Did You Know?

- The following important events took place in the history of agriculture:
  - Jethro Tull developed the first horse drawn seed drill in 1701.
  - The first steam-powered plowing was done in 1830.
  - The first successful combine harvester was developed in 1836.
  - The first successful gasoline tractor was developed in 1892.

- The average American eats this amount of the following foods each year:
  - About 300 pounds of fruit.
  - About 420 pounds of vegetables.
  - About 200 pounds of meat, poultry, and fish.
  - About 10 pounds of nuts.
  - About 200 pounds of flour and cereal products.
Objectives

The information given in this chapter will help you do the following:

➤ Explain what agriculture is.
➤ Name the two major types of agriculture.
➤ List the six major groups of crops grown on farms.
➤ Describe the seven main types of machines used in growing and harvesting crops.
➤ Label the five main types of livestock farms.
➤ Give examples of how technology is used in aquaculture.
➤ Summarize how biotechnology can be used in agriculture.
➤ Identify five methods of food preservation used today.
➤ Paraphrase the definition of artificial ecosystem.

Key Words

These words are used in this chapter. Do you know what they mean?

agricultural technology
agriculture
animal husbandry
animal science
aquaculture
artificial ecosystem
baler
biotechnology
combine
crop
cultivator
disc
drip irrigation
forestry
gene splicing
grain drill
harrow
harvest
hydroponics
irrigation
pest control
pivot sprinkler
plant
plant science
plow
sprinkler
swather
tillage
tractor
Early nomads are thought to have become the world’s first farmers. They planted seeds of certain grasses for food. These grasses produced a new crop we now call grain. These people built villages as they waited for the seeds to grow and ripen. All this took place about ten thousand years ago. It happened in several places, including areas that are now Jordan, Iraq, and Turkey. The villagers tended the crops with crude hoes and bone sickles (cutters). This was some of the first technology people developed.

Today, modern farming uses both science and technology. Science is used in cross-pollinating crops and crossbreeding livestock. These types of science are called plant science and animal science. Likewise, science is used to describe the seasons. Scientific knowledge of weather helps guide planting and harvesting. Technology, however, has caused massive changes in farming. See Figure 19-1. New and modern machines and equipment allow fewer people to grow more food. Technological advances have helped people preserve and store food for later use. These and other advancements are part of agricultural technology.

What is agriculture? It is using science and technology in planting, growing, and harvesting crops and raising livestock. Agriculture includes using materials, information, and machines to produce the food and natural fibers needed to maintain life.
Types of Agriculture

Agriculture takes place on the farms and ranches of the world. See Figure 19-2. Agriculture is also practiced on small plots of land called gardens.

Agriculture has two main branches. Crop production grows plants for various uses. It provides human food, animal feed, and natural fibers to meet daily needs. Crop production produces ingredients for medicines and industrial processes. It provides plants for landscaping needs. Crop production produces trees for ornamental and wood product needs.

Animal husbandry involves breeding, feeding, and training animals. These animals are used for food and fiber for humans. In some cases, they are used to do physical work. Many animals are raised for pleasure. They are used in hobbies, for riding, and in racing.

Agricultural Crops

The crops raised today have evolved from specific regions of the world. Corn, beans, sweet potatoes, white potatoes, tomatoes, tobacco, peanuts, and sunflowers came from North and South America. China and
central Asia gave us peas, sugar cane, lettuce, onions, and soybeans. Sugar cane, rice, citrus fruits, and bananas came from Asia. The Middle East, southern Europe, and North Africa gave us the common grains. This region also was the home of sugar beets, alfalfa, and most grasses. Crops can be divided into several major groups:

- Grains. These are members of the grass family grown for their edible seeds. See Figure 19-3. This group includes wheat, rice, corn (maize), barley, oats, rye, and sorghum. Grains are the main food energy source for about 75 percent of the world’s population. All the grains can be used in processed human food. Also, they can be used to produce oils, such as soybean, corn, and canola oils. Grains are widely used for animal feed.

