ___________________________

Date ___________________________

Complete this plant diagram by following the instructions of your teacher.

Feature	Partner A	Partner B	Outcome
Leaf			
Fruit			
Flower			
Stem			
Root			

Reminder

- Two dominate traits = dominant trait
- Two recessive genes = recessive trait
- One dominant gene and one recessive gene = dominant trait

Plant Diagram

Peanut Butter Broccoli

Creating New Produce Items Through the Selection of Genetic Traits

Purpose

The purpose of this activity is to illustrate that produce items have a wide variey of traits that can potentially be combined to produce a new food. Selective breeding and genetic engineering are two ways desired traits can be incorporated into plants and animals.

Time

4 forty-minute sessions

Materials

For the class:

- Several varieties of one type of produce item such as apples, lettuce, or potatoes *(if using lettuce–iceberg, red leaf, green leaf, Romaine, endive, butter lettuce, etc.)*
- Sticky notes *(several per student)*

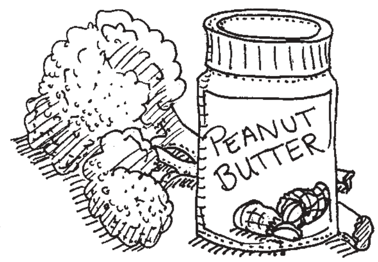
For each small group:

- Art supplies necessary to create an ad to share with the class

Background Information

Agriculture is highly responsive to the consumer demands on produce. Traditional breeding and biotechnology are used to create fruits and vegetables consumers prefer. Selective breeding is the practice of identifying certain desirable traits in a plant or animal and breeding to obtain off-spring with those desirable traits. This procedure normally takes many generations of breeding before the desired off-spring results. For example, cotton plants are continually cross-bred with each other to produce cotton with longer, silkier fibers for finer quality clothing. The beef industry continually cross-breed muscular, lean cattle to produce leaner beef.

Genetic engineering, sometimes referred to as biotechnology, is the process of adding, removing, or transferring genetic material from one organism to another. While genetic engineering has the potential to create specific desirable traits in a product, it is a complex process with limitations and is not used without great consideration. Identifying and isolating a target gene for transfer is a complex process. Scientists and biotechnology companies must consider ethics, cost, benefits and drawbacks of the process, as well as whether the final product is worth the effort.



One such product was the MacGregor tomato. This tomato was altered to resist rotting—the end result was a better-tasting fresh market tomato that could be available to consumers several months each year. This tomato proved not to be economically beneficial for continuous production. There are now other fresh market tomatoes, grown in greenhouses, that provide consumers with good-tasting tomatoes year-round.

Genetic engineering has been used to incorporate a starch gene from a bacterium into potatoes. This change allows the potato to be fried without absorbing as much oil. The end result is French fries and potato chips that contain less fat.

Besides changes made for consumer demands, biotechnology including selective breeding is used to aid in farming practices. For example, some varieties of carrots are grown because of their disease-resistant traits. Certain squash and cantaloupe varieties have been genetically altered to protect themselves against viruses; thus, fewer pesticides are required on these plants.

Peanut Butter Broccoli

Creating New Produce Items Through the Selection of Genetic Traits

Content Standards

Grade 5

Science
Investigation and Experimentation • 6a, 6g, 6h

Reading/Language Arts
Writing • 1.6
Written and Oral Language Conventions • 1.0
Listening and Speaking 1.7, 1.8

Mathematics
Statistics, Data Analysis, and Probability • 1.0, 1.2
Mathematical Reasoning 1.0, 1.1, 1.2

Grade 6

Science
Investigation and Experimentation • 7c

Reading/Language Arts
Writing • 1.3, 1.6
Written and Oral Language Conventions • 1.0
Listening and Speaking 1.8

Mathematics
Mathematical Reasoning 1.0, 1.1, 1.3

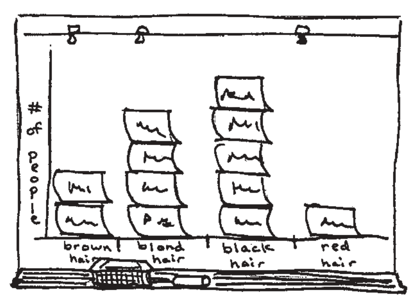
As you will continue to hear in the media, there is controversy over benefits and drawbacks of genetically engineered foods. Research continues as does open discussion about this topic. Be sure to share related news articles with your students. As always, take note of the authors of the articles and what their agendas are.

Traits from different types of plants can also be combined to form a new plant, such as broccoflower (broccoli and cauliflower combined) or plumcots (plum and apricot combined). This activity*, Peanut Butter Broccoli*, encourages students to use their imagination in designing a new produce item. How can the students improve the food they like to eat? How can they make the foods they do not like to eat more appealing? How can crops be grown to make production easier for the farmer? Is it theoretically possible to produce the food the students have created? These sensitive topics can be addressed in this fun activity.

Procedure

1. To introduce the concept of physical traits and inheritance, begin collecting information from the class regarding a certain physical trait (i.e. how many students have black hair, how many have blond hair, etc.). Differentiate between inherited traits and traits that result from changes over time (such as gray hair) or from outside sources (hair dye). Compare similarities and differences.

2. Create a bar graph showing class data you have gathered. One simple way of making a bar graph is described below:



   - Hand one sticky note to each student.
   - Have each student write his or her name on the sticky note.
   - Draw the axes of the graph on the chalkboard or on a piece of butcher paper.
   - Ask all the students with a certain trait (brown hair for example) to bring their sticky notes to the board.
   - Arrange the notes in a single column (or bar).

Peanut Butter Broccoli

Creating New Produce Items Through the Selection of Genetic Traits

Content Standards

(continued)

Grade 7

Science
Cell Biology • 1c
Genetics • 2c, 2d, 2e
Evolution • 3a

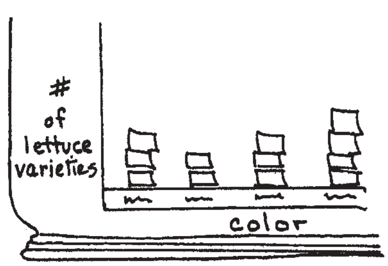
Reading/Language Arts
Writing • 1.7
Written and Oral Language Conventions • 1.0, 1.4

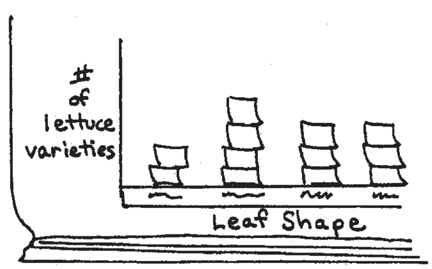
Mathematics
Statistics, Data Analysis, and Probability • 1.0
Mathematical Reasoning 1.0, 1.1, 1.3

- Ask all the students with one variation of that trait (black hair for example) to bring their sticky notes to the board.
- Arrange these notes in a single column (or bar) parallel to the first.
- Continue this procedure until all the sticky notes have been placed on the bar graph.
- Label the axes.

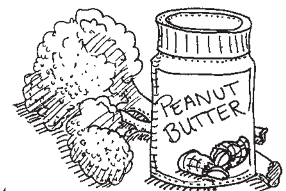
3. Review the idea of traits and that they are obtained from one's parents. Discuss that just as people have traits, so do produce items.

4. Now the students will compare several traits of a produce item such as lettuce, potatoes, or apples.
   - Divide the students into groups of 3 or 4.
   - Hand each group one variety of the produce item.
   - As a class, make a list of traits each group will analyze. If using lettuce, some traits may include leaf shape, color, head shape, taste, and leaf size.
   - To each group, pass out a sticky note for each trait to be examined (i.e. number of leaves, color, texture, size, etc.). The group should identify the expression of each trait for their variety of the produce item.
   - In advance, prepare large bar graphs for each of the selected traits for each variety. Have the students place their sticky notes on a variety of bar graphs based on the identified traits. Some examples of bar graphs are shown below.
   - Discuss the desirability and limitations of the various traits.





5. Working in teams of two or three, have the students design and promote an imaginary produce item. It should have various traits that will make it desirable for specific uses. For example, a group could create a two-pound head of broccoli that tastes like peanut butter. It can be promoted as a non-messy, healthy, family-sized snack. The following procedure may provide guidance and encourage your students to stay on task. Encourage students to think of traits other than taste, including weather adaptations, disease resistance, length of growing cycle, or nutritional value.



   - In small groups, have the students brainstorm different fun imaginary produce items that they would like to eat.
   - Have them select one item they will create.
   - Have the students decide where the desired traits will come from (i.e. another plant, bacteria, animal, eggs, etc.).
   - Explain the concepts of selective breeding and genetic engineering. Have students decide whether the item can possibly be selectively bred or must be genetically engineered. You may need to help them with this. If you are uncertain, chances are the item must be genetically engineered.
   - Have the students decide how they could promote their item.
   - Giving appropriate guidelines, have students create a magazine advertisement for their product.

6. Display the advertisements around the classroom.

7. Discuss the topic of genetic engineering and why different traits are desirable. Discuss how produce traits may be altered through natural means or through genetic engineering practices. Have the students discuss the ethics of altering traits through genetic engineering.

Variations

- Use magazine photos to design a new food item. Pictures can be cut out and combined to create the new item, such as a lettuce plant that also grows carrots and tomatoes.

- Instead of a magazine advertisement, have students create a television commercial, radio commercial, or newspaper article about their new food item. Video tape commercials or publish a class newspaper full of student articles.

Extensions

- Identify the newly created product with a new scientific binomial (the genus and species names). For ideas, students should research the genus and species of common produce items.

- Create and collect puns, jokes, and riddles relating to produce items.

- Develop uses for the newly created produce item. Write appropriate recipes.

- Discuss real produce items that are the result of combining two produce items such as a plumcot (plum and apricot), tangelo (tangerine and orange), or broccoflower (broccoli and cauliflower).

- Invite a geneticist into the classroom to describe his or her daily routine.

