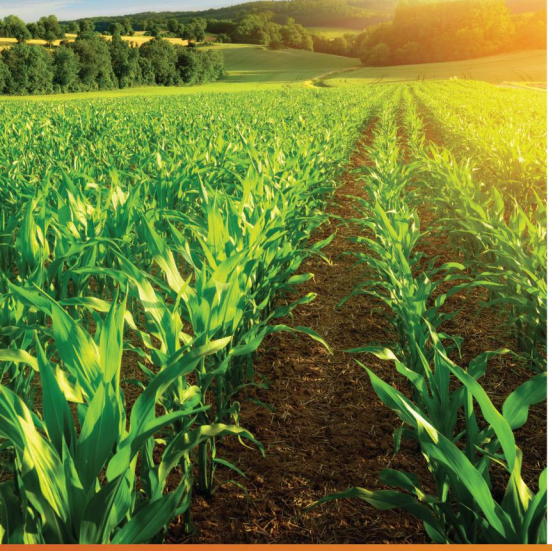

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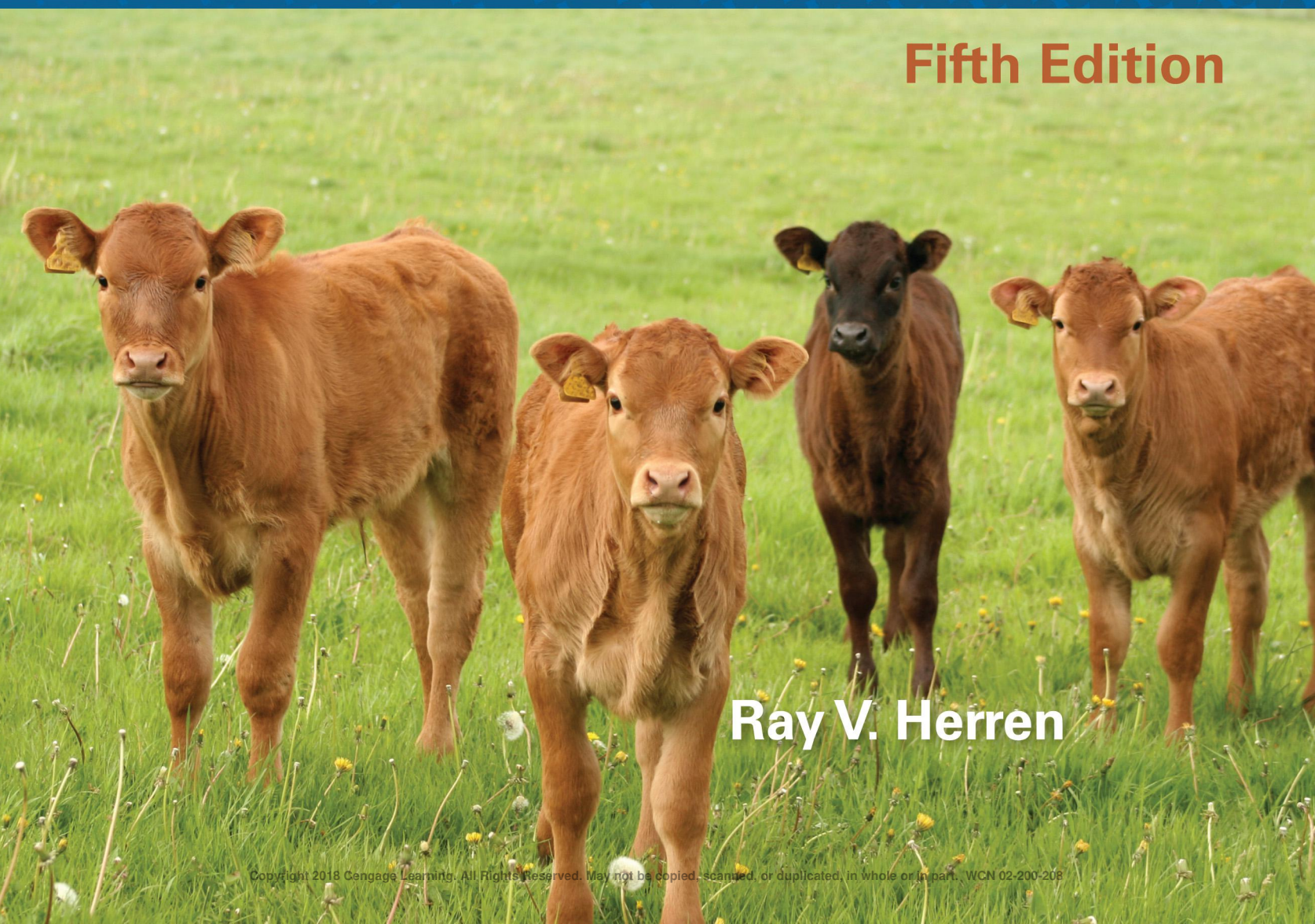

Ray V. Herren

Exploring AGRISCIENCE

Fifth Edition



Exploring AGRISCIENCE

Fifth Edition

Ray V. Herren

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Exploring Agriscience, Fifth Edition
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This fifth edition is dedicated to my wife, Mary Herren who has been a constant source of inspiration and help with all my work. Without her help and encouragement my writing would be much more difficult and not nearly as much fun.

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Preface

Agriculture is a rapidly changing science. Change comes about so rapidly that it is difficult to keep up with all the developments. However, basic scientific principles are the foundation of modern agriculture, and these principles drive change. *Exploring Agriscience* Fifth Edition is intended to introduce you to the dynamic industry of agriculture. Integrated throughout are principles of science behind the industry. Research has shown that most Americans have a misconception of agriculture. Many think of agriculture as farming. While this is a basic component of agriculture, the scope of agriculture is much broader. This industry employs more people than any other and is responsible for much of the nation's wealth. This text provides you with an overview of the different aspects of that industry, and introduces the main areas of agriculture that have made the industry great.

Features of this Text

Start your journey through the exciting world of agriculture armed with the following tools:

- Reader-friendly narrative presents information in an interesting and engaging way
- A hands-on exploratory, science-based approach to agriscience provides an experience that is both stimulating and educational
- Full-color photos, illustrations, and design bring key points to life and bridge the gap between the readings and real-world application.
- A spotlight on FFA activities provides you with insight into these fun and valuable programs essential to personal and career development.
- Each *Chapter Review* includes questions and activities to help track your learning and provide stimulating hands-on experiences.

New to this Edition

This fifth edition of *Exploring Agriscience* offers many exciting enhancements:

- An all-new chapter, "Urban Agriculture," reflects the

growing importance of local-sourced food, and the benefits of community gardens and natural surroundings in urban environments.

- "For Further Exploration" highlights newly added fun facts throughout the readings that challenge you to expand your knowledge of the topic under discussion.
- New full-color images reflect modern industry equipment and practices in agriculture and agriscience.

All aspects of the agricultural industry are based on science. Principles of biology and physics have been researched, manipulated, and used to provide advancements in the production of food and fiber. These advancements have made life better for all Americans. No education would be complete without an understanding of the role of agriculture in our lives.

Extensive Teaching and Learning Package

The complete learning package was developed to achieve two goals:

1. To assist students in learning the essential information needed to continue their exploration into the exciting field of agriscience.
2. To assist instructors in planning and implementing their instructional program for the most efficient use of time and other resources.