- Vegetables. Plants grown for their edible leaves, stems, roots, and seeds are called *vegetables*. See Figure 19-4. These watermelons are a vegetable crop. (U.S. Department of Agriculture)

Figure 19-4. These plants provide important vitamins and minerals for the daily diet. Vegetables include root crops, such as beets, carrots, radishes, and potatoes. They also

Figure 19-3. Grains are a major food crop. (Deere and Company)
include leaf crops, such as lettuce, spinach, and celery. Other vegetables provide food from their fruit and seeds. This group includes sweet corn, peas, beans, melons, squash, and tomatoes. Vegetables such as cabbage, cauliflower, and broccoli are called cole plants. Vegetables are widely grown on commercial farms called truck farms.

- Fruits. Other plants cultivated for their edible parts are called fruits and berries. See Figure 19-5. They include apples, peaches, pears, plums, and cherries, which are grown in temperate climates. Citrus fruits (oranges, lemons, limes, grapefruits, and tangerines), olives, and figs are grown in warmer climates. Tropical fruits include bananas, dates, and pineapples. Smaller fruits and berries include grapes, strawberries, blackberries, blueberries, raspberries, and cranberries. Fruits are grown on farms called orchards or berry farms.

- Nuts. Plants grown for their hard-shelled seeds are called nuts. They include walnuts, pecans, almonds, filberts (hazelnuts), coconuts, and peanuts. All, except peanuts, are grown on trees in orchards. Peanuts grow underground on plants grown on farms.

- Forage crops. Plants grown for animal food are classified as forage plants. These plants include the hay crops, such as alfalfa and clover.
Also grasses used for pasture and hay are included in this group.

- Nonfood. Plants are grown for uses other than food. These plants include tobacco, cotton, and rubber. They also include nursery stock grown for landscape use and Christmas trees.

**Technology in Agriculture**

Crops, like all living things, have a life cycle. They are born when seeds germinate. Crops grow and reach maturity. They can be harvested or allowed to die. Farming takes advantage of this cycle through four processes. These include planting, growing, harvesting, and, in some cases, storing. See Figure 19-6. The edible parts of many crops are processed into food. For example, wheat can be processed into flour. Flour can be further processed, with other ingredients, into bread.

At one time, growing crops was labor-intensive. It took many people to grow the food and fiber people needed. Today, technological advancements allow a few people to grow food for many people in a relatively short period of time. Farming has become equipment-intensive. New tools and machinery have been designed to make work easier and more productive. Fewer people are involved with producing food now, but more people are needed for processing, packaging, and distributing it.

Growing crops involves a number of technological devices and systems. These specialized pieces of equipment are used to improve the production of food, fiber, fuel, and other useful products. These devices can be divided into the following classifications:

- Power (pulling) equipment.
- Tillage equipment.
Planting equipment.

> Pest control equipment.

> Irrigation equipment.

> Harvesting equipment.

> Storage equipment.

**Power, or Pulling, Equipment**

People tamed and trained animals to pull loads in the Stone Age. By 3,500 B.C., oxen were used to *plow* fields. Until the twentieth century, animals provided the majority of the pulling power needed in farming. See Figure 19-7. During the 1900s, the *tractor* replaced animal power on most farms. In the early 1900s, the modern all-purpose tractor was developed. By the 1950s, there were more than 3.5 million of these tractors in use. Today, the farm tractor can be found in all parts of the world. These devices provide the power to pull all types of farm equipment. There are two basic types of tractors: wheel tractors and track machines. See Figure 19-8. Both of these types of machines have the following features:

> A power source (engine).

> A way to transmit the power (transmission and drive train) for pulling a load.

> A method of controlling speed and direction.

> Traction devices (wheels or tracks).

*Figure 19-7.* Up until the mid-1900s, horses, mules, and oxen provided pulling power needed on farms. (U.S. Department of Agriculture)
An operator’s area (seat, cab, and controls).

A hitch onto which equipment can be fastened.

**Tillage Equipment**

*Tillage* equipment is designed to break and pulverize the soil. It develops a seedbed for the seeds and plants. The cornerstone of tillage is the moldboard plow. It can be traced back to tree branches and antlers used to prepare the soil. In the 1800s, iron and steel plows were developed. They, like modern plows, had a blade-shaped plow-share that cut, lifted, and turned over the soil. See Figure 19-9.