- Discuss the variety of marketing techniques companies use to promote their products.

California Foundation For Agriculture In The Classroom

The Geniacs

Biographies of Genetics Researchers

Purpose

The purpose of this activity is to read about and compare the lives and contributions of people who have worked in the fields of genetics and biotechnology.

Time

3 forty-minute sessions

Materials

For each small group:

- Copies of one biography (pages 35-41)
- One *Biography Comparison Chart* (page 34)

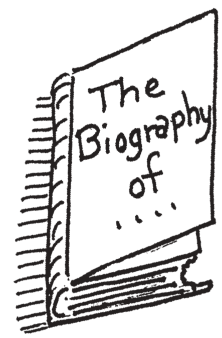
For each student:

- Writing paper

Background Information

The study of genetics formally began in 1865 by an Augustinian Monk named Gregor Mendel. In 1900, his work was rediscovered by three scientists working independently. Since then, many scientists and researchers have made important discoveries about heredity. Many studies have utilized bacteria, yeast, viruses, insects, plants, and animals, and the knowledge acquired has been applied to human genetic studies. Initially, research in genetics was very time consuming, but with the advent of modern technology and the computer, research has progressed rapidly. Like many areas of science, genetic research frequently nets results that can be applied to many situations and can be beneficial to other research in the future.

The biographies provided describe people who have had an influence on genetics in one way or another. Some of the people are well known for their work, historically, and others represent important geneticists of today. This language arts lesson can be incorporated into an autobiography lesson or biography writing assignment.



Procedure

1. Divide the students into small groups. Have each group read one of the provided biographies about a person associated with genetics.

2. Hand out a blank comparison chart (provided). Have the groups reread the biography and fill in the comparison chart for their scientist.

3. When each group is finished, have them share the information about their scientist with the class. Each group should complete the remainder of the comparison chart from the information shared by other groups. The note taking should be shared among group members. Photocopy the page for all members of the group to have.

4. Have each student write a biography about a hypothetical geneticist of the future. What discoveries will this person make? What previous discoveries led to the new discovery? What will the benefits of the discoveries be? What challenges will arise because of this discovery? Encourage students to be creative yet realistic with their writing. Have the students make an illustration or book cover that depicts their scientist and his or her discoveries.

Content Standards

Grade 5

Reading/Language Arts
Reading • 1.0, 2.0, 2.3
Writing • 1.0, 1.2
Written and Oral Language Conventions • 1.0

Grade 6

Reading/Language Arts
Reading • 1.0, 1.4, 2.0, 2.3, 2.6, 2.7
Writing • 1.0, 1.2, 2.2
Written and Oral Language Conventions • 1.0

Grade 7

Reading/Language Arts
Reading • 1.0, 2.0
Writing • 1.0, 1.7, 2.5
Written and Oral Language Conventions • 1.0, 1.4

5. Share the biographies with the class, parents, and school.

Variations

- Use an overhead transparency to fill in the comparison chart information.
- Have students research other scientists who have made a contribution to our understanding of genetics.
- Instead of writing individual biographies, have students work in pairs on an interview. One partner can pretend to be the geneticist of the future while the other partner does the interviewing. The scientist and interviewer should prepare and practice before presenting the interview to the class.

Extensions

- Encourage the students to find photographs of the scientists they study.
- Have students compile news items featuring genetic research and the scientists involved in the research.
- Have students draw “before” and “after” pictures of a contribution made by the real scientists they read about in the biographies.
- Compare the lives of the scientists in the biographies with the lives of other famous people with whom the students are familiar.
- Discuss the acceptance of the research done by each scientist and whether others felt the discoveries were important at the time. Was the research found to be beneficial long after it was first made public?
- Discuss ethical issues pertinent to the scientists’ research.
- Invite a geneticist to speak to your class. Seed companies, universities, and medical centers may have geneticists who will be willing to come to your class.

Biography Comparison Chart

Name ___________________________

Date _______________________________

Name	Nationality	Date of Birth	Scientific Contribution	Importance of Scientific Contribution	Other Contributions

Luther Burbank

(1849-1926)

The Burbank potato, Santa Rosa plum, and the Shasta daisy are all creations of an American plant breeder, nurseryman, and horticulturist named Luther Burbank. He was the 13th of 15 children. Burbank grew up on his parents' farm in Lancaster, Massachusetts. From an early age, he had a love for plants. His mother shared his interest. She had a talent for making things grow in her garden. Burbank attended Lancaster Academy, which was a college preparatory school, until the age of 21. About this time, his father died. It became necessary for Burbank to help support his family. This he did by raising and selling vegetables. He decided that he would make his living by breeding plants. Burbank found that he was especially interested in growing hybrids, which are plants produced from breeding two kinds of plants or two plants with different traits.

The event that launched Burbank's career was his development of two special potato seedlings. In his efforts to create a better potato, Burbank discovered a rare seed ball with 23 ripening seeds on one of his Early Rose potato plants. He was able to grow the seeds, two of which showed promise of producing the kind of potato Burbank was hoping to create. These two seedlings were sold to a seedsman for $150. That was enough money to let Burbank move to California to continue his plant breeding career.

Potato Plant

Burbank arrived in Santa Rosa, California in 1875. He was enthusiastic about living in a climate that would be helpful to his nursery business. In 1885, Burbank purchased a farm in Sebastopol. He was well established in the nursery business by this time and began to work on a special plum. He knew of a Japanese plum that was juicy and red in color. He knew that the plum tree would not likely survive in many of America's climates and soils, but Burbank wanted to introduce this plum to American fruit growers. Once he received twelve of the plum seedlings from Japan, he cross bred them with other stronger, but less tasty, varieties. Several generations later, Burbank produced the Santa Rosa plum—a flavorful, purple flesh plum that could grow well in California.

During his life, however, Burbank was a controversial figure. It was upsetting to some people that he would try to breed plants that were native to one area with plants that were native to another. What Burbank attempted seemed unnatural. Burbank seemed to work on an instinctive level when cross breeding plants. Many of the plants he developed served as ancestors to many of the vegetables and flowers we enjoy today.

Adapted from *Here a Plant, There a Plant, Everywhere a Plant, Plant* written by Robert Quackenbush; World Book Encyclopedia, 1984.

George Washington Carver

(1864-1943)

George Washington Carver was known as the "Plant Doctor" from a very early age. He was born in 1864 in Mississippi to parents who were slaves. Carver's parents both died before he was old enough to know them.

Although Carver did not start his formal education until he was ten years old, he was always very curious and intelligent. He had a tremendous interest in plants. Having neither education nor science books, Carver taught himself about plants by wandering through woods and fields. He studied nature and learned about the habits of plant growth through careful observation and by trying different methods of making sick plants well again. He drew and painted pictures of plants in detail.

It was important to Carver to have an education. This meant that he would have to work hard so that he could afford to go to school. He worked as a farm hand, cook, and laundry helper. At first, when Carver attended college, he wanted to be an artist. Then his desire to learn more about botany grew. Botany is the study of plants. Carver first entered Simpson College in 1890 when he was 25 years old. After a couple of years at Simpson College, Carver was admitted to Iowa State College to study agriculture. He studied botany, chemistry, mathematics, bacteriology, zoology, and entomology. He also continued painting, winning several prizes, including an honorable mention from the World's Fair in Chicago. By 1896, Carver received a bachelor's degree and then a master's degree in agriculture from Iowa State University.

Tuskegee Institute was an important part of George Washington Carver's life. In 1896, he moved to Alabama to become a member of the faculty at Tuskegee. His first job was agricultural department head and director of a state agricultural station. In 1910, Carver became head of Tuskegee's newly formed Department of Research. He spent the rest of his life at Tuskegee Institute.

George Washington Carver is remembered for many accomplishments. While at Iowa State College, he established a fungi collection that brought him fame. He was also able to persuade farmers in the South to grow crops other than cotton. Through research he had done, Carver knew that peanuts would be a good crop for Southern farmers to grow in a field that had just grown cotton. Cotton takes nitrogen out of the soil when it is growing. When only cotton is grown on the same soil year after year, the soil becomes very poor. Its lack of nitrogen makes it harder and harder for the farmer to grow a good crop of cotton. Peanuts put nitrogen back into the soil when they are growing. Peanut crops can help poor soil become nitrogen-rich and better for growing crops.

George Washington Carver

(continued)

After an invasion of a pest very harmful to cotton called the boll weevil, farmers were eventually willing to try growing peanuts. With so many peanuts being grown, it became important to create products that used peanuts so the farmers could sell their crops. Carver developed over 300 products from peanuts, including peanut butter, soap, oil, and shaving cream. Carver also made more than 100 products from the sweet potato. He was one of the first chemurgists. Chemurgy is a field of science that finds new uses for plants, uses for plant waste products, and develops new plants for industrial use.

Peanut Plant

Cotton Plant

George Washington Carver never married nor had a family. He donated his life savings of $33,000 to the George Washington Carver Foundation for Agricultural Research which was established in 1940 at Tuskegee. Today, the George Washington Carver Museum at the Tuskegee Institute houses Carver's discoveries, collection, and paintings.

Adapted from *African American Scientists* by Robert C. Hayden; World Book Encyclopedia, 1984.

Barbara McClintock

(1902-1993)

Barbara McClintock was a disciplined scientist of keen intelligence. She was born the third of three daughters to Sara and Thomas Henry McClintock in Hartford, Connecticut in 1902. She also had a younger brother. In 1908, McClintock moved with her family to Brooklyn, New York, where she attended school.

Contrary to what was popular for women at the time, McClintock was determined to continue her education when she reached college age. She attended Cornell University in Ithica, New York in 1919. It was here that she truly became interested in science. McClintock received her Bachelor of Science degree in 1923. Her next stop was to register as a graduate student in the botany department. She was especially interested in the genetic study of maize, or Indian corn. Maize is a colorful kind of corn. On one ear there may be kernels of several colors and patterns. Geneticists can study generations of maize to learn how the colors are inherited. As a graduate student, McClintock was able to identify each of the ten chromosomes in maize. Chromosomes are inside cells and carry hereditary information. It was revolutionary that these microscopic comparisons could be made.