Companion Site

NEW! The Companion site to accompany *Exploring Agriscience, Fifth Edition* features tools to support learning and facilitate teaching:

- *Answers to Review Questions*, appearing at the end of each chapter, allow teachers to track and validate student learning.
- *Answers to the Lab Manual* provide responses to the *Questions for Thought* found in the exercises. In addition, it provides a complete *Materials List* for each of the activities and helpful notes to help teachers prepare for classroom experiments.
- *Lesson Plans* provide an outline of the key topics in each chapter, and correlate to the accompanying PowerPoint® presentations.
- *PowerPoint®* presentations align with the Lesson Plans and include photos and illustrations to visually reinforce the key points in each chapter.
- *Testing Powered by Cognero,* a flexible online system, provides chapter-by chapter quizzes, and enables teachers to
  - author, edit, and manage test bank content from multiple sources;
  - create multiple test versions in an instant;

- deliver tests from teacher/school-specific learning management system (LMS) or classrooms.
- *All-New Projects for Students* offer additional hands-on experience in agriculture techniques. Step-by step instructions for each project, as well as a list of tools and level of difficulty, help teachers tailor classroom instruction to the needs of students. Projects include such fun activities as creating various types of gardens, building raised beds and cold frames, planting a mini food forest, and more!
- *Image Gallery* offers full-color photos and illustrations from the text to enable teachers to further enhance classroom presentations.

For these instructor-specific resources, please visit CengageBrain.com at http://login.cengage.com and follow the prompts for obtaining access this secure site.

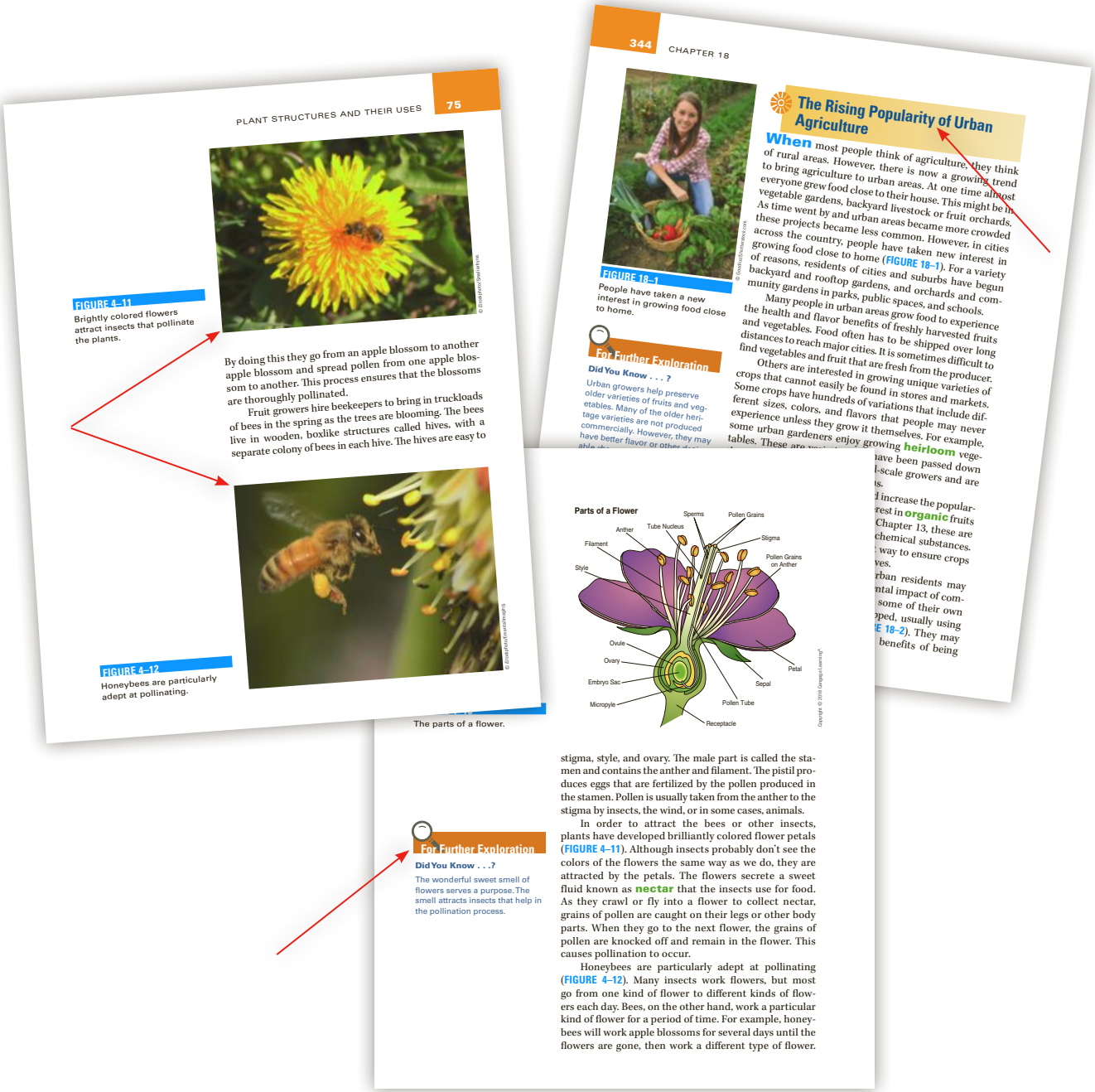
Lab Manual

Revised for the fifth edition, the lab manual contains a variety of exercises to help students retain and apply key concepts and information presented in the book. Labs are organized by book topics, and this edition features a materials list for each activity and new activities related to urban agriculture.

MindTap for Exploring Agriscience 5E

NEW! The MindTap for *Exploring Agriscience, 5th Edition* features an integrated course offering a complete digital experience for the student and teacher. This MindTap is highly customizable and combines assignments, videos, interactivities, lab exercises, and quizzing along with the enhanced ebook to enable students to directly analyze and apply what they are learning and allow teachers to measure skills and outcomes with ease.

- A Guide: Relevant interactivities combined with prescribed readings, featured multimedia, and quizzing to evaluate progress will guide students from basic knowledge and comprehension to analysis and application.
- Personalized Teaching: Teachers are able to control course content—hiding, rearranging existing content, or adding and creating their own content to meet the needs of their specific program.
- Promote Better Outcomes: Through relevant and engaging content, assignments, and activities, students are able to build the confidence they need to ultimately lead them to success. Likewise, teachers are able to view analytics and reports that provide a snapshot of class progress, time in course, engagement, and completion rates.



PLANT STRUCTURES AND THEIR USES 75

FIGURE 4–11
Brightly colored flowers attract insects that pollinate the plants.

By doing this they go from an apple blossom to another apple blossom and spread pollen from one apple blossom to another. This process ensures that the blossoms are thoroughly pollinated.

Fruit growers hire beekeepers to bring in truckloads of bees in the spring as the trees are blooming. The bees live in wooden, boxlike structures called hives, with a separate colony of bees in each hive. The hives are easy to

FIGURE 4–12
Honeybees are particularly adept at pollinating.

344 CHAPTER 18

FIGURE 18–1
People have taken a new interest in growing food close to home.