*Discs* (or disc plows) are also used to prepare the seedbed. Sometimes these machines are used after the plow. At other times, the disc is used instead of a plow to start preparing a field for planting. A disc, like its name implies, is a series of curved discs on a shaft. See Figure 19-10. When the machine is pulled through the ground, it slices and crumbles the earth.

Generally, a *harrow* is used after plowing and discing are completed. A harrow is a frame with teeth. These teeth may be spikes or spring-shaped. The harrow is dragged over the ground to give the soil tilth. This means fine and crumbly soil.

Today, farmers are reducing the amount of tillage they do. This is especially true on soil that can erode easily. This technique is called *minimum tillage*. It uses small amounts of
work to prepare the soil. Often, a set of chisels on a frame is used to open the soil. In some cases, no-tillage systems are used. In these cases, crops are planted without working the soil from the previous crop. Special planters slice open the soil and plant the seeds.

**Planting Equipment**

Once the soil is prepared, fertilizer must be applied. Fertilizer is a liquid, powder, or pellets containing important chemicals. It primarily delivers nitrogen, phosphorus, and potassium to the soil. Other nutrients are also in many fertilizers. Fertilizer can be applied before, during, or after planting seeds. It may be applied with special equipment or along with a seed planter. Often, dry fertilizer is scattered (broadcast) before planting. Liquid and gaseous (anhydrous ammonia) fertilizer is applied by injecting it into the soil. A machine with a series of knives is pulled over the ground. The liquid or gaseous fertilizer is injected into the trench the knives create.
The seeds must be planted to start the crop cycle. Over most of history, this was done by hand. In the early 1700s, however, a new machine was developed. It was called the seed drill or grain drill. See Figure 19-11. As it is pulled along, it opens a shallow trench, and then a seed is dropped. The trench is closed, covering the seed.

Other planting machines have been developed for potatoes and corn. See Figure 19-12. Specialized machines are used to plant vegetable plants, such as tomatoes and cabbage.

Pest Control Equipment

In nature, not all plants that sprout live to maturity. Diseases and insects kill some of the plants. Neighboring plants crowd out others. Farm crops face the same dangers. A number of machines have been developed to help control these pests.

Cultivators are used to remove weeds and open the soil for water. These machines are a series of hoe-shaped blades pulled through the ground. See Figure 19-13. The blades break the crust and allow rain and irrigation water to enter the soil. They...
also cut off and pull out weeds. (A weed is any out of place plant.) Sprays can be applied to control weeds and insects. Those controlling weeds are called herbicides. Insect sprays are called pesticides. Ground equipment or airplanes can apply both of these materials. The equipment has a tank, a pump, and spray nozzles on a boom. See Figure 19-14.

As the plane or ground applicator crosses the field, a mist of pest control is applied.

**Irrigation Equipment**

In parts of the world, rainfall is sufficient to raise crops. Many places, however, are too dry for successful farming. In some of these areas, irrigation is used. This is artificial watering to maintain plant growth.

Irrigation systems can be traced back to 2100 B.C. The Egyptians developed systems using the water from the Nile to irrigate crops. Their systems, like all irrigation systems, contained these elements:

- A reliable source of water.
- Canals, ditches, or channels to move the water.
- A way to control and distribute the water.

The source of water is usually a lake, a river, or an underground source (an aquifer). A dam at its outlet often controls water in the lake. A dam backs up river water to form a reservoir. See Figure 19-15. A well and pump obtain underground water. A series of canals and pipes moves the water from the source to farm fields. One of three basic methods is used to apply the water to the land.

Flood irrigation is used on level fields and where there is a lot of water available. A sheet of water advances from a ditch across the field. Lateral ditches and pipes with holes along their...
lengths supply the water to one side of the field. Gravity causes the water to flow across the field. Other ditches or pipes may carry off excess water. In row crops, furrows (small ditches) between rows of plants are used. They move the water from one end of the field to the other. See Figure 19-16. Pipes or tubes are used to control the water entering each furrow.

Sprinkler irrigation is used to better control water. It also uses less water. These systems involve a water source, a pump, main (distribution) lines, lateral (sprinkler) lines, valves, and sprinkler heads. The pump forces water into the main distribution lines. The water flows through them to pipes that have sprinkler heads attached at set intervals. Valves between the main and lateral lines can shut off or control the water flow. The water in the lateral lines enters the sprinkler heads, which spray water onto the land.