Corn Plant

McClintock continued her education, earning her master's degree in 1925 and her doctorate in 1927. Being a research scientist was McClintock's choice of careers. Between 1929 and 1931 she published articles that told about her work. She and her colleagues were making progress in understanding the genetic make-up of maize. In 1931, she made a very important discovery. Her research proved that chromosomal material is exchanged during a special kind of cell division called meiosis. That same year she left Cornell. She continued her research for several years while being associated with several schools and research organizations. In 1941, she became a member of the Carnegie Institution at Cold Springs Harbor.

It was at Cold Springs Harbor that McClintock made the most important discovery of her career. When this discovery was made, McClintock had been studying maize for about 25 years. McClintock's research seemed to show that genes on chromosomes could move. She also believed that when genes did "jump" they made a difference in the way the plant looked because of their new location on a chromosome. Her theory became known as "jumping genes." This theory did not go along with what scientists who studied heredity and genetics had believed.

In 1951, McClintock published and presented her findings to a group of scientists at Cold Springs Harbor. Most of the scientists at the meeting did not understand how important

Barbara McClintock

(continued)

McClintock's information was. It was not until the mid-1970s that McClintock's research was given the credit it deserved. In 1983, she received a Nobel Prize for her research and discoveries. It is not common for a woman to receive a Nobel Prize. It is also not common for anyone to receive the Nobel Prize for work that was done 40 years before.

Barbara McClintock lived and continued to do research for ten years after she received her Nobel Prize. Geneticists have been able to learn about heredity and how genes work and influence the way plants, animals, and people are. Scientists are able to apply their knowledge in ways that would have seemed impossible at the beginning of McClintock's career. Much of what is known today has its basis in the life long work of Barbara McClintock.

Adapted from *Women and the Nobel Prize* by Barbara Shiels; Winners Publishing Company, 1985.

Gregor Mendel

(1822-1884)

The science of genetics had its start with Gregor Mendel. He was born in Heinzendorf, Austria in 1822. His parents were peasant farmers. Mendel's interest in plants and animals began on the farm where he learned about growing crops and beekeeping. He was an excellent student. In 1943 at the age of 21, Mendel entered the monastery of St. Thomas in Brunn, Austria, and became a priest in 1847.

Besides being a religious center, the monastery was an important place of science. Mendel was exposed to many scholars at St. Thomas. The monastery also had a fine botanical garden. Mendel taught biology and physics at the local high school for fourteen years beginning in 1853. During this time, he began his now-famous research on peas and heredity. When Mendel was elected abbot of the monastery in 1868, he found that his new administrative duties limited his time for research.

Pea Plant

Mendel studied the expression of seven traits in the garden pea plants and their pea seeds. Three of the traits were seed shape, seed color, and plant height. Mendel cross-pollinated the plants, harvested the offspring, sorted and kept records of each separate trait. Through his studies, Mendel believed that traits are handed down through gametes, which contained hereditary elements. These elements are now called genes. He also found that some traits were dominant and some were recessive. Dominant traits are expressed in the plant while recessive traits may or may not be expressed in the present generation but may show up in future generations. Mendel did work with round and wrinkled seeds as well as tall and short plants. Mendel also determined that each parent plant hands down to offspring only one of its pair of genes for each trait.

In 1866, Mendel published what he had learned about heredity in pea plant heredity. Mendel presented his paper to fellow scientists. It was sent to more than 100 libraries, scientific societies, and universities. What he said in his paper was very complex. It used math in a way that scientists had not thought of before. That kind of math is now called probability and statistics. People did not understand how important Mendel's work was until 30 years later. By that time, Mendel had been dead for sixteen years. Finally, in 1900, three scientists in three different countries, who were each working separately, rediscovered what Mendel stated in his paper. Then Mendel's work received the recognition and value it deserved.

Adapted from *Why You Look Like You Whereas I Tend to Look Like Me* written by Charlotte Pomerantz; World Book Encyclopedia, 1984.

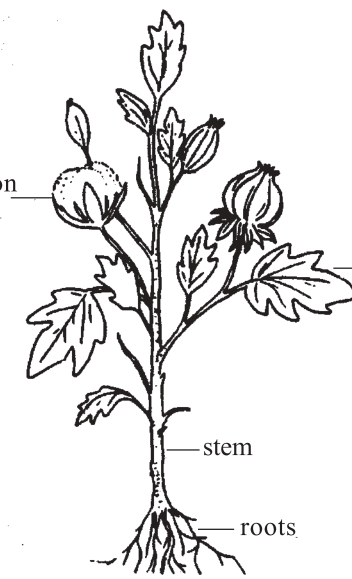
Sally Fox

(1956 to Present)

Little did San Francisco native Sally Fox know when she was a teenager that she would one day be a world-famous inventor of "naturally colored cotton."

Fox, born in 1956, attended Cal-Poly, San Luis Obispo where she studied entomology – the study of insects. But her hobby of spinning yarn and thread from wool, cotton, and even dog hair, made her curious about spinning new kinds of fiber.

While working for a cotton breeder in Davis, California, Fox received some seeds for brown cotton. Most cotton is white with long, silky fibers well suited for spinning. It is dyed various colors to make clothing and fabrics. Brown cotton naturally has short fibers which means it is not very easy to spin into yarns for clothing.



Cotton Plant

Fox planted the brown cotton seeds in pots in her backyard and then crossbred them with white cotton seeds. Eventually the brown cottons began to get longer fibers; soon they were long enough to spin. To her surprise, a green cotton emerged which she also began to breed with white cotton.

In order to support her cotton enterprise, Fox worked as a microbiologist at a biological insecticide plant. She kept breeding her new brown and green cotton and eventually began growing several acres of it near Bakersfield, California. When enough of the cotton was available, she began selling it to textile mills. It is now made into jeans, T-shirts, towels, and sheets.

Some of the cotton growers in the Bakersfield area were concerned that if Sally grew large fields of colored cotton, the pollen might travel to large white cotton fields and make the white cotton a different color. If this happened then the white cotton growers may not get as much money for their so-called "white cotton." Due to the presented challenge and Ms. Fox's desire to continue to grow colored cotton, she decided to relocate her operation.

Today Sally Fox has a farm and marketing operation in Wickenburg, Arizona. Her cottons are sold all over the world for use in a wide variety of cotton products. She is currently working on a new brick-red colored cotton. Her hope is to develop even more naturally colored cotton.

Information obtained by freelance journalist Beth Brookhart and curriculum specialist Pamela Emery.

Catch Up on Tomato Technology

A Study of How Tomato Production Has Changed Over the Years

California Foundation For Agriculture In The Classroom

Purpose

The purpose of this lesson is for students to see how technological advances have benefited a particular commodity. Skills in collaborative working, critical thinking, and oral communication are emphasized.

Time

3 forty-minute sessions

Materials

For each small group:

- One of the seven *Tomato Fact Sheets* (pages 47-54)
- *Tomato Display Guidelines* (pages 45-46)
- Art supplies, as needed, to create a visual representation to share with the class

For each student:

- *What I Learned . . . and Still Want to Know!* (page 55)

Background Information

It is agriculture's quest to grow more and better crops using fewer resources. Many factors affect the production of a crop. Selective breeding, genetic engineering, and better farming practices have enabled tomato growers to produce crops that are more plentiful, safer for the environment, more nutritious, and better tasting.

Natural selection is the process of having certain traits selected and expressed over time. In natural selection, the traits that are passed on from one generation to the next have to do with environmental conditions and other natural processes. One of the most noted studies of natural selection is Charles Darwin's study of the finches on the Galapagos Islands.

Selective breeding is the process of purposely crossing two plants, animals, bacteria, yeasts, or viruses with desired traits to produce offspring with those desired traits. For example, a tomato plant that produces large tomatoes might be crossed with a tomato plant that produces sweet tomatoes in order to produce large, sweet tasting tomatoes. Selective breeding practices have occurred for a very long time. The book *Corn is Maize* by Aliki (see page 67) describes the selective breeding that occurred to produce the sweet corn we eat today.

Genetic engineering is a process where genetic material (DNA) is taken from one organism and inserted into the genetic code of another organism. This science has progressed because scientists now know that a gene for a certain trait is a universal gene. That is to say, a gene for the color red in bacteria can also produce a red color in other species of living organisms. The MacGregor tomato was created by using bacterial genes to manipulate a tomato gene which causes softening in tomatoes. Using advanced scientific techniques, the gene for ripening is removed from the tomato DNA and reinserted backwards rendering it inactive. Genetic engineering processes are very complex and can be studied by students when they take advanced science courses in high school.

You and your students will take a closer look at the history of the tomato and observe how various scientific techniques have produced

Catch Up on Tomato Technology

A Study of How Tomato Production Has Changed Over the Years

California Foundation For Agriculture In The Classroom

Content Standards

Grade 5

Reading/Language Arts
Reading • 2.1, 2.3, 2.4
Writing • 1.6
Written and Oral Language Conventions • 1.0
Listening and Speaking 1.0, 1.1, 1.2, 1.3, 2.2

Grade 6

Reading/Language Arts
Reading • 1.0, 1.1, 2.0, 2.3, 2.4
Writing • 1.1
Written and Oral Language Conventions • 1.0
Listening and Speaking 1.0, 1.4, 1.5, 1.6, 2.2

Grade 7

Reading/Language Arts
Reading • 1.0, 1.3, 2.0, 2.6
Writing • 1.0, 1.3, 1.7
Written and Oral Language Conventions • 1.0
Listening and Speaking 1.0, 1.3, 1.4, 1.5

the fresh market and processing tomatoes farmers grow today. Many social issues related to technological advances can be discussed throughout this activity.

Procedure

1. Make several copies of the tomato fact sheets. Gather the art supplies you would like your students to use for the development of their visual aids.

2. As a class, read and discuss the *Catch Up on Tomato History* reading provided in this packet.

3. Divide the class into small groups. Give each group a different tomato fact sheet. Have the student groups read and discuss the information.