For Further Exploration

Did You Know . . . ?

Urban growers help preserve older varieties of fruits and vegetables. Many of the older heritage varieties are not produced commercially. However, they may have better flavor or other

The Rising Popularity of Urban Agriculture

When most people think of agriculture, they think of rural areas. However, there is now a growing trend to bring agriculture to urban areas. At one time almost everyone grew food close to their house. This might be in vegetable gardens, backyard livestock or fruit orchards. As time went by and urban areas became more crowded these projects became less common. However, in cities across the country, people have taken new interest in growing food close to home (FIGURE 18–1). For a variety of reasons, residents of cities and suburbs have begun backyard and rooftop gardens, and orchards and community gardens in parks, public spaces, and schools.

Many people in urban areas grow food to experience the health and flavor benefits of freshly harvested fruits and vegetables. Food often has to be shipped over long distances to reach major cities. It is sometimes difficult to find vegetables and fruit that are fresh from the producer.

Others are interested in growing unique varieties of crops that cannot easily be found in stores and markets. Some crops have hundreds of variations that include different sizes, colors, and flavors that people may never experience unless they grow it themselves. For example, some urban gardeners enjoy growing heirloom vegetables. These are

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benefits of being

Parts of a Flower

The parts of a flower.

stigma, style, and ovary. The male part is called the stamen and contains the anther and filament. The pistil produces eggs that are fertilized by the pollen produced in the stamen. Pollen is usually taken from the anther to the stigma by insects, the wind, or in some cases, animals.

In order to attract the bees or other insects, plants have developed brilliantly colored flower petals (FIGURE 4–11). Although insects probably don't see the colors of the flowers the same way as we do, they are attracted by the petals. The flowers secrete a sweet fluid known as nectar that the insects use for food. As they crawl or fly into a flower to collect nectar, grains of pollen are caught on their legs or other body parts. When they go to the next flower, the grains of pollen are knocked off and remain in the flower. This causes pollination to occur.

Honeybees are particularly adept at pollinating (FIGURE 4–12). Many insects work flowers, but most go from one kind of flower to different kinds of flowers each day. Bees, on the other hand, work a particular kind of flower for a period of time. For example, honeybees will work apple blossoms for several days until the flowers are gone, then work a different type of flower.

For Further Exploration

Did You Know . . . ?

The wonderful sweet smell of flowers serves a purpose. The smell attracts insects that help in the pollination process.

About the Author

Dr. Ray V. Herren has been actively involved in agriculture for most of his life. He grew up on a diversified farm, where he played a major role in the production of livestock. He obtained a Bachelor of Science degree in Agricultural Education from Auburn University, a Master's degree in Agribusiness Education from Alabama A&M University, and a Doctorate in Vocational Education (with an emphasis in Agricultural Education) from Virginia Polytechnic Institute and State University. Dr. Herren has taught at Gaylesville High School, Virginia Tech, Oregon State University, and the University of Georgia in Athens, where he recently retired as head of the Department of Agriculture Leadership, Education, and Communication.

In addition to serving as National President of the FFA Alumni Association, he has served on numerous committees from the local to international level, including a national task force to develop FFA programs for middle school students and the National Committee for Career Development Events. His prolific scholarly activity includes 26 journal articles, 51 invited or refereed presentations, and 12 books and manuals. He has also earned several awards for his commitment to service, including induction into the Georgia Agricultural Teacher Hall of Fame and UGA's prestigious College of Education Outstanding Teaching Award.

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Chapter 1

The World of Agriculture

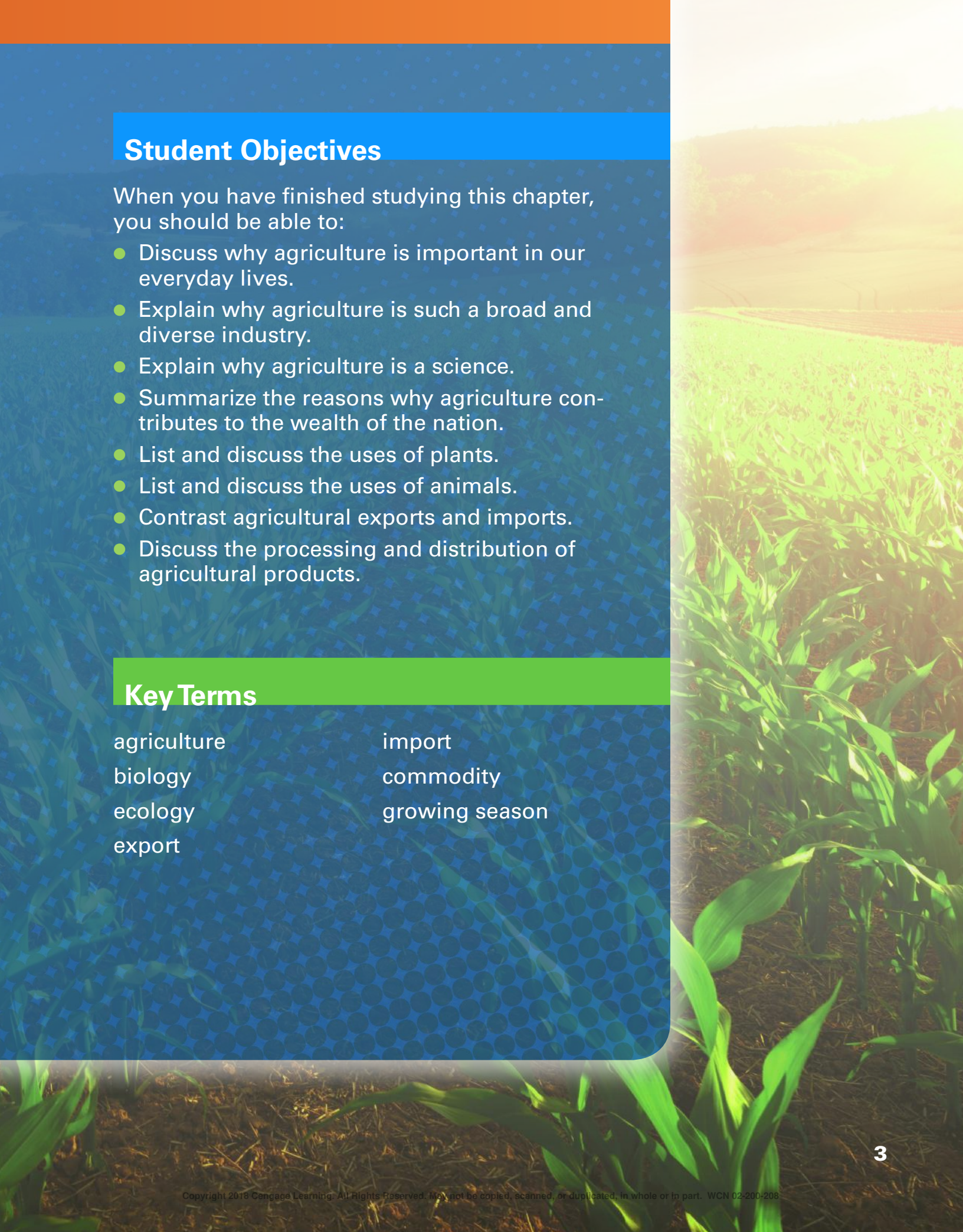
Student Objectives

When you have finished studying this chapter, you should be able to:

- Discuss why agriculture is important in our everyday lives.
- Explain why agriculture is such a broad and diverse industry.
- Explain why agriculture is a science.
- Summarize the reasons why agriculture contributes to the wealth of the nation.
- List and discuss the uses of plants.
- List and discuss the uses of animals.
- Contrast agricultural exports and imports.
- Discuss the processing and distribution of agricultural products.