Sprinkler systems may have a number of straight sprinkler lines. Each line can apply water to a long, narrow band across the field. The
water is allowed to run for a set time. This irrigates the bands on each side of the sprinkler lines. Then these lines are moved by hand or rolled to the next position. Here, they apply water to the next bands.

A large number of straight lines may be used to cover the entire field. When the lines are turned on, the entire field is irrigated at once. This eliminates the need to move individual lines. These lines are called solid set sprinklers.

Other sprinkler systems are called pivot sprinklers. See Figure 19-17. These systems use one long line. It is attached at one end to a water source. The line pivots around this point on large wheels electric motors power. The line is constantly moving very slowly in a circle. Sprinkler or mist heads apply the water as the line pivots.

Drip irrigation is the third type of irrigation. The system uses main lines to bring water near the plants. Individual tubes or emitters bring water from the main lines to each plant. This ensures each plant is properly watered. It also reduces the amount of water lost to evaporation.

Harvesting Equipment

Once a crop reaches maturity, it must be harvested. Each type of crop has its own special harvesting equipment. Combines are used to harvest grains. See Figure 19-18. A combine is a combination of two early farm machines: the header (cuts heads from the grain) and thresher (removes grain...
from chaff). The combine cuts off the tops of the plants containing the grain. The heads and straw move into the machine. A cylinder causes the grain to break away from the heads. Blasts of air and screens separate the grain from straw, chaff, and weed seeds. The grain is moved into storage hoppers on the machine. The unwanted materials are conveyed out the back of the machine and dropped onto the ground.

Other crops use different harvesting machines. A combine or a special corn-picking machine can harvest corn. Mechanical pickers are used to harvest almost all cotton grown in the United States. Vegetables may be harvested by special purpose machines or by hand. See Figure 19-19. Special machines dig and collect onions and
potatoes. See Figure 19-20. Fruits and grapes are usually picked by hand and placed in boxes. Special machines may, however, be used. They shake the trees, causing the fruit to fall into raised catching frames. Nuts are also harvested in this manner.

A series of machines harvests hay. A mover may cut the plants and let them fall on the ground. After the hay has dried for a day or more, a rake is used to gather it into windrows (bands of hay). In other cases, a windrower, or *swather,* may be used. This machine cuts and windrows the hay in one pass over the field. See Figure 19-21. After the hay has dried, it is usually baled. A hay *baler* picks up a windrow and conveys it into a baling chamber. There, the hay is compressed into a cube. Wire or twine is tied around the cube to maintain its shape. The finished bale is ejected out the back of the machine. See Figure 19-22. Special balers have been produced to make round bales.
Storage Equipment

Many crops are stored before they are sent to processing plants. Grain is stored in silos or buildings at grain elevators. See Figure 19-23. Hay is stored in hay barns that are roofs attached to long poles. These buildings generally do not have enclosed sides or ends. Many vegetables and fruits are stored in climate-controlled (cold storage) buildings. The crops will be transported to processing plants throughout the country and world, as demand requires.

Raising Livestock

Farmers and ranchers raise large numbers of livestock. These include cattle, sheep, goats, horses, swine (pigs), and poultry (chickens and turkeys). These animals are primarily raised to provide meat, milk, or materials for clothing.

In historical time, many farms raised a few of each of these animals. Today, most livestock are raised on single-purpose farms. These farms include the following:

- Cattle ranches. They raise beef cattle for meat and hides.
- Dairies. They raise dairy cattle primarily for milk.
- Swine farms. They raise hogs for meats and hides.
- Horse farms. They raise horses for pleasure riding and racing.
- Poultry farms. They raise turkeys for meat and chickens for meat and eggs.

A number of different technologies are involved in livestock raising.
Specialized equipment and practices are used in the care of animals. Many livestock operations require buildings to house animals and process feed. See Figure 19-24. These buildings are erected using construction technology. Livestock production also includes machines used to feed animals. Feed processing mills are required. They contain machines that grind and mix feed for the animals. Feed troughs or bunkers are required so the animals can eat grain and hay. See Figure 19-25. Water must be provided using manufactured pumps and tanks. Finally, machines and equipment are used to
dispose of the animal waste (such as manure). See Figure 19-26.