4. After making sure that each group understands the facts and focus of their fact sheet, distribute the *Tomato Display Guidelines* to each group. Have each student group decide how they will present their knowledge to the class.

5. Allow the students time throughout the week to design and complete their display.

6. At an appropriate time, have the students explain their displays to the class and complete the *What I Learned . . . and Still Want to Know!* activity.

7. Share the student displays with the rest of the student body, parents, and faculty by placing them in the library or other appropriate location.

Variations

- Have each student group research and make a display of the history and development of a different food or fiber commodity.

- Use the visual representations to make a large bulletin board or time line about tomato development.

Extensions

- Use calculators to project quantitative increases in the production of crops. For example, if production improvements are known for one plant, a calculator may be used to help the student discover production increases per acre.
- Collect news articles about new developments in tomato production and/or other commodities. Discuss how technological advances are affecting the world's food supply.
- Research the development and production of tomatoes and other crops in other countries. Determine whether their developments are similar to those in the United States.
- Write a news article or comic strip about an imaginary future development in tomato production.
- Write a tomato grower. Have this person discuss his/her operation and how advances in technology have assisted or challenged tomato production.
- Have a tomato product tasting party where students try various tomato dishes using spaghetti, salsa, and fried green tomatoes!
- Read the book *88 Pounds of Tomatoes* (see page 68) and have students do related math problems.

Tomato Display Guidelines

In your small groups, follow the procedure described below.

1. Read and discuss your tomato fact sheet.

2. Write down at least five new things you learned from your fact sheet that you would like to share with others.

3. Discuss and write down how the facts have affected the tomato industry and consumers.

4. Discuss any challenges your fact sheet mentions.

5. As a group, decide how you would like to share the information you have gathered. Some possible ideas are listed below. You may use one or more of the suggestions or an idea of your own.

   - Cartoon strip
   - Charts or graphs
   - News editorial
   - Pictures
   - Radio news report
   - Television news report
   - Science fair display
   - Before and after pictures
   - Diorama
   - Skit with props

1. Organize the appearance of your final product and decide what each person's responsibilities are. **Have your plan approved by your teacher before beginning your final product**.

2. Prepare your display, making sure you have enough time to complete your work by the deadline.

3. Determine what each person will say when presenting your display to the rest of the class. Practice your presentation.

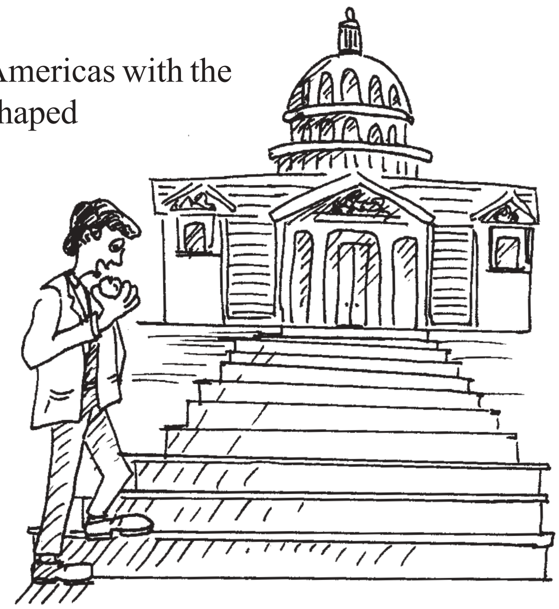
4. Present your display to the class and listen to the other presentations.

Catch Up on Tomato History

People used to think tomatoes were poisonous and for years no one ate them. Let's learn a little more about the tomato's history.

Tomatoes first grew as wild, cherry-sized berries in the South American Andes. But the tomatoes we eat today were developed in Mexico. Tomatoes are known as a "tomatils" in Mexico. People kept pollinating the large sized cherry tomato flowers with other large sized cherry tomato flowers so the fruit would be larger. This process is called selective breeding.

The tomato traveled to Europe and returned to the Americas with the Conquistadors. In Italy, the tomato appeared heart-shaped and was called *poma amoris*, which means "love apple."



The American colonists believed that since the tomatoes were related to the deadly nightshade plant, they were poisonous and avoided eating them. In 1820, Robert Gibbon Johnson bravely stood on the New Jersey courthouse steps and ate a tomato! He never got sick and lived to the age of 79!

Since then, the tomato has become increasingly popular, not only as a fresh product in salads but in many ethnic food dishes. Italian and Mexican cuisine feature tomato recipes including salsa, pasta, and tortilla sauces.

There are two kinds of tomatoes grown by farmers: **fresh market tomatoes**, which are purchased at grocery stores for use in salads and other dishes, and **processing tomatoes**, which are used to make tomato sauce, catsup, salsa, and other processed products. Generally, fresh market tomatoes are picked by hand while processing tomatoes are picked by machine.

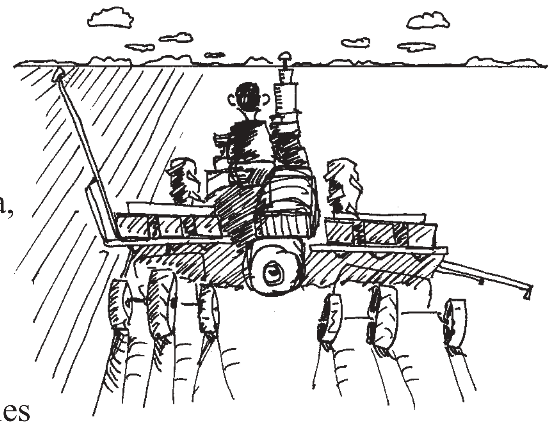
You will learn more interesting information about the tomato as you work in your teams on a tomato project.

Information obtained from *Blue Corn and Square Tomatoes* by Rebecca Rupp; Story Communications, Inc., 1987.

Tomato Planting

Fact Sheet #1

Tomato seed can cost from $40 to $865 per pound, depending on the type and variety of seed to be planted. The more expensive seeds produce tomatoes with specific characteristics such as thicker skins or less juice. Seeds are collected from tomatoes that have been grown in greenhouses or from fields that are carefully monitored. Farmers plant one-half to one pound of seed per acre.



Processing tomatoes are planted by putting seeds in the ground or by planting a small tomato plant, called a transplant, into the ground. The transplants are grown from a seed in a greenhouse. In California, tomatoes are planted from January through June. Processing tomato farmers have contracts with tomato processing companies that make products such as tomato paste and catsup. The contracts state what variety of tomato and at what time the companies want the tomatoes at the processing plant. This is so the processing plant does not have too many or not enough tomatoes at any given time. The farmer must predict when to plant the seeds so tomatoes are ready at the appropriate harvest time. When the seedlings reach two to three inches in height, farm workers thin out the plants so they are six to ten inches apart from each other. Plants that are too close together compete for nutrients and the plants will produce smaller tomatoes.

Fresh market tomatoes are the kind people put into salads. Farmers purchase seedlings from a supplier and the seedlings are placed into the ground by a special planter pulled by a tractor. Planting seedlings rather than seeds insures a higher rate of survival. This, then, insures a greater yield of fresh market tomatoes per acre. Fresh market tomatoes are more expensive than processing tomatoes because of the greater labor involved at the farm, during transport, and storage.

Both types of tomatoes, processing and fresh market, are irrigated six to ten times during the growing season. The farmer stops irrigation two to four weeks before harvest. The halt of irrigation makes the vines die back for easy harvest and makes the tomatoes firmer because they contain less water. Processing tomato farmers get paid more if their tomatoes have less juice. The tomatoes are simmered to remove water to make a paste—the less extra water there is, the more paste produced. Fresh market tomato growers need to make sure their tomatoes are not too mushy for transport.

Information obtained from Bruce Rominger, a tomato grower in Winters, California; and Andy Kennedy, a tomato field representative and buyer for the Colusa County Canning Company in Williams, California.

Tomatoes and Your Health

Fact Sheet #2

Even though tomatoes were at one time thought to be poisonous, they have been a common household food in the United States since the colonial days. Thomas Jefferson grew tomatoes in his garden at Monticello.

The reason tomatoes were once thought to be poisonous is because they belong to the nightshade family. Members of this botanical family, including potatoes, tobacco, and petunias, contain alkaloids. Alkaloids, such as nicotine, strychnine, and morphine, can be quite toxic. Tomato plant leaves and stems contain the alkaloid tomatine. It is present only in small quantities in green tomatoes and disappears as the tomatoes ripen. Historically, people did not know this and considered the tomato inedible.

Tomatoes are eaten fresh and in processed forms including tomato paste, catsup, salsas, and sauces. Since 1994, California has produced about 10 million tons of processing tomatoes on 300,000 acres of land each year. Eighty-five percent of American households purchase fresh tomatoes each year. Ninety-nine percent of American households eat processed tomato products, such as catsup and tomato sauce, each year.

Tomatoes, as compared to other foods such as broccoli and spinach, are not high ranking as a source of vitamins. A major study of fruits and vegetables ranks tomatoes sixteenth as a source of vitamin A and thirteenth as a source of vitamin C. But since people eat so many, tomatoes rank third in consumption as a source of both vitamins A and C.

Nutrition Facts

Serving Size
1 Medium Tomato
(5.5 oz./148 g)

Amount Per Serving	
Calories 35	
Fat	1g
Carbohydrates	6g
Dietary Fiber	1g
Sodium	10mg
Protein	1g
	%U.S. RDA
Vitamin A	20
Citamin C	40
Calcium	*
Iron	2

* less than 2 percent of U.S. RDA

Source: U.S. Food and Drug Administration

Studies show that processing tomatoes are the leading source of lycopene in the American diet. Lycopene is an antioxidant, a type of chemical that blocks damage to cells in the human body. Antioxidants such as lycopene help prevent certain kinds of cancer.