Key Terms

agriculture
biology
ecology
export
import
commodity
growing season



You are about to begin a study of one of the most dynamic industries the world has ever known! This industry—American **agriculture**—is involved with growing plants and animals for use by all the people of this country and much of the world. There are many types of industries in this country. These include manufacturing, transportation, services, and many others. None of these is as basic or important as agriculture (**FIGURE 1–1**). If people didn't have food to eat, clothes to wear, and houses for shelter, none of the other industries could operate. We live in a country with one of the highest standards of living in the world. Americans are the envy of most of the world! Much of the affluence we enjoy is either a direct or indirect result of the agriculture industry. Compared to people in other countries, we pay a very small portion of our income for food. According to the United States Department of Agriculture (USDA), we spend around 6.1 percent of our income on food (**FIGURE 1–2**). This compares to over 50 percent in some countries. The USDA collects data on 83 countries around the world and has found that people in the United States spend a smaller percent of their income on food than people in any of the other countries.

Our prosperity began because of the fertile soil and ideal climate we enjoy in the United States. Our soil and climate provided the basis for our great agricultural industry. New discoveries and developments as a result of scientific research in agriculture promoted the growth

FIGURE 1–1
Agriculture is our most basic and important industry.

FIGURE 1–2
We spend about 6.1% of our income on food.

of the agriculture industry. This industry has been one of the major causes of the wealth of the country.

The American Farm Bureau has compiled the following list about the importance of American agriculture:

- There are 2.2 million farms in the United States.
- Agriculture is America's leading export.
- About 23 percent of raw U.S. agriculture products are exported yearly (**FIGURE 1–3**).
- One-fourth of the world's beef and nearly one-fifth of the world's grain, milk, and eggs are produced in the United States.
- One in three U.S. farm acres is planted for export, and 31 percent of gross farm income comes directly from exports.

FIGURE 1–3
23% of U.S. agricultural products are exported. This wheat will be shipped overseas.

- Americans enjoy one of the safest food supplies in the world.
- Through research and changes in production practices, today's food producers are providing Americans with the widest variety of foods ever.
- Research and advancements in biotechnology are now in the marketplace, with tastier fruits and vegetables that stay fresh longer and are not damaged by insects.
- Consumers derive health benefits from changes in farm production, including less fat in meat. Tofu, a soybean product, has been shown to reduce the risk of some cancers and heart disease.
- With modern methods, one acre of land in the United States (about the size of a football field) can produce 42,000 lbs. of strawberries; 11,000 heads of lettuce; 25,400 lbs. of potatoes; 8,900 lbs. of sweet corn; or 640 lbs. of cotton lint (**FIGURE 1–4**).
- American consumers spend the lowest percentage of their annual income on food—around 6.1 percent.
- Cotton is by the far the most dominant fiber produced in the United States and is used for apparel and home fabrics, as well as industrial applications.

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FIGURE 1–4
42,000 pounds of strawberries can be grown on an acre of land.

- The agricultural industry employs 15 percent of America's workforce, or approximately 21 million people.
- Farmers and ranchers are the first environmentalists, maintaining and improving the soil and natural resources to pass on to future generations.
- Farmers use reduced tillage practices on more than 63 percent of cultivated acres to prevent erosion.
- Farmers maintain over 1.3 million acres of grass waterways, allowing water to flow naturally from crops without eroding soil.
- Contour farming, planting crops on hillsides instead of up and down, keeps soil from washing away. About 26 million acres in the United States are managed this way.
- Cattle ranchers and others control water runoff with sod waterways and diversions, erosion control structures, and catch basins.
- Just as urban families recycle grass, newspaper, and aluminum, farm families have practiced recycling for a long time by applying manure to fields to replace nutrients in the soil.
- Agricultural land provides habitat for 75 percent of the nation's wildlife.

Science and Agriculture

Science is the study of or the explanation of natural phenomena. In other words, science deals with the laws of nature and our understanding of them. Agriculture fits this definition very well. No other discipline deals more directly with the laws of nature than does agriculture. Recognized areas of science such as physics, chemistry, geology, meteorology, and **biology** all are a part of agriculture. Biology is the study of living organisms—their life cycles and how they live, grow, and reproduce. All of the knowledge we have of living things (biology)

has only three applications: medicine, ecology, and agriculture. In fact, medicine and **ecology** (the study of the relationship of organisms in an environment) are related to agriculture. Medicine is related to agriculture because good nutrition is dependent on humans obtaining plenty of wholesome food. Ecology is related because of the tremendous impact agriculture has on the environment.

Agriculture is the most important of all the sciences because we depend on agriculture for the food we eat (FIGURE 1–5). Without a steady intake of food, we would soon die. Through the scientific developments that have made agriculture so efficient, fewer than half of the people in this country are involved with getting food to the rest of the population. Our system has become so efficient that one American farmer feeds more than 155 people. Of course, a large number of people support the farmer, in providing supplies and distributing the produce. This allows all of the people not involved in agriculture to produce manufactured goods and conduct services that would otherwise be impossible. If it were not for our agricultural system, people would spend most of their time gathering something to eat.

Many people think of agriculture in terms of a farmer out plowing a field, and this is a part of agriculture. However, farmers represent a small percentage of the people

FIGURE 1–5
Agriculture is our most important science.

who work in agriculture. The agriculture industry hires more people each year than any other industry. These jobs involve such diverse occupations as marketing specialists, chemical manufacturers, food inspectors, and research scientists. Yet all of these people are a part of agriculture.

The growing of plants and animals involves many different applications. At one time, living things were grown only for food and clothing. In modern times in this country, however, there are many other uses for the plants and animals we grow. In fact, new uses are constantly being found. For example, for many years our country has relied on other countries to supply a large portion of our petroleum that is used for fuel. We are now beginning to grow plants that supply fuel to meet our energy needs. Corn is used to produce ethanol for fuel to replace gasoline. Diesel engines were originally developed to run on vegetable oil, and modern diesel engines can be made to run quite well on vegetable oils such as peanut or soybean oil.

Growing Plants

In a very real sense, the foundation of all agriculture is the growing of plants. Without plants, the animals we grow for food would have nothing to eat (**FIGURE 1–6**).

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FIGURE 1–6
Growing plants is basic to agriculture. Plants provide us with food for ourselves and feed for livestock.

Much of the food we eat comes from plants. The flour that goes into our breads and the oil that we use for cooking come from plants. The fresh fruits that supply us with vitamins and other nutrients are plant products. Just think of all the vegetables you ate during the past week! All of these were produced by our agriculture industry. The seeds of plants supply us with a rich source of protein. Did you know that peanut butter is made from the roasted and ground-up seeds of a plant?

Plants also supply us with clothing. The fiber from cotton plants gives us comfortable clothing. This crop has been grown in this country since before it was a country. Today, only China grows more cotton than the United States.