Special Types of Agriculture

There are several unique types of agriculture practiced in North America. The three main types are hydroponics, aquaculture, and forestry:

- **Hydroponics.** This consists of growing plants in nutrient solutions without soil. Hydroponic systems supply nutrients in liquid solutions, while the plants grow in a porous material.

- **Aquaculture.** This is growing and harvesting fish, shellfish, and aquatic plants in controlled conditions. It uses ponds, instead of soil, to grow its crop. See Figure 19-27.

- **Forestry.** This includes growing trees for commercial uses, such as lumber and timber products, paper and pulp, and chips and fibers.

Agriculture and Biotechnology

A specific technology that has greatly impacted agriculture is **biotechnology.** The term, biotechnology, is fairly new. The practice, however, can be traced into distant history. Evidence suggests the Babylonians used biotechnology to brew beer as early as 6000 B.C. The Egyptians used biotechnology to produce bread as far back as 4000 B.C. Both of these activities are directly related to agriculture.

Modern biotechnology can be traced back to at least World War I. Scientists used an additive to change the output of a yeast fermentation process. The result was glycerol instead of ethanol. The glycerol was a basic input to explosives manufacturing.

During World War II, the next stride in biotechnology took place. This involved the production of antibiotics (antibodies). These drugs are also the products of fermentation processes.

What is biotechnology? Specifically, biotechnology deals with using biological agents and principles in
processes to produce commercial goods or services. The biological agents are generally microorganisms (very small living things), enzymes (a special group of proteins), or animal and plant cells. They are used as catalysts in the selected process. The word *catalyst* means they are used to cause a reaction. The catalyst does not, however, enter into the reaction itself.

Agricultural biotechnology is a type of biotechnology. It consists of techniques used to create, improve, or modify plants, animals, and microorganisms. This biotechnology can be used to improve many different activities impacting agriculture.

Biotechnology technology can be used to combat *diseases*. This was the first major use of biotechnology. For example, insulin used to treat diabetics can be produced less expensively using biotechnology. Also, enzymes reducing blood clots can be produced using biotechnology. Golden rice providing infants in developing countries with beta-carotene to fight blindness is a result of biotechnology. Biotechnology can be used to promote human health. The nutritional value of foods can be improved using biotechnological techniques.

Another use of biotechnology is fighting animal diseases. See Figure 19-28. It was used in developing a vaccine for shipping fever. This disease is a major factor in feedlot deaths. Biotechnology was also used in producing a vaccine protecting wild animals against rabies.

![Figure 19-28. Biotechnology can be used to fight diseases in animals.](image-url)
Biotechnology is a major factor in increasing crop yields. It has helped produce more food on the same number of acres. This factor has allowed farmers to feed more people using the same effort. For example, biotechnology was used to produce soybeans resistant to certain herbicides (weed sprays). Also, it was used to develop a cotton plant resistant to major pests.

It can be used to supplement the common techniques of selective breeding and pollinating. This specific application is often called genetic engineering. It enables people to move genes in ways they could not before. It allows people to develop plants and animals with desirable traits.

Gene splicing is based on a major discovery called recombinant DNA. The structure of DNA is a double helix (spiral) structure. It consists of a jigsaw-like fit of biochemicals. The two strands have biochemical bonds between them.

The DNA molecule may be considered a set of plans for living organisms. It carries the genetic code determining the traits of living organisms. Scientists can use enzymes to cleanly cut the DNA chain at any point. The enzyme selected will determine where the chain is cut. Then two desirable parts can be spliced back together. This produces an organism with a new set of traits. The process is often called gene splicing.

This process allows scientists to engineer plants having specific characteristics. See Figure 19-29. For example,
resistance to specific diseases can be engineered into the plant. This could reduce the need for pesticides to control insect damage to crops.

This activity has received many headlines in newspapers and magazines. It is controversial. Some people think it will make life better. Others think we should not change the genetic structures of living things.

Food Production

People must eat to live. We eat many different kinds of food, prepared in a variety of ways. Few crops produced through agricultural technology are sold in their natural states. Most foods have been processed or preserved in some way by the time we eat them. Food processing is one of the most important of all agricultural technology processes.