In most cases, tomatoes are used in cooking. However there are a few interesting uses for the tomato plant and fruit. Some people believe that putting tomato juice on surfaces (like your dog's fur!) that have been exposed to skunk "perfume" removes the skunk odor. Tomato pulp salve was used in colonial days to heal certain skin irritations. The alkaline tomatine is used medicinally today in ointments for the treatment of fungal diseases. Perhaps you have heard of some interesting uses for tomatoes or tomato plants.

Information obtained from *Begert's Nutritional and Physical Fitness* by George M. Briggs, W.B. Saunders Company, 1979.

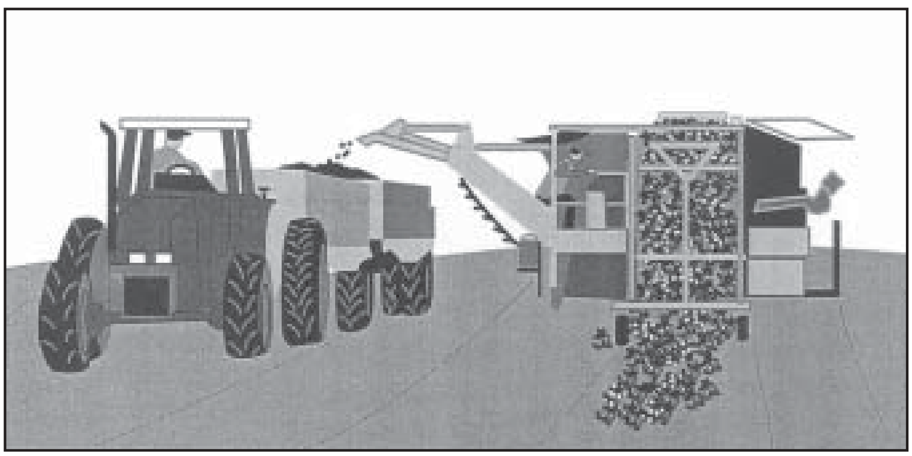
Improvements in Tomato Harvesting

Fact Sheet #3

Most tomatoes Americans eat are grown in California, Florida, and Mexico. Ninety-five percent of the processing tomatoes and about 75 percent of all tomatoes grown in the United States are grown in California. In 2000, California harvested 10.2 million tons of processing tomatoes—over 290,000 acres of California land was planted with tomatoes. California is now the nation's tomato capital.

Many major changes have been made in the tomato plant during the last 40 years. Some of these improvements have been made through genetic engineering—where a gene from one organism is inserted into another organism or where an identified tomato gene is reversed and reinserted. Others have been made by selectively breeding tomato plants that have desired traits.

With increasing farm costs, a reduction in available land to farm, and a continuing increase in human population, farmers are always concerned on how much food they can produce on a certain plot of land. The amount they produce is called their yield. One way tomato yields have increased is through the injection of a gene in tomatoes which produces "uniform ripening." This eliminates a dark green "shoulder" that sometimes appears on tomatoes. It also makes all of the tomatoes on the vine ripen at one time. This makes it easier for pickers since they only have to go into the fields once rather than several times. Since less labor is involved, the price of the fresh market tomatoes can be cheaper. Would a home gardener want all of his/her tomatoes to ripen at once?



Another development is the introduction of a gene which causes the tomato plant to "self prune." This means the tomato plant does not grow too bushy and widespread. The branches of this special tomato plant only grow a certain length. The result is a plant that is easier to harvest by machine.

Fresh tomatoes are picked by hand. Processing tomatoes are picked by mechanical harvesters. Not only has genetic engineering helped in the harvesting of tomatoes, but advances in the technology used on harvesters have helped as well. For example, a special instrument called a "color sorter" is put on the harvesters. This machine is able to identify green tomatoes that pass by it. When a green tomato is identified, an electronic signal triggers a lever to push the green tomato off of the harvester and back into the field. Hand sorting is still required to some extent however, because sometimes a tomato may be red on one side and green on the other and can be missed by the color sorter.

At the University of California in Davis, scientists selectively bred a more rectangular shaped processing tomato, so it could more easily be harvested by machine.

Information obtained from Dona Mast, a tomato grower in Esparto, California, and Andy Kennedy, a tomato field representative and buyer for the Colusa County Canning Company in Williams, California.

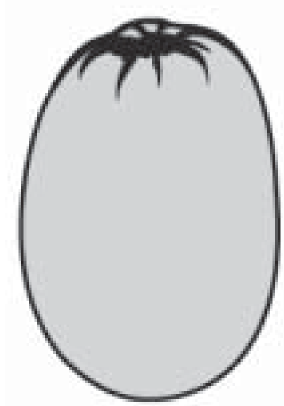
Selective Breeding Produces Desirable Processing Tomatoes

Fact Sheet #4

Over many years, plant breeders have worked to develop tomatoes that have certain characteristics. This fact sheet gives you some information on how selective breeding—when two plants with certain characteristics are bred on purpose—has produced tomatoes with characteristics that help in the processing tomato industry.

One of the most beneficial developments in tomato technology has been the development of processing tomatoes that can be machine harvested. Tomato breeders wanted a small, compact plant with tomatoes whose shape and skin texture could handle machine picking. After years of diligent breeding, a tomato that was "square round" was developed. It had a shape that could be picked by machine and a tough skin. Machine harvesting meant farmers saved the cost of expensive hand labor to pick tomatoes and the fruit could be harvested quickly.

Tomato breeders have also produced a wide range of tomato varieties through selective breeding. One variety of tomato has a small amount of juice, has good peel ability, and the ability to hold up after being diced. These meaty tomatoes are used to make tomato paste. This tomato paste is either sold in stores as tomato paste or is reconstituted (water added back into it) to produce tomato sauces and catsup during the off season. This makes tomato products available year-round. Another variety of tomato is easy to peel and has a little more juice that other varieties. This type of tomato is used to make tomato juice and tomato sauce right after harvest.



Another feature that has been selectively bred into tomatoes is the size of the stem scar—the part of the tomato where it attaches to the stem. A smaller stem scar makes the tomatoes easier to harvest and also provides a better product. It may not seem that a 1/4" reduction in stem scar size could increase the amount of tomato paste produced by a tomato, but imagine if millions of tomatoes had a smaller stem scar (like a truck load full). Then the stem scar size does make a difference!

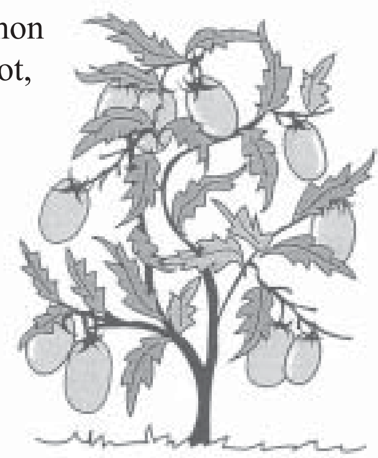
There are other things that have been selectively bred into (or out of) tomatoes as well. Your classmates will learn about some of the other characteristics and share them with you.

Information obtained from Andy Kennedy, a tomato field representative and buyer for Colusa County Canning Company in Williams, California; and Donna Mitten, a genetic engineering consultant.

Producing Tomato Plants That Resist Pests

Fact Sheet #5

Controlling pests is always a challenge in agriculture. A pest is a living organism that is unwanted in a particular location at a particular time. Pests include molds, bacteria, rodents, weeds, and viruses as well as insects and spiders. Pests are controlled in many ways. Sometimes chemicals are used. Other times farmers mechanically remove pests with a cultivator or by hand with a hoe. Biological methods are also used. That is when a living organism helps to control a pest. The most effective method of pest control is to monitor a field or crop and to take action before the pests become unmanageable.



There are numerous pests that affect tomatoes. The most common pests include verticillium wilt, fussarium wilt, nematode root rot, bacterial speck, bacterial spot, mold, and the notorious tomato hornworm. Any of these pests can destroy a crop in a short period of time.

Selective breeding has successfully helped tomatoes resist fussarium wilt. Fussarium wilt causes tomato plants to wilt and eventually die. Researchers discovered that some tomato plants were naturally resistant to fussarium wilt. The scientists kept breeding the tomato plants that were resistant to this fungus with other tomato plants that had the preferred skin thickness and taste. Eventually they ended up with lots of tomato seeds that would be planted in large fields. The tomatoes that grew were resistant to fussarium wilt and had the characteristics the farmers preferred. This procedure of crossing tomatoes with certain characteristics with tomatoes that had other desired characteristics has assisted farmers in managing other pests such as nematode root knot (a small round worm that eats the roots of tomato plants), another type of wilt called verticillium wilt, and bacterial speck.

Genetic engineering has also assisted in making tomato plants pest resistant. Geneticists have been able to genetically engineer plants that are resistant to certain viruses. They have take what are called “coat protein” genes from viruses and inserted them into tomato plants. This gene makes the plant create an antibody type substance called a coat protein that does not allow the virus to reproduce. The tomato mosaic virus is one virus to which certain varieties of tomato plants are resistant because of this process.

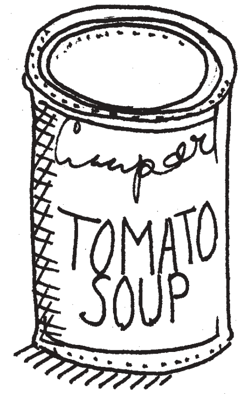
Information obtained from Dona Mast, a tomato grower in Esparto, California; Andy Kennedy, a tomato field representative and buyer for the Colusa County Canning Company in Williams, California; and Charles Rivara, the director of the California Tomato Research Institute.

Future Plans for the Tomato

Fact Sheet #6

Scientists have realized that tomatoes used in processed foods need to have different characteristics than tomatoes eaten fresh. Therefore, there are now two major classes of tomatoes—processing tomatoes and fresh market tomatoes. Plant breeders and geneticists have drastically improved the quality of tomatoes over the last 40 years. However, there is always the goal to develop the "ultimate" tomato. The goal for processing tomatoes is to develop one that can easily be peeled, diced, and sliced, as well as be meaty and have good flavor and texture. In fresh market tomatoes, the goal is to develop a tomato that can withstand transport, stay fresh for long periods of time, taste delicious, and be easily sliced. Scientists continue to do research in these areas.