Our houses also come from plants. Trees supply the lumber for buildings and furniture. You might not have thought of forestry as being agriculture, but most of the trees that are harvested each year have been planted and cared for by tree producers (**FIGURE 1–7**). Trees also supply the paper to make printed books. Just think of all the paper Americans use every day. This industry represents a large portion of the nation's economy.

Many medicines come from plants. A good example is the drug digitalis, which is used to help people with heart problems. This important medicine comes from the

For Further Exploration

Did You Know . . . ?

China and India each produce twice as much cotton as the United States. These countries rank first and second in cotton production. The United States ranks third.

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FIGURE 1–7
Growing and harvesting trees is a part of agriculture.

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FIGURE 1–8
Foxglove is a plant that provides a medicine for people with heart problems.

foxglove plant, which is grown by agricultural producers (**FIGURE 1–8**). Currently, over 120 different chemicals that come from plants are used as important ingredients in commercially produced drugs.

One large and expanding aspect of agriculture is the growing of ornamental plants. Americans spend millions of dollars each year on plants to beautify their homes. Drive through almost any neighborhood and you will see a broad variety of plants used to enhance the value of homes. Trees, shrubs, grass seed, and turf are all grown on farms and nurseries (**FIGURE 1–9**). Potted plants and flowers are produced in greenhouses for people to buy.

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FIGURE 1–9
Turfgrass used for lawns and football fields is grown on farms.

FIGURE 1–10
Many people make their living raising plants in greenhouses.

Each year, many people make their living raising plants in greenhouses (**FIGURE 1–10**).

Plants are used in ways you probably never even considered. Did you realize that chewing gum comes almost entirely from plants? The gum is made from a substance called chicle that comes from the sap of a tree. The sugar used to sweeten it comes from sugar beets or sugarcane. Even flavorings such as mint come from cultivated plants. All these plants are planted, cultivated, and harvested to produce chewing gum. This makes chewing gum an agricultural product!

The growing of the plants is supported by other parts of agriculture. Fertilizers are produced that supply the plants with nutrients. Chemicals are manufactured to produce pesticides that kill weeds and insects that attack the plants. Tractors, cultivators, and harvesting equipment have to be designed and built (**FIGURE 1–11**). Fuel and lubricants have to be produced for the tractors and equipment. Large irrigation systems have to be built, installed, and maintained. All of these items have to be marketed and sold to the producer. The growing of plants is big business!

The Animal Industry

Most of the animals produced in this country are raised for food. The cattle industry supplies us with beef. The steaks you eat for dinner and the hamburgers you buy

FIGURE 1–11
Tractors and other farm equipment are made in factories that employ a lot of people.

at the fast food restaurant come from the cattle industry. The swine industry gives us such meat products as pork chops, ham, and sausage. The sheep industry supplies meat for a large part of our population. The poultry industry produces meat for such products as fried chicken and chicken potpies. The poultry industry provides a source of nutritious, inexpensive meat and protein-rich eggs (**FIGURE 1–12**). Fish, shellfish, and other aquatic animals are grown by producers to be used as food. The dairy industry supplies us with fresh milk, cheese, butter, cream, yogurt, ice cream, and other products.

FIGURE 1–12
The poultry industry provides nutritious meals at a reasonable cost.

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FIGURE 1–13
Working dogs are used to herd livestock.

The animals that are slaughtered give us other products. Leather for making shoes, belts, and other clothing comes from cattle, hogs, and other animals. In addition, several medicines and other by-products are made from animal products.

Animals are still used for work. In many places in the western part of our country, horses are used to herd cattle. They are used as pack animals. Horses provide us with recreation through riding and horse racing. Dogs are also produced for work (**FIGURE 1–13**). They are valuable in herding sheep and are used in moving cattle and hogs.

An increasing part of the animal industry is the raising of companion animals. Dogs are raised and trained to be used to help visually impaired people, and are raised for pets. The pet industry is broad and diverse. Animals from goldfish to cats are raised as companions to humans.

Like the plant industry, the animal industry has a lot of support areas. Animals have to be fed. The feed industry supplies producers with high-quality feeds that contain the nutrients animals need (**FIGURE 1–14**). Medicines are needed to keep the animals healthy. Pesticides are needed to keep the animals free from parasites. Fencing has to be produced. Buildings and facilities have to be built to house the animals. Trailers and trucks are needed to transport the animals. Buyers, brokers, inspectors, and processors are all involved in the industry. And it is all a part of agriculture.

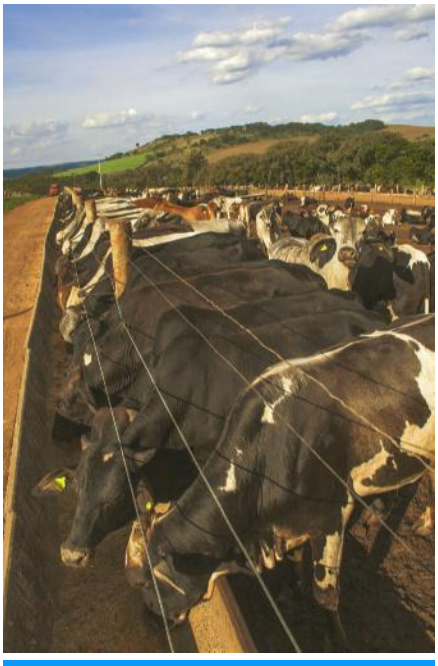

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FIGURE 1-14
A large industry provides feed for livestock.

Physical Science in Agriculture

When we think of agriculture, we usually think of biology involved in of growing plants and animals. However, the physical sciences such as chemistry and physics are a part of the science of agriculture as well. Think of all the chemistry that goes into the developing of fertilizers and pesticides (FIGURE 1–15). Physics and chemistry are both involved in understanding how a plant makes use of nutrients from the soil. The same can be said of how an animal ingests and makes use of nutrients from the feed it eats.

A very large part of agriculture is agricultural mechanization, or the use of machines in the industry. Simple tools such as the wheel and axle, incline planes, and fulcrums are all the basis of everything from ordinary hand tool to the most complicated tractors. Electrical energy must be supplied for many aspects of agriculture. The use of electrical devices and equipment is rooted in the basic physics of electron flow. A section of this text is devoted to explaining the use of physical science in agriculture.

Agricultural Exports and Imports

An **export** is a product that is shipped from the United States to a foreign country. An **import** is a product that is brought into this country from another country. Agriculture in this country both exports and imports

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FIGURE 1–15
A lot of chemistry goes into the development of agricultural chemicals such as pesticides.

commodities. A **commodity** is any useful thing that can be produced, sold, or bought. Commodities are the end result of agricultural production. The trade balance of agricultural products is good news for our country. The trade balance refers to the value of goods shipped out of this country (exports) compared to the value of goods shipped into this country (imports). In recent years, some industries have lost a large share of their market to companies in other countries. However, American agriculture still dominates the world's agricultural demand. Our wheat, corn, soybeans, and other products are shipped all over the world to feed people. Every year we export almost 70 percent more agricultural goods than we import. Each day we export many tons of agricultural products to other countries around the world. This generates more than $150 billion annually for our economy by creating business activities and millions of jobs.