Food production is primarily the job of farmers. Many other people, however, handle the food the farmers produce before it reaches the consumers. After being harvested, most food products go to processing plants. Then, the food products must be transported to consumers. The transportation chain they follow includes truck, airfreight, and train personnel; food brokers; distributors; food wholesalers; and finally, food retailers, such as your local grocery store. See Figure 19-30.
Food Processing

The conversion of harvested crops into food that is ready to eat is called processing. This is not just a single process, however; it includes many different processes, which vary depending on the food being processed. At the processing plants, skilled workers perform many jobs, including sorting, washing, peeling, slicing, roasting, grinding, canning, flash freezing, boxing, cooking, adding preservatives, and packaging.

Early humans ate their food exactly as they found it. They ate fruits, nuts, leaves, and roots as they gathered them, and they even ate the fish and game they hunted without cooking it. These people began cooking with the discovery of fire about 1 million years ago. This is the first way food was processed.

Cooking makes food softer and easier to digest. The heat kills bacteria that might cause the food to rot or make you sick. Most modern cooking appliances use heat from electricity or gas flames. Microwave ovens use radio waves to heat the food.

Some foods are sold ready to eat. Other foods come partly prepared. You must cook these types of foods, such as frozen pizzas, TV dinners, and cake mixes, before you eat them.

Grains are processed in mills. They can be ground, sifted, steamed, shredded, or toasted. Then they are made into products such as flour, bread, and cereal products. See Figure 19-31. Fruits and vegetables must be peeled before being processed, and sometimes fruits are crushed to make juice.

Milk is processed into whole milk, skim milk, condensed milk, cheese, butter, and cottage cheese.

Some processed foods contain additives. These are chemicals that improve the food or keep it from spoiling. Preservatives, flavorings, and dyes are all additives.

Food Preservation

Most food spoils after a while. Bacteria, mold, and insects feed on it. Because food is so important to survival, food preservation is one of the oldest technologies used by humans. Some of these technologies have been used for thousands of years. Over
time, people began to understand why these methods work. They learned how to create the conditions preventing the growth of microorganisms that spoil food. These are some of the techniques used today for preserving food:

- Refrigeration and freezing.
- Canning.
- Dehydration.
- Chemical preservation.
- Irradiation.

Other methods of food preservation include freeze-drying, pasteurization, fermentation, carbonation, smoking, and cheese making.

**Refrigeration and Freezing**

Refrigeration and freezing are the most popular forms of food preservation used today. See Figure 19-32. Long ago, people used to bury food in snow or ice to keep it fresh. This is because cold temperatures cause bacteria to stop growing. Refrigeration slows the growth of bacteria so food stays fresh longer—usually a week or two—instead of spoiling in just a few hours. Freezing stops bacterial growth all together. It keeps food fresher than refrigeration does. These methods are so popular because they have very little, if any, effect on the taste and texture of most foods.
Bacteria stop growing below 14°F, but they do not die. To destroy all bacteria, food is steamed before freezing. In food preserved in this way, once the food is thawed, bacteria can grow again.

Vegetables, fish, and poultry are frozen by dipping the packaged foods into tanks of freezing salt water. The same process is used to freeze canned juices. A spray of liquid nitrogen with a temperature of −320°F freezes more expensive foods, like shrimp. Meat is frozen by traveling through a tunnel, as fans blow air at a temperature of −40°F on it. This process is called blast freezing.

**Canning**

Canning uses a cooking process to preserve food in glass jars or metal cans. It uses heat to remove oxygen from the container, kill microorganisms in the food, and destroy enzymes that could spoil the food. During the canning process, the can or jar is filled with food. The air is pumped out to form a vacuum, and the container is sealed. The food is heated, then cooled to prevent the food from becoming overcooked. This heating inactivates enzymes that could change the food’s color, flavor, or texture. Canning is used to preserve many foods, including fruits, vegetables, jams and jellies, soups, and juices.

**Dehydration**

Dehydration is the process by which foods are dried to preserve them. During this process, most water is removed from the food. This increases the concentrations of salt and sugar, and these high concentrations kill any bacteria. Dried foods kept in airtight containers can last a relatively long time.