Research still continues to make tomato plants that can resist pests, including the common tomato hornworm and weeds; tolerate small amounts of water or water that is salty; and produce more tomatoes per plant. Many of these varieties exist to some degree but must be improved upon. These types of changes in tomato production are being looked at because the ever-increasing human population and the reduction of farmland, due to the increase in population, will make it difficult to produce enough food in the future.



Another goal of the tomato industry is the creation of new tomato products. Amazingly, salsa has surpassed catsup in consumption. This is due to its diversity of uses. The production of canned salsas is a recent development in tomato history as is the production of ready-to-use spaghetti sauces, Mexican sauces, and sun-dried tomatoes. Believe it or not, chocolate covered dried tomatoes are being tested in market right now! We will have to wait and see what new tomato products are made available to consumers.

Farmers and researchers have realized the need to maintain a wide variety of tomato breeds. This will insure that tomatoes will be able to survive over time even as environmental conditions change. The key to survival is to have a large gene pool of a species. If the gene pool is large enough, there is bound to be a particular variety of tomato that can withstand a certain disease, climate, or water condition. Scientists travel all around the world gathering seeds that live in a variety of climates and conditions. Unusually colored and shaped tomatoes have become very popular at restaurants and farmers markets. This trend is sure to continue.

What do you think scientific researchers, product inventors and farmers should work on, regarding tomatoes, in the future?

Information compiled by Donna Mitten, a genetic engineering consultant.

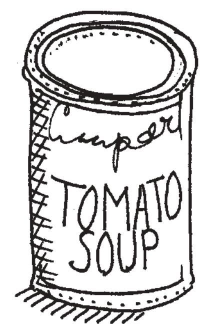
This and That About Tomatoes

Fact Sheet #7

Your classmates are learning about one particular aspect of tomatoes. You are going to learn a variety of little facts about tomatoes.

Tomatoes have a variety of uses. There is a history to many of these uses.

- In 1800, Napoleon's chef prepared a dish of crayfish, eggs, tomatoes, and garlic to celebrate his master's victory over the Italians at the Battle of Marengo. The dish is now called Chicken Marengo.
- Catsup (ketchup) got its name in the 1760s from the Malayan word ketchup meaning a spicy pickled fish sauce. The first catsup was made from walnuts—not tomatoes!
- The first formal recipe for tomato catsup was published in the *Sugar House Book* in 1801. It explained how to prepare the tomatoes and mix them with many spices. It called for 100 tomatoes to make 4-5 bottles of the sauce. Today, about 10-20 processing tomatoes make one bottle of catsup.
- In 1876, Henry Heinz made famous the catsup we know today.
- In 1897, Joseph Campbell produced the first condensed soup—tomato soup. John Dorrence, the person who figured out how to condense it, made a weekly salary of $7.59.



Other Interesting Facts About the Tomato

- In 1820, The Landreth Seed Company introduced tomato seeds to home gardeners.
- There are some tomatoes in the Galapagos Islands that can grow right on the edge of the ocean—they are salt tolerant.
- There is a drought resistant variety of tomato native to western Peru. It survives purely on the water it gets from fog!
- There are tomatoes in Siberia that can grow in very cold temperatures—38 degrees Fahrenheit.
- Some of the largest tomatoes have grown to be over five pounds each!
- Most tomato plants grow about 5-10 pounds of fruit. However, there is a Japanese wire cage that has allowed some plants to produce over 100 pounds of tomatoes from one plant.
- There are a wide variety of tomato colors—red, orange, yellow, and even purple.

Information obtained from *Blue Corn and Square Tomatoes* by Rebecca Rupp; Storey Communication, Inc., 1987.

What I Learned . . . and Still Want to Know!

Name ____________________
Date________________________

In three or more well written paragraphs, write what you have learned about the tomato industry and what other information you would still like to know about it.

California Foundation For Agriculture In The Classroom

Background Information on Biotechnology

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 <u>improve</u> 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 <u>suppress</u> 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 <u>new</u> 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.

- 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 consumed and 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.

- 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 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. It is believed that 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 pages 65-66.

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 corn and cotton has also been developed. These methods of weed control are very efficient and greatly reduce the total amount of herbicide used on crops while increasing the yield of cotton or corn 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 or fuel additive, 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 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.

Teacher Resources and References

California Foundation For Agriculture In The Classroom

Ag Experience
Teaching kits providing materials and activities for hands-on lessons about agriculture. 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

American Quarter Horse Association
Booklets and posters with general information, anatomy and history of the American Quarter Horse. List of free loan videos also available.

American Quarter Horse Association
Post Office Box 200
Amarillo, TX 79168
(806) 376-4811
Fax: (806) 349-6409
Web Site: www.aqha.com

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 teacher packet.

California Foundation for Agriculture in the Classroom
2300 River Plaza Drive
Sacramento, CA 95833
(800) 700- 2482
Fax: (916) 561-5697
Web Site: www.cfaitc.org

CDE Press
The Content Standards for California Public Schools and subject matter frameworks are available through this company and are listed on the 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

Teacher Resources and References

Ridin', Ropin, & Wranglin'
A 20-minute video about cowboys and cattle. Six lessons and an interactive unit teach students math, language arts, stewardship, and more. A detailed directory lists books, videos, and more to help teachers and students learn more about the life of the modern day cowboy.

Ridin', Ropin', & Wranglin'
Quality Video Service
2936 Paradise Road
Modesto, CA 95358
(800) 341-1071
Fax: (209) 526-9571
E-Mail: ellen@pc-intouch.com

Seeds of Success
Free vegetable and flower seeds for California schools as well as non-profit organizations serving low-income communities in California. Seeds are sent once a year, in early spring, along with growing instructions and a copy of the Planting Seeds, Growing Minds curriculum. Seeds of Success is a partnership with California Women for Agriculture.

Grades K-12, adult
Free

Seeds of Success
c/o Michelle and Noelle Campbell
Post Office Box 321
Clarksburg, CA 95612

Related Web Sites

This list is offered as an informational resource only. It contains Web sites established by various entities and, at the time of printing, included information on pest management or a subject matter related to the instructional materials unit *Where'd You Get Those Genes?* 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 of *Where'd You Get Those Genes?*

4-H Virtual Farm
www.ext.vt.edu/resources/4h/virtualfarm

About Produce.com
Aboutproduce.com

Ag Experience
www.galaxymall.com/education/teaching

Agricultural Research Magazine
www.ars.usda.gov/is/AR

American Quarter Horse Association
www.aqha.com

Biotechnology Industry Organization
www.bio.org/food&ag/foodwelcome.html

Biotechnology Information Center, National Agricultural Library
Warp.nal.usda.gov/bic

Broccoli Town, USA
www.broccoli.com

California Farm Bureau Federation
www.cfbf.com

California Foundation for Agriculture in the Classroom
www.cfaitc.org

California Thoroughbred Breeders Association
www.ctba.com

California Tomato Commission
www.tomato.org

California Tomato Growers Association
www.ctga.org

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Related Web Sites

Council for Biotechnology Information
www.whybiotech.com

Monsanto
www.monsanto.com

Peanut Butter
www.peanutbutterlovers.com

University of California Biotechnology Program
www.biotech.ucdavis.edu

University of California Department of Agriculture and Natural Resources
anrcatalog.ucdavis.edu

California Foundation For Agriculture In The Classroom

Related Literature

Aliki. ***Corn is Maize***. Harper & Row, 1976. The story of how ancient Indian farmers discover a wild grass plant, use it in their lives and how they eventually share it with the new settlers of America.

Busenberg, Bonnie. ***Vanilla, Chocolate & Strawberry***. Lerner Publications Co., 1994. Describes the history, today's uses, and chemistry of vanilla, chocolate, and strawberry flavorings.

Edback, Arlene. ***Peanut Butter***. Lerner Publishing, 1994. Describes how peanut butter is made, from the cultivation of peanuts through filling jars with the nutty spread. Includes simple, no-bake recipes.

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.

Genick, Larry. ***The Cartoon Guide to Genetics***. Harper Collins Publishers, 1991. A humorous look and view of genetics.

Hausherr, Rosemarie. ***What Food is This?*** Scholastic, 1994. Fish, sausage, carrots and many more foods are detailed in this tale of food origins.

Hayden, Robert C. ***African American Scientists***. World Book Encyclopedia, 1984. Highlights African American scientists including George Washington Carver.

Herren, Ray V. and Roy L. Donahue. ***The Agricultural Dictionary***. Delmar Publishers, Inc., 1991. Provides definitions of agricultural terms.

Hughes, Meredith Sayles. ***Cool as a Cucumber, Hot as a Pepper***. Lerner Publications Company, 1999. Background information on many vegetables which are scientifically fruits. Includes colorful photographs and historical information.

Hughes, Meredith Sayles. ***Green Power: Leaf & Flower Vegetables***. Lerner Publications Company, 2001. Contains colorful photographs and interesting information on vegetables that are leaves or flowers.

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Related Literature

Johnson, Sylvia A. ***Tomatoes, Potatoes, Corn and Beans***. Simon and Schuster, 1997. Describes many foods native to the Americas including corn, peppers, peanuts, and chocolate.

Koch, Maryjo. ***Seed Leaf Flower Fruit***. Collins Publishers, 1999. Wisdom and wit blend with loving, precise brush strokes to create this botanical book which springs a global garden to life.

Neuschwander, Cindy. ***88 Pounds of Tomatoes***. Scholatistic Inc., 2001. This Hello Math Reader has students think in a whimsical way about the math concepts of addition and multiplication using tomatoes as a theme.

Palacios, Argentina. ***Peanut Butter, Apple Butter, Cinnamon Toast: Food Riddles for You to Guess***. Raintree Steck-Vaughn, 1992. A book of food riddles for children.

Pomerantz, Charlotte. ***Why You Look Like You Whereas I Tend To Look Like Me***. World Book Encyclopedia, 1984. Basic information on heredity and inherited traits. Includes a description of Gregor Mendel and his work.

