### Catch Up on Tomato Technology
A Study of How Tomato Production Has Changed Over the Years

<table>
<thead>
<tr>
<th>Purpose</th>
<th>Background Information</th>
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<td>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.</td>
<td>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.</td>
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<tr>
<td><strong>Time</strong></td>
<td><strong>Natural selection</strong> 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.</td>
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<td>3 forty-minute sessions</td>
<td><strong>Selective breeding</strong> 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 <em>Corn is Maize</em> by Aliki (see page 67) describes the selective breeding that occurred to produce the sweet corn we eat today.</td>
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<td><strong>Materials</strong></td>
<td><strong>Genetic engineering</strong> 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.</td>
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<td><strong>For each small group:</strong></td>
<td>You and your students will take a closer look at the history of the tomato and observe how various scientific techniques have produced</td>
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<tr>
<td>- One of the seven Tomato Fact Sheets (pages 47-54)</td>
<td>- What I Learned . . . and Still Want to Know! (page 55)</td>
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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.
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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.

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.

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<tr>
<th>Nutrition Facts</th>
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<tr>
<td>Serving Size</td>
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<tr>
<td>1 Medium Tomato (5.5 oz./148 g)</td>
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<tr>
<td>Amount Per Serving</td>
</tr>
<tr>
<td>Calories 35</td>
</tr>
<tr>
<td>Fat 1g</td>
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<tr>
<td>Carbohydrates 6g</td>
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<tr>
<td>Dietary Fiber 1g</td>
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<tr>
<td>Sodium 10mg</td>
</tr>
<tr>
<td>Protein 1g</td>
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<tr>
<td>%U.S. RDA</td>
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<tr>
<td>Vitamin A 20</td>
</tr>
<tr>
<td>Vitamin C 40</td>
</tr>
<tr>
<td>Calcium *</td>
</tr>
<tr>
<td>Iron 2</td>
</tr>
<tr>
<td>* less than 2 percent of U.S. RDA</td>
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Source: U.S. Food and Drug Administration
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
Improvements in Tomato Harvesting  
(continued)

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

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

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, fusarium 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 fusarium wilt. Fusarium wilt causes tomato plants to wilt and eventually die. Researchers discovered that some tomato plants were naturally resistant to fusarium 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 fusarium 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.
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

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!

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.

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