Early humans dried meat and fruit in the sunshine. Today, many foods, such as powdered milk, soup, potatoes, dried fruits and vegetables, beef jerky, pasta, instant rice, and orange juice, can be dehydrated. See Figure 19-33. You may eat them as they are sold, or you may need to add water. Drying often completely changes the taste and texture of foods, but many new foods created by dehydration have proven to be just as popular as the original forms.

*Figure 19-33. We eat many foods, such as these dried cherries, that have been preserved through dehydration. (Cherry Marketing Institute)*
**Chemical Preservation**

People have used salt, sugar, and vinegar to preserve foods, especially meat, for thousands of years. When salt or sugar is used, the process is called *curing*. The salt or sugar dissolves in the water in the food and kills the bacteria. Today, this process is most often used to create foods such as “country ham,” dried beef, corned beef, and pastrami. When vinegar is used, the process is called *pickling*. This process has been used to preserve meat, fruits, and vegetables, but today it is used almost exclusively for making pickles, or pickled cucumbers. See Figure 19-34.

Today, new chemicals, such as nitrites, benzoates, and sulphites, are used as preservatives. They either inhibit the growth of bacteria or kill them. These chemicals can be found on the ingredient lists of many different foods. For example, sulfur dioxide preserves fruits used to make jam, fruit juice, and dried fruits. All of these chemicals may be harmful if used in large amounts. The Food and Drug Administration (FDA) limits the amounts of these chemicals allowed in foods.

**Irradiation**

Irradiation is the process by which X-ray radiation is used to kill bacteria in food. This process kills bacteria without significantly changing the food. It can occur after foods have been packaged, which is a big advantage. If a food is sealed in plastic and then irradiated, it becomes sterile and can be stored on a shelf without refrigeration for a long time. The FDA has approved the irradiation of chicken and beef. The use of this technique could prevent many forms of food poisoning. Large amounts of radiation must be used, however, and many people are not sure whether or not it is safe. People generally do not like the term *radiation*, so this process is still not very common in the United States.

**Artificial Ecosystems**

*Artificial ecosystems* are human-made complexes reproducing some facets of the natural environment. They can be used to study agricultural processes and systems as they would...
be useful to biological ecosystems. Some examples of artificial ecosystems are terrariums and the hydroponics stations discussed earlier. They function as part of a larger closed system supporting living organisms.

A terrarium is used to nurture plant or animal life in an enclosed environment. It acts as a complete habitat using all the systems of life, such as food, water, shelter, and space. Terrariums can be used for decoration and enjoyment, but they can also be used to study the ways in which the elements of an ecosystem depend on one another. See Figure 19-35. Some
greenhouses can be considered large-scale terrariums, and they can be used to grow plants and animals in areas differing from their natural habitats. A hydroponics station is used to grow plants without soil. Similar to terrariums, these stations are controlled environments supplying the light, humidity, food, and water the plants need for growth. They are an alternative to traditional agriculture for farmers in areas with poor soil. Using hydroponics stations, farmers can grow vegetables and other plants in the middle of a desert or in an alley in a crowded city.
Managing an artificial ecosystem entails collecting facts to plan, organize, and control processes, products, and systems. Operating such a system necessitates absolute control and cultivation. Temperature, nutrients, light, water, air, circulation, waste recycling, and monitoring of insects all require management in order for the system to function well.

Quality Control in Agriculture and Biotechnology

Quality control is critical in agriculture technology and biotechnology. The U.S. Food and Drug Administration (FDA) regulates food to ensure public health. Agricultural processes must adhere to FDA guidelines. Food products must be FDA approved before they can be sold.

There are many areas of quality control. In livestock farming, for example, the feed given to the animals must meet quality standards. The animals must be carefully checked to ensure that they have no harmful diseases. The preparation of meat for consumption must occur in a sanitary environment. In crop raising, crops are inspected for diseases or other signs of distress. Fertilizers must be approved for use on crops. Fruits and vegetables are inspected after they are harvested.

Food processing systems also have quality controls in place. Since these systems prepare food for human consumption, a breakdown of the quality control system could have health risks for the consumer. Therefore, the systems must be carefully designed to ensure that the food products do not become contaminated or spoiled. Food product is inspected as part of the system. All materials the food product contacts must be kept clean and sanitary.