Redenas, Paul. ***Random House of Horses and Horsemanship***. Random House, 1991. Basic and detailed information on various breeds of horses.

Sheils, Barbara. ***Women and the Nobel Prize***. Winners Publishing Company, 1985. Describes in general terms the women in history who received the Nobel Prize for their work. Includes information on Marie Curie and Barbara McClintock.

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.

Watts, Barrie. ***Tomato***. Silver Burdett Press, 1989. Describes in simple text and illustrations how a tomato develops from a blossom in the spring to a ripe fruit in the summer.

Content Standard Details

Content Standards for California Public Schools Addressed in *Where'd You Get Those Genes?*

Obtained from the California Department of Education*

Grade 5		
Standard	**Lesson(s) in which Standard is Taught or Reinforced**	**Standard Description**
Science		
Investigation and Experimentation 6	Rock, Paper, Scissors	Understand that scientific progress is made by asking meaningful questions and conducting careful investigations.
Investigation and Experimentation 6a	Peanut Butter Broccoli	Classify objects in accordance with appropriate criteria.
Investigation and Experimentation 6g	Peanut Butter Broccoli	Record data by using appropriate graphic representations and make inferences based on those data.
Investigation and Experimentation 6h	Junior's Family Tree Peanut Butter Broccoli	Draw conclusions from scientific evidence and indicate whether further information is needed to support a specific conclusion.
Reading/Language Arts		
Reading 1.0	Geniacs	Students use their knowledge of word origins and word relationships to determine the meaning of specialized vocabulary and to understand the precise meaning of grade-level appropriate words.
Reading 1.1	Junior's Family Tree	Read aloud narrative and expository text fluently and accurately and with appropriate pacing, intonation, and expression.
Reading 1.2	Rock, Paper, Scissors	Use word origins to determine the meaning of unknown words.
Reading 1.5	Junior's Family Tree	Understand and explain the figurative and metaphorical use of words in context.
Reading 2.0	Geniacs	Students read and understand grade-level appropriate material.
Reading 2.1	Junior's Family Tree Catch Up on Tomato Technology	Understand how text features make information accessible and usable.
Reading 2.3	Geniacs Catch Up on Tomato Technology	Discern main ideas and concepts presented in texts, identifying and assessing evidence that supports those ideas.
Reading 2.4	Junior's Family Tree Catch Up on Tomato Technology	Draw inferences, conclusions, or generalizations about text and support them with textual evidence and prior knowledge.

Content Standard Details

Grade 5 *(continued)*		
Standard	**Lesson(s) in which Standard is Taught or Reinforced**	**Standard Description**
Writing 1.0	Junior's Family Tree Geniacs	Students write clear, coherent, and focused essays. The writing exhibits the students' awareness of the audience and purpose.
Writing 1.2	Geniacs	Create multiple-paragraph narrative compositions.
Writing 1.3	Junior's Family Tree	Use organizational features of printed text to locate relevant information.
Writing 1.6	Peanut Butter Broccoli Catch Up on Tomato Technology	Edit and revise manuscripts to improve the meaning and focus of writing by adding, deleting, consolidating, clarifying, and rearranging words and sentences.
Written and Oral Language Conventions 1.0	Peanut Butter Broccoli Geniacs Catch Up on Tomato Technology	Students write and speak with a command of standard English conventions appropriate to fifth grade.
Written and Oral Language Conventions 1.4	Junior's Family Tree	Use correct capitalization.
Written and Oral Language Conventions 1.5	Junior's Family Tree	Spell roots, suffixes, prefixes, contractions, and syllable constructions correctly.
Listening and Speaking 1.0	Catch Up on Tomato Technology	Students deliver focused, coherent presentations that convey ideas clearly and relate to the background and interests of the audience. They evaluate the content of oral communication.
Listening and Speaking 1.1	Junior's Family Tree Catch Up on Tomato Technology	Ask questions that seek information not already discussed.
Listening and Speaking 1.2	Junior's Family Tree Catch Up on Tomato Technology	Interpret a speaker's verbal and nonverbal messages, purposes, and perspectives.
Listening and Speaking 1.3	Junior's Family Tree Catch Up on Tomato Technology	Make inferences or draw conclusions based on an oral report.
Listening and Speaking 1.7	Peanut Butter Broccoli	Identify, analyze, and critique persuasive techniques; identify logical fallacies used in oral presentations and media messages.
Listening and Speaking 1.8	Peanut Butter Broccoli	Analyze media as sources for information, entertainment, persuasion, interpretation of events, and transmission of culture.
Listening and Speaking 2.2	Junior's Family Tree Catch Up on Tomato Technology	Deliver informative presentations about an important idea, issue, or event.

Content Standard Details

Grade 5 *(continued)*		
Standard	**Lesson(s) in which Standard is Taught or Reinforced**	**Standard Description**
Mathematics		
Statistics, Data Analysis, and Probability 1.0	Junior's Family Tree Peanut Butter Broccoli	Display, analyze, compare, and interpret different data sets, including data sets of different sizes.
Statistics, Data Analysis, and Probability 1.2	Junior's Family Tree Peanut Butter Broccoli	Organize and display single-variable data in appropriate graphs and representations and explain which types of graphs are appropriate for various sets of data.
Mathematical Reasoning 1.0	Rock, Paper, Scissors Peanut Butter Broccoli	Students make decisions about how to approach problems.
Mathematical Reasoning 1.1	Junior's Family Tree Rock, Paper, Scissors Peanut Butter Broccoli	Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, sequencing and prioritizing information, and observing patterns.
Mathematical Reasoning 1.2	Junior's Family Tree Rock, Paper, Scissors Peanut Butter Broccoli	Determine when and how to break a problem into simpler parts.
Mathematical Reasoning 2.3	Rock, Paper, Scissors	Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.

California Foundation For Agriculture In The Classroom

Content Standard Details

Grade 6		
Standard	**Lesson(s) in which Standard is Taught or Reinforced**	**Standard Description**
Science		
Investigation and Experimentation 7	Rock, Paper, Scissors	Understand that scientific progress is made by asking meaningful questions and conducting careful investigations.
Investigation and Experimentation 7c	Rock, Paper, Scissors Peanut Butter Broccoli	Construct appropriate graphs from data and develop qualitative statements about the relationships between variables.
Investigation and Experimentation 7e	Junior's Family Tree	Recognize whether evidence is consistent with proposed explanation.
Reading/Language Arts		
Reading 1.0	Junior's Family Tree Geniacs Catch Up on Tomato Technology	Students use their knowledge of word origins and word relationships, as well as historical and literary context clues, to determine the meaning of specialized vocabulary and to understand the precise meaning of grade-level-appropriate texts.
Reading 1.1	Junior's Family Tree Catch Up on Tomato Technology	Read aloud narrative and expository text fluently and accurately and with appropriate pacing, intonation, and expression.
Reading 1.2	Junior's Family Tree Rock, Paper, Scissors	Identify and interpret figurative language and words with multiple meanings.
Reading 1.4	Geniacs	Monitor expository text for unknown words or words with novel meanings by using word, sentence, and paragraph clues to determine meaning.
Reading 2.0	Geniacs Catch Up on Tomato Technology	Students read and understand grade-level-appropriate material. They describe and connect the essential ideas arguments, and perspectives of the text by using their knowledge of text structure, organization and purpose.
Reading 2.3	Geniacs Catch Up on Tomato Technology	Connect and clarify main ideas by identifying their relationships to other sources and related topics.
Reading 2.4	Catch Up on Tomato Technology	Clarify an understanding of texts by creating outlines, logical notes, summaries, or reports.
Reading 2.6	Geniacs	Determine the adequacy and appropriateness of the evidence for an author's conclusions.
Reading 2.7	Geniacs	Make reasonable assertions about a text through accurate, supporting citations.
Writing 1.0	Junior's Family Tree Geniacs	Students write clear, coherent, and focused essays with the awareness of audience and purpose.

Content Standard Details

Grade 6 *(continued)*		
Standard	**Lesson(s) in which Standard is Taught or Reinforced**	**Standard Description**
Writing 1.1	Catch Up on Tomato Technology	Choose the form of writing that best suits the intended purpose.
Writing 1.2	Geniacs	Create multiple-paragraph expository compositions.
Writing 1.3	Junior's Family Tree Peanut Butter Broccoli	Use a variety of effective and coherent organizational patterns, including comparison and contrast, organization by categories, and arrangement by spatial order, order of importance, or climactic order.
Writing 1.6	Peanut Butter Broccoli	Revise writing to improve the organization and consistency of ideas within and between paragraphs.
Writing 2.2	Junior's Family Tree Geniacs	Write expository compositions that state a thesis or purpose, explain the situation, follow an organizational pattern appropriate to the type of composition, and offer persuasive evidence to validate arguments and conclusions needed.
Written and Oral Language Conventions 1.0	Peanut Butter Broccoli Geniacs Catch Up on Tomato Technology	Students write and speak with a command of standard English conventions appropriate to this grade level.
Written and Oral Language Conventions 1.4	Junior's Family Tree	Use correct capitalization.
Written and Oral Language Conventions 1.5	Junior's Family Tree	Emphasize salient points to assist the listener in following main ideas and concepts.
Listening and Speaking 1.0	Catch Up on Tomato Technology	Students deliver focused coherent presentations that convey ideas clearly and relate to the background and interests of the audience. They evaluate the content of oral communication.
Listening and Speaking 1.3	Junior's Family Tree	Restate and execute multiple oral instructions and directions.
Listening and Speaking 1.4	Catch Up on Tomato Technology	Select a focus, an organizational structure, and a point of view, matching the purpose, message, occasion, and vocal modulation to the audience.
Listening and Speaking 1.5	Catch Up on Tomato Technology	Emphasize salient points to assist the listener in following the main ideas and concepts.
Listening and Speaking 1.6	Junior's Family Tree Catch Up on Tomato Technology	Support opinions with detailed evidence and with visual media displays that use appropriate technology.
Listening and Speaking 1.8	Peanut Butter Broccoli	Analyze the use of rhetorical devices for intent and effect.