Some agricultural products are brought into this country. Although we have a near ideal climate for agricultural production, some crops grow better elsewhere. For example, coffee grows best in the mountainous areas of South America (FIGURE 1–16). Bananas grow in the tropical areas of Central America, and many specialty foods such as cocoa and vanilla are brought in from other countries.

Another reason for importing agricultural products is so that we can enjoy fresh produce year-round. Because much of South America is south of the equator, their seasons are opposite from ours. This means that

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FIGURE 1–16
Coffee grows best in the mountain areas of Central and South America.

FIGURE 1–17
Watermelons can be grown in Mexico a lot earlier than they can in the United States.

when it is winter here it is summer there. We take advantage of this by bringing such produce as grapes into the United States so we can enjoy them all year. Countries such as Mexico that are closer to the equator have a longer **growing season** and can produce vegetables and melons earlier than we can in the United States. By shipping them in from Mexico, we can enjoy watermelons even before it is time to plant them in most parts of this country (**FIGURE 1–17**).

All of the industries involved in exporting and importing agricultural products create a lot of jobs. This adds to the economy and well-being of our nation. When the imports of manufactured products exceed the exports, agricultural exports help to make up the gap.

Distribution

If you are an average person you probably eat beef from Iowa, apples from Washington State, cheese from Wisconsin, tomatoes from California, potatoes from Idaho, and oranges from Florida. You wear clothes made of cotton from Arizona and live in a house built fromlumber grown in Oregon. Of course, other states also produce these products—agricultural products come from a wide area. The states mentioned are ideal for the production of these items because of their climate and other factors. Cotton grows poorly in Washington State, and Arizona is more suited to growing cotton than timber.

Agricultural products are grown where the climate and other factors are suitable for production. However, people in Arizona need lumber, and people in Washington State need cotton. To solve this problem, agriculture has a marvelous system for distributing products all over the country. Many people make their living buying farm produce from producers and selling to wholesale distributors or to processors. These people process and package the produce and sell to retail stores that offer the produce to the public. All this involves a complicated network of transportation. The produce is carried by railroad or by truck. Produce that is easily spoiled may be transported in a refrigerated railcar or truck.

Food and fiber processing is a huge industry that is a part of agriculture. Consumers want products that are as nearly ready to eat as possible (**FIGURE 1–18**). People no longer want to wash, shell, and cook beans in the hulls as they come from the producer. Instead, they prefer to have the beans processed and frozen in packages that go into the microwave oven and come out ready to eat. Few people want to make a pizza from scratch when they can have one that is ready to be popped into the oven for a few minutes. Think a minute about all of the processing that had to go into making that pizza. The tomato sauce had to be made from raw tomatoes and spices. The crust was made from flour that was processed from wheat. The cheese had to be processed from milk, and the sausages had to be processed from various meats and spices. All of the processing required that large numbers of people work together just to get the pizza ready for you—and they are all a part of agriculture.

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FIGURE 1–18
Consumers want products that are close to ready to eat.

Summary

Look around you. Agriculture is very much a part of your life. Without it our lives would be dramatically changed. This industry has made America one of the richest countries in the world. All of agriculture involves the application of basic biological and physical principles of science. In the following chapters we will explore the wonderful world of American agriculture.

Chapter Review

True/False

1. _____ Physics, chemistry, geology, meteorology, and biology are all part of agriculture.
2. _____ The foundation of all agriculture is growing plants.
3. _____ Most of the animals produced in this country are raised for producing dairy products.
4. _____ U.S. agricultural imports greatly exceed exports.
5. _____ Compared to people in other countries, we pay a very large portion of our income for food.
6. _____ Soil and climate provide the basis for the agricultural industry.
7. _____ A large portion of the medicines we use comes from plants.
8. _____ No other country produces more agricultural products than the United States.
9. _____ Companion animals assist farmers with work on the farm.
10. _____ One large and expanding aspect of agriculture is the growing of ornamental plants.

Multiple Choice

1. The study of or the explanation of natural phenomena is called
   a. agriculture
   b. science
   c. farming

2. One American farmer feeds more than
   a. 100 people
   b. 200 people
   c. 500 people
3. The country that leads in the production of cotton is
   a. the United States
   b. India
   c. China
4. Most of the animals produced in this country are raised for
   a. work
   b. dairy products
   c. food
5. No other discipline deals more directly with the laws of nature than does
   a. agriculture
   b. horticulture
   c. floriculture
6. Agriculture is the most important of all the sciences because we depend on it for
   a. dairy products
   b. jobs
   c. food
7. The foundation of all agriculture is
   a. raising animals
   b. growing plants
   c. growing fruit
8. The seeds of plants supply us with a rich source of
   a. carbohydrates
   b. protein
   c. vitamins
9. Each year many people make their living raising plants in
   a. greenhouses
   b. their homes
   c. gardens

10. Pesticides are needed to keep animals free from
    a. predators
    b. parasites
    c. poor weather conditions

Discussion

1. How are medicine and ecology related to agriculture?
2. List some jobs involved with agriculture.
3. Why are some plants so important in our daily lives?
4. What are companion animals?
5. What is needed to raise healthy animals?
6. List the uses we have for animals.
7. Why is agriculture the most important of all sciences?
8. Where does chewing gum come from?
9. Why is food and fiber processing such a large part of agriculture?
10. List the three applications available for all of our knowledge about living things.

Student Learning Activities

1. Make a list of all the jobs in your community that are involved in agriculture. Choose a particular job and list all the qualifications one would need for the job.
2. Go to the library and research the agricultural products grown in your state. Write an essay on these products. Which are the most important? Are the products used within the state, or are they shipped to other places?
3. Interview 10 people about their perceptions of agriculture. Draw a conclusion as to whether or not the majority of the perceptions are correct.
4. Keep a journal of all your activities for a week. At the end of the week, list all the ways agriculture has affected your life.

Chapter 2

The History of Agriculture

Student Objectives

When you have finished studying this chapter, you should be able to:

- Describe the importance of agriculture.
- Discuss how agriculture was necessary to the development of civilizations.
- Explain how the potato affected the people of Europe and America.
- Tell how the cotton industry brought wealth and created problems in the United States.
- Describe how the cattle industry developed.
- List some of the inventions that had an impact on agriculture.
- Discuss how scientific research helped develop agriculture.
- Define the Land Grant concept of education.
- Explain how the Land Grant institutions have helped shape agriculture.

Key Terms

civilizations
hunters and gatherers
scientific research
Land Grant Act
USDA
experiment stations

The science of agriculture is almost as old as the human race. In the history of humans on the planet, many **civilizations** have come and gone. Some were powerful and warlike, and some were small and peaceful. Some civilizations, such as the Greeks and Romans, provided the foundation for future civilizations. Architecture, art, literature, and political theories came from these civilizations. Other peoples accomplished great feats of engineering and building. Many aspects of ancient civilizations were different, but they all had one thing in common. Before any civilization could exist and flourish, a strong agricultural base had to be established (**FIGURE 2–1**). The reason for this was simple: Before roads could be built, buildings designed, or works of art created, the people had to be fed.

Before the creation of agriculture, people had to spend most of their time hunting and gathering food. These people are known as **hunters and gatherers**. In order to survive, they had to find and collect the food nature had to offer. This was a full-time job for all people, and little time could be spent doing anything else. This caused the people to have to travel all the time because food in an area would soon be depleted. When people found they could grow their own food, many of their problems were solved. Now they have a ready supply of food, and could now settle down in one place.

For Further Exploration

Did You Know . . . ?

Most anthropologists agree that agriculture began in what is known as the Fertile Crescent. This area is a half-moon-shaped area extending from the Persian Gulf through modern-day Iraq, Syria, Jordan, and Lebanon to Egypt. This is also where civilization began.

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FIGURE 2–1
Before any civilization can flourish, an agricultural base has to be established.

Shortly after people began to plant seed and tame animals, they began to search for better ways of growing food. By trial and error, they discovered the best time to plant, the best plants to grow, and the best animals to raise (**FIGURE 2–2**). As they got better at growing plants and raising animals, more food could be produced. As more and more food was produced, it took fewer people to grow the crops and keep the animals. In time, only certain people grew food, and others were then free to accomplish other things. A system of trade was established where goods such as pottery or clothing were traded for the food produced by the farmers. When farmers became really proficient, people could settle in one place and create villages. They could then build roads and towns and create art. This was because other people produced the food needed to feed the workers and builders. The stronger the agriculture of a civilization, the stronger the army and groups of workers could be. Without plenty of food to feed all of the people, little progress can be made by any people.

Agricultural advancements have had a large impact on the entire world. A good example is the potato. Potatoes originated thousands of years ago in South America. When European explorers brought potatoes home, most people were suspicious of them. When they finally realized that the crop could be grown in large quantities anywhere and that potatoes were highly nutritious, production rapidly increased

FIGURE 2–2

The best methods were discovered by trial and error.

FIGURE 2–3
The production and consumption of potatoes led to a growing population in Europe.

(**FIGURE 2–3**). Many historians contend that the widespread production and consumption of potatoes led to a boom in the population of Europe. By the mid-1800s, almost the entire population of Ireland consumed potatoes as their primary food. Around 1840, a disease began to wipe out entire crops of potatoes and the Irish people were left without their primary source of food. This led to starvation, and people began to leave Ireland. They immigrated to America and Australia, and the populations of these countries grew. The Irish people made a tremendous contribution to the development of our country.

American Agriculture

The United States is among the wealthiest nations on Earth. Much of this wealth can be attributed to the tremendously successful agriculture system. As we pointed out in the first chapter, American agriculture is the envy of the world. No other country comes close to matching the agricultural production of this country.

Our agricultural system began before we were a country. Most of the immigrants who first came to the New World were farmers. The colonists made their living producing crops that could be sent back to Europe. At the time of the American Revolution, well over 90 percent of the colonists made their living through agriculture.

FIGURE 2–4
Many early colonists grew tobacco.

In fact, most of the signers of the Declaration of Independence were farmers. At this time the main crops grown were tobacco, sugarcane, and rice (**FIGURE 2–4**). The produce that was not used by the colonists was sent to England, where it was exchanged for manufactured goods. The rich soil and climate of the New World made it an ideal place for agriculture. These conditions allowed the development of a variety of crops. But before agriculture could advance very far, certain developments had to take place. The following is a description of some of these developments.

King Cotton

Perhaps the first huge impact that agriculture had on the wealth of the nation came about as a result of cotton production. Cotton had been grown in India, Egypt, and China for thousands of years. It had also been grown in the New World in what is now known as Peru and Mexico from 2500 B.C. It was introduced into the coastal areas of Georgia and South Carolina in very early colonial days. The fiber from the plant was much prized as a material to use in making clothes. It was easy to spin and weave, easy to dye, and comfortable to wear.

There were two types of cotton—upland and Sea Island cotton. Sea Island cotton was the most widely grown. The fibers were longer (called *staple length*), and

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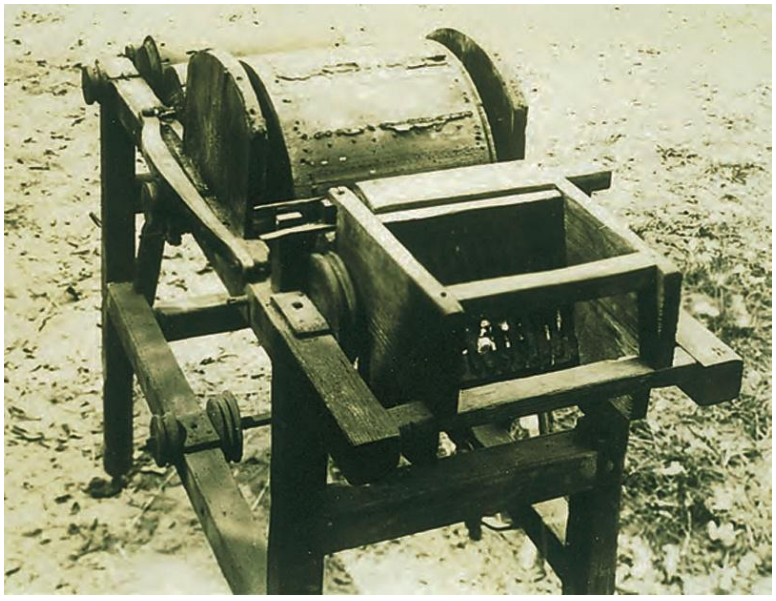
FIGURE 2–5

Upland cotton has seeds that seem to be glued to the fibers.

the seeds could be easily removed from the fibers. The problem with upland cotton was that the fibers seemed to be glued to the seeds and were extremely difficult to remove (**FIGURE 2–5**). Even though it was a slow process, the seeds from the Sea Island cotton could be separated from the lint by hand very easily. The problem was that this type of cotton would only grow along the coasts of the southern colonies.

About 1790, an inventor named Eli Whitney built a machine called a cotton engine (the name was later shortened to *cotton gin*) that could remove the seeds from upland cotton (**FIGURE 2–6**). The device consisted of spikes on a revolving drum that passed through slots and separated the lint from the seeds. A rotating brush then removed the lint from the seeds. One person turning the crank of the gin could remove more seeds than many dozen people removing them by hand. When the gin was fully developed and powered by steam, removing seeds was no longer an obstacle to growing cotton. This new device had a profound effect on the history of our country. For the first time, upland cotton could be profitably grown. This meant that a large area from what is now southern Missouri to Virginia and all of the areas south of there could be used to produce cotton. Cotton was an ideal crop to grow. Only so much tobacco, sugar,



Courtesy of National Cotton Council of America

FIGURE 2–6

The cotton gin removed seeds from the cotton lint.

Courtesy of National Cotton Council of America

FIGURE 2–7

One family could clear the land and make a living producing cotton.

and rice could be used and the market could be easily flooded. But cotton was a product that everyone could use. Now that the seeds could be efficiently removed, a gigantic market opened for cotton. As the demand grew, more cotton was produced. When this happened, the price fell. This caused the cloth to be affordable to poor people as well as rich. Cotton clothing was cheaper than the traditional wool or linen. It also had characteristics such as comfort that people wanted. When the price fell, more people could buy it and demand increased.

As more and more cotton was produced, new fields to the west in Alabama, Tennessee, and Mississippi were cleared and planted. A family could clear the ground and plant, cultivate, and harvest enough cotton to make a living (**FIGURE 2–7**). Although a lot of cotton was produced by large plantations using slave labor, even more cotton was produced by families who worked the land themselves. The entire southern portion of the United States was settled primarily because of the cotton industry. Cotton became so important that it became known as King Cotton.

Most of the cotton produced went to Europe (**FIGURE 2–8**). The textile factories of England, France, and Germany ran night and day using cotton from the

FIGURE 2–8

In the mid-1800s most of the cotton produced in the United States went to Europe.

Courtesy of National Cotton Council of America

United States. Ships that delivered the cotton returned with manufactured goods that were sold to the people of the southern states. By the 1850s these industries were almost totally dependent on American cotton.

While the South was developing its economy on cotton, the northern states were developing industries. These two diverse sections of the country developed disputes over the role of the federal government, taxation, and the issue of slavery. Ultimately, these differences led to the American Civil War. The development of agriculture had had a profound effect on the young country!

The Cattle Industry

The cattle industry in this country had a slow beginning. Beef was expensive. In the areas close to population centers, cattle had to be fed expensive grain or had to be fed on pastures that could have been put to better use growing crops. In the newly settled areas of the West, cattle could be raised on vast areas of grass (**FIGURE 2–9**). These areas were suited to the growing of cattle but not crops. The only problem was that the cattle-grazing areas were far from the centers of population.

After the American Civil War, western cattle producers decided the best way to get their cattle to the large cities was to ship cattle on the new railroads that had recently stretched westward. This would provide a way of

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FIGURE 2–9
On the newly settled territories of the west, cattle could graze on the vast areas of grass.

FIGURE 2–10

Refrigeration allows meat to be shipped over great distances.

getting the live cattle close enough to the consumer. This was necessary because the animals had to be slaughtered and consumed within a short period or the meat would spoil. The big problem was that there were only a few places where the railroad ran. Certain areas such as central and western Texas had no rails at all. Towns like Sedalia, Missouri and Abilene, Kansas became established as "railheads" where cattle were brought for shipment. The only way to get the cattle to the railheads was to drive them. The fabled cattle drives of the West were started in this manner. For a period of about 20 years, this was the means of getting cattle to market. This allowed cattle producers to make a profit by using the millions of acres of grassland to graze cattle.

After the railroads were finally completed around the turn of the twentieth century, cattle could be delivered live without the long arduous drives. A problem still remained. Even the rail journey took several days. During this time, the cattle lost weight from the stress of the long trip. Producers reasoned that more profit could be made if the cattle were slaughtered close to where they were raised and the meat shipped. However, this was impossible because the meat would spoil before it could reach market.

People had known for centuries that if meat was kept cool it could be kept longer without spoiling. The first attempt at cooling meat was the use of ice that had been cut from frozen lakes during the winter and stored in icehouses. The ice blocks were suspended from the ceiling in the meat storage rooms in an effort to keep the meat cool. This effort was not very successful. The ice melted quickly and did not keep the meat cool enough. Then, during the 1880s, mechanical refrigeration was developed. This allowed storage rooms to be kept cool all year long.

A few years later the refrigerated boxcar was invented (FIGURE 2–10). This innovation allowed the transportation of meat anywhere in the country at any time of the year. Now not only could animals be slaughtered at any time of the year, but also the meat could be stored for a long period of time. This meant that meat could be distributed to everyone in the country. This had the added effect of lowering the price of meat. Americans began to enjoy a healthy diet at a relatively low cost.

For Further Exploration

Did You Know . . . ?

The development of the refrigerated box car led to the development of home air conditioning. The same principles of operation led to the cooling of homes. Millions of people now live more comfortably because of this innovation.

Crop Production

Advances also were made in the producing of crops. As people moved westward, vast areas of fertile land were opened for farming. A particularly fertile area was the grassy plains of the Midwest. When settlers first came into the area, they had difficulty plowing the soil. The heavy soil could not be turned with the wooden plows used by the settlers. A heavy cast-iron plow would not work because animals could not pull it through the sod (FIGURE 2–11). The problem was solved in the 1830s by a man named John Deere. He developed a plow with a cutting edge and share made from steel like that used for saw blades. The strong tempered steel allowed the plow to be thinner and lighter (FIGURE 2–12).

FIGURE 2–11
Settlers had trouble plowing the thick, heavy soils of the prairie.

FIGURE 2–12
The tempered steel of Deere's plow allowed it to be lighter.

Wheels were later mounted to make the plow easier for animals to pull. With this invention, the fertile ground could be plowed under and cultivated.

Another problem was that of harvesting crops. For example, wheat was difficult to harvest because the plants had to be cut by hand. They were tied together into bundles called shocks and stacked. They were then gathered and threshed until the grain left the plants. This took a lot of time and reduced the amount of wheat that could be grown.

In 1831, Cyrus McCormick invented a machine that was used for reaping wheat (**FIGURE 2–13**). The horse-drawn implement cut wheat that previously had to be cut by hand. It operated by means of a sickle cutter that was powered by the turning of the wheels. Soon threshing machines were developed to separate the grain from the rest of the plant. This machine was run by steam power. People fed wheat shocks into the machine and it threshed the wheat grain out. After the invention of the internal combustion engine, the process of cutting the wheat and threshing was combined into one operation with a machine that came to be known as a combine (**FIGURE 2–14**).

The development of the internal combustion engine had a revolutionary effect on agriculture. After its development, work that once took days using human or animal power could now be done in a matter of minutes and with a much better result. Today almost all operations involved in the production of agricultural products are mechanized.

Courtesy of CASE IH

FIGURE 2–13
McCormick's reaper made harvesting grain more efficient.

FIGURE 2–14
A modern combine cuts and threshes the grain.

Scientific Research

All of the developments mentioned so far had a real impact on American agriculture. However, by far the most important aspect of the development was scientific research. **Scientific research** is the systematic search for new knowledge. As mentioned earlier, better ways of growing plants and animals were developed by trial and error. However, this method was too costly and took too long. Dramatic progress was not made until the development of methods of scientific research.

Systematic scientific research began in this country around the middle of the 1800s. It had become apparent that agriculture was a major economic basis for the nation. Leaders thought that our abilities should be strengthened, and the best way to do that was to educate people about agriculture. At that time, the universities in the United States taught a curriculum known as the classics. Students studied subjects such as Latin, Greek, history, philosophy, and mathematics. Though these were challenging disciplines, they had little practical use. People began to realize there was a need for institutions of higher learning where students could study subjects such as agriculture that had a practical application.

Courtesy of Frank Flanders, University of Georgia

FIGURE 2–15
In 1862, Land Grant universities were established.

In the late 1850s a senator from Vermont, Justin Morrill, introduced a bill to provide public land and funds to establish universities to teach practical methods of producing food and fiber. The bill was passed in 1862 and became known as the **Land Grant Act**, or the Morrill Act. This act provided each state with public land to build a "college for the common people" (**FIGURE 2–15**). The purpose of these colleges was to teach agriculture and mechanics. Many of these institutions were called A&M (Agriculture and Mechanics) universities. Many, such as Texas A&M, still use this name. During that same year, President Lincoln signed into law a bill that established the United States Department of Agriculture (**USDA**). Soon almost all of the states in the country established Land Grant colleges.

As students enrolled and classes began, a severe problem