Summary

Agriculture involves growing plants and animals on farms and ranches. It includes crop production and animal husbandry. It involves the use of many types of machines. It uses pulling, tilling, planting, pest control, irrigation, harvesting, and storage equipment. It also uses structures and equipment to feed and care for cattle, hogs, horses, and poultry. A special kind of agriculture is aquaculture. It
involves raising fish and plants in controlled water environments.

Agriculture often employs biotechnology. This type of technology applies biological organisms to production processes. We use biotechnology to produce new strains of plants and drugs.

Technology is also used in food production. The food agriculture produces must go through many processes before reaching consumers. Technology is used to make sure the food stays fresh.

Natural agricultural environments can be recreated artificially. They may be used for enjoyment or for educational purposes. Terrariums and hydroponics stations are the most common types of these artificial ecosystems.

**Agricultural Managers**

**The Job:** Agricultural managers manage the daily activities of farms, ranches, nurseries, and other agricultural establishments. Their activities deal with running the farm, rather than performing actual production activities. They hire and supervise workers, who perform the production tasks. Agricultural managers determine what crops to plant, oversee production activities, hire workers, assign duties to workers, and oversee maintenance activities.

**Working Conditions:**
These managers spend time in the office and in the field, supervising workers. Work for livestock farm managers is continuous throughout the year. Crop farm managers usually work long hours during the planting and harvesting seasons. During the rest of the year, they have a reduced work schedule as they plan for next season’s activities.

**Education and Training:**
Growing up on a family farm was once the major training program for farmers and farm managers. The increasingly complex scientific and business aspects of farming, however, require advanced education from community colleges or universities. Many younger agricultural managers hold a bachelor’s degree in business, with a concentration in agriculture. Additionally, they often need farm or ranch work experience.
Curricular Connections

Social Studies
Develop a timeline for the invention of agricultural equipment. Select one machine and write a report on its inventor, operation, and importance.

Science
Research how cross-pollination and crossbreeding are used to improve animal and plant species.

Mathematics
Measure the school plot and convert the measurement to hectares and acres.

Science
Research DNA and its application to gene engineering.

Mathematics
Research the units of measurement used for agricultural crops. Develop a poster or other display presenting and contrasting these units of measurement.

Activities
1. Select a food you eat. Describe how its basic ingredient was planted, grown, and harvested.
2. Go to a local farm implement dealer or locate an appropriate site on the Internet. Gather information on how a specific piece of farm equipment operates.
3. Build a diorama (model) of a farm. Show the technology used on it.
Test Your Knowledge

Do not write in this book. Place your answers to this test on a separate sheet of paper.

1. What is agriculture, and why is it important?
2. What are the two branches of agriculture?
3. Members of the grass family that have edible seeds are called _____.
4. Grass and hay crops grown for animal feed are called _____.
5. The four processes in growing crops using technology are _____, _____, _____, and _____.
6. Growing and harvesting fish in controlled conditions is called _____.
7. Using biological agents to produce goods is called _____.
8. Producing a new organism by cutting and joining genes is called _____.
9. Label the following types of food preservation:
   A. Used to preserve pasta, instant rice, beef jerky, and powdered soup. _____
   B. Can be used to preserve meat, but people are concerned about its safeness. _____
   C. Used to make pickles and corned beef. _____
   D. The most common form of food preservation today. _____
10. Summarize the purpose of artificial ecosystems.

Technology Teachers

The Job: Technology teachers help students learn information and apply concepts about the development, production, and use of technology. They must have the ability to select, organize, and deliver appropriate material to students.

Teachers must possess excellent communication skills and understand their subject area well. They need to know how to help students solve problems, work in groups, and document progress and solutions.

Working Conditions: These teachers generally work in laboratory-type classrooms equipped with a variety of tools and machines. They can experience rewards from students successfully completing work, but they can also become frustrated from having to deal with unmotivated or disrespectful students. Most teachers work in individual classrooms, causing them to be somewhat isolated from their colleagues. Many teachers work more than 40 hours a week.

Education and Training: All public school teachers need to be licensed by the state in which they teach. Technology teachers must hold a bachelor’s degree from an approved teacher education program. They must have completed a set number of classes and completed a practice teaching assignment. In addition, most states require applicants to pass a basic competency test before they receive a teaching license. Also, many states require teachers to participate in continuing education programs.