Content Standard Details

Grade 6 *(continued)*		
Standard	**Lesson(s) in which Standard is Taught or Reinforced**	**Standard Description**
Listening and Speaking 2.2	Catch Up on Tomato Technology	Deliver informative presentations.
Mathematics		
Statistics, Data Analysis, and Probability 2.0	Junior's Family Tree	Students use data samples of a population and describe the characteristics and limitations of the samples.
Statistics, Data Analysis, and Probability 2.3	Rock, Paper, Scissors	Analyze data samples and explain why the way in which the question was asked might have influenced the results obtained and why the way in which the results were displayed might have influenced the conclusions reached.
Statistics, Data Analysis, and Probability 2.4	Rock, Paper, Scissors	Identify data that represent sampling errors and explain why the sample might be based.
Statistics, Data Analysis, and Probability 2.5	Rock, Paper, Scissors	Identify claims based on statistical data and, in simple cases, evaluate the validity of the claims.
Statistics, Data Analysis, and Probability 3.0	Junior's Family Tree	Students determine theoretical and experimental probabilities and use these to make predictions about events.
Mathematical Reasoning 1.0	Junior's Family Tree Peanut Butter Broccoli	Students make decisions on how to approach problems.
Mathematical Reasoning 1.1	Junior's Family Tree Peanut Butter Broccoli Rock, Paper, Scissors	Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, identifying missing information, sequencing and prioritizing information, and observing patterns.
Mathematical Reasoning 1.3	Junior's Family Tree Peanut Butter Broccoli	Determine when and how to break a problem into simpler parts.

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Content Standard Details

Grade 7		
Standard	**Lesson(s) in which Standard is Taught or Reinforced**	**Standard Description**
Science		
Cell Biology 1c	Peanut Butter Broccoli	The nucleus is the repository for genetic information in plant and animal cells.
Genetics 2	Junior's Family Tree Rock, Paper, Scissors	A typical cell of any organism contains genetic instructions that specify its traits. Those traits may be modified by environmental influences.
Genetics 2b	Junior's Family Tree Rock, Paper, Scissors	Sexual reproduction produces offspring that inherit half of their genes from each parent.
Genetics 2c	Junior's Family Tree Rock, Paper, Scissors Peanut Butter Broccoli	An inherited trait can be determined by one or more genes.
Genetics 2d	Rock, Paper, Scissors Peanut Butter Broccoli	Plant and animal cells contain many thousands of different genes and typically have two copies of every gene. The two copies of the gene may or may not be identical, and one may be dominant in determining the phenotype while the other is recessive.
Genetics 2e	Peanut Butter Broccoli	DNA is the genetic material of living organisms and is located in the chromosomes of each cell.
Evolution 3	Rock, Paper, Scissors	Biological evolution accounts for the diversity of species developed through gradual processes over many generations.
Evolution 3a	Junior's Family Tree Rock, Paper, Scissors Peanut Butter Broccoli	Both genetic variation and environmental factors are causes of evolution and diversity of organisms.
Investigation and Experimentation 7	Rock, Paper, Scissors	Understand that scientific progress is made by asking meaningful questions and conducting careful investigations.
Investigation and Experimentation 7c	Junior's Family Tree Rock, Paper, Scissors	Communicate the logical connection among hypotheses, science concepts, tests conducted, data collected, and conclusions drawn from the scientific evidence.
Reading/Language Arts		
Reading 1.0	Junior's Family Tree Geniacs Catch Up on Tomato Technology	Students use their knowledge of word origins and word relationships to determine the meaning of specialized vocabulary and to understand the precise meaning of grade-level appropriate words.
Reading 1.1	Junior's Family Tree	Identify idioms, analogies, metaphors, and similes in prose and poetry.
Reading 1.2	Rock, Paper, Scissors	Use knowledge of Greek, Latin, and Anglo-Saxon roots and affixes to understand content-area vocabulary.

Grade 7 *(continued)*		
Standard	**Lesson(s) in which Standard is Taught or Reinforced**	**Standard Description**
Reading 1.3	Rock, Paper, Scissors Catch Up on Tomato Technology	Clarify word meanings through the use of definition, example, restatement, or contrast.
Reading 2.0	Geniacs Catch Up on Tomato Technology	Students read and understand grade-level appropriate material.
Reading 2.6	Catch Up on Tomato Technology	Assess the adequacy, accuracy, and appropriateness of the author's evidence to support claims and assertions, noting instances of bias and stereotyping.
Writing 1.0	Junior's Family Tree Geniacs Catch Up on Tomato Technology	Students write clear, coherent, and focused essays.
Writing 1.3	Catch Up on Tomato Technology	Use strategies of notetaking, outlining, and summarizing to impose structure on composition drafts.
Writing 1.4	Junior's Family Tree	Identify topics, ask and evaluate questions; develop ideas leading to inquiry, investigation and research.
Writing 1.7	Peanut Butter Broccoli Geniacs Catch Up on Tomato Technology	Revise writing to improve organization and word choice after checking the logic of the ideas and the precision of the vocabulary.
Writing 2.5	Geniacs	Write summaries of reading materials which include the main ideas and most significant details, use the students' own words, and reflect underlying meaning.
Written and Oral Language Conventions 1.0	Peanut Butter Broccoli Geniacs Catch Up on Tomato Technology	Students write and speak with a command of standard English conventions appropriate to the grade level.
Written and Oral Language Conventions 1.4	Junior's Family Tree Peanut Butter Broccoli Geniacs	Demonstrate the mechanics of writing and appropriate English usage.
Listening and Speaking 1.0	Catch Up on Tomato Technology	Deliver focused coherent presentations that convey ideas clearly and relate to the background and interests of the audience.
Listening and Speaking 1.3	Catch Up on Tomato Technology	Respond to persuasive messages with questions, challenges, or affirmations.
Listening and Speaking 1.4	Catch Up on Tomato Technology	Organize information to achieve particular purposes and to appeal to the background interests of the audience.

Content Standard Details

Grade 7 *(continued)*

Standard	Lesson(s) in which Standard is Taught or Reinforced	Standard Description
Listening and Speaking 1.5	Junior's Family Tree Catch Up on Tomato Technology	Arrange supporting details, reasons, descriptions, and examples effectively and persuasively in relation to the audience.
Mathematics		
Statistics, Data Analysis, and Probability 1.0	Rock, Paper, Scissors Peanut Butter Broccoli	Students collect, organize, and represent data sets that have one or more variables and identify relationships among variables within a data set by hand and through the use of an electronic spreadsheet software program.
Mathematical Reasoning 1.0	Junior's Family Tree Rock, Paper, Scissors Peanut Butter Broccoli	Students make decisions about how to approach problems.
Mathematical Reasoning 1.1	Junior's Family Tree Rock, Paper, Scissors Peanut Butter Broccoli	Analyze problems by identifying relationships, distinguishing relevant from irrelevant information, identifying missing information, sequencing and prioritizing information, and observing patterns.
Mathematical Reasoning 1.3	Junior's Family Tree Peanut Butter Broccoli	Determine when and how to break a problem into simpler parts.
Mathematical Reasoning 2.0	Rock, Paper, Scissors	Students use strategies, skills, and concepts in finding solutions.
Mathematical Reasoning 2.1	Rock, Paper, Scissors	Use estimation to verify the reasonableness of calculated results.
Mathematical Reasoning 2.4	Rock, Paper, Scissors	Make and test conjectures by using both inductive and deductive reasoning.
Mathematical Reasoning 2.5	Rock, Paper, Scissors	Use a variety of methods, such as words, numbers, symbols, charts, graphs, tables, diagrams, and models, to explain mathematical reasoning.
Mathematical Reasoning 3.0	Rock, Paper, Scissors	Students determine a solution is complete and move beyond a particular problem by generalizing to other situations.
Mathematical Reasoning 3.1	Rock, Paper, Scissors	Evaluate the reasonableness of the solution in the context of the original situation.
Mathematical Reasoning 3.2	Rock, Paper, Scissors	Note the method of deriving the solution and demonstrate a conceptual understanding of the derivation by solving simpler problems.
Mathematical Reasoning 3.3	Rock, Paper, Scissors	Develop generalizations of the results obtained and the strategies used and apply them to new problem situations.

* For a complete listing of the Content Standards for California Public Schools, contact CDE Press, Sales Office, California Department of Education, Post Office Box 271, Sacramento, CA 95812-0271; (916) 445-1260; www.cde.ca.gov.

California Foundation For Agriculture In The Classroom

Glossary

Agriculture: The science and art of food and fiber.

Biography: Factual story of a person's life.

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.

Burbank, Luther: Famous agricultural botanist who created new varieties of fruits and vegetables.

Carver, George Washington: A botanist known for his studies on many commodities including peanuts and cotton.

Cell: The smallest structural unit of a living organism that is able to grow and reproduce independently.

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

Co-dominant: 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.

Comparison: To examine similarities and differences.

Cross breed: To take plants or animals of the same species and breed them with the same kind of plant or animal that has differenct characteristics. For example, pollinating short corn plants with pollen from tall corn plants with the hope of producing taller plants.

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.

California Foundation For Agriculture In The Classroom

Glossary

Equestrian: Having to do with horses.

Express: In genetics, to show the characteristics of a specified gene.

Family Tree: A graphic representation of ancestry.

Fox, Sally: A grower of colored cotton.

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.

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.

Genetics: The study of DNA and heredity.

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

Interview: To speak with someone for a specific purpose.

McClintock, Barbara: A famous geneticist who won a Nobel Prize.

Mendel, Gregor: A monk who studied the genetics of peas.

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."

Outcome: The results of a combination of genes.

Paint Horse: A quarterhorse with certain types of markings.

Produce: Fresh fruits and vegetables.

Quarterhorse: A special type of horse known for its big hips, short back, long neck, and a small head.

Glossary

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

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

Technology: The study of applied sciences such as engineering and mechanics.

Trait: A specific inherited characteristic.

Variation: Something different than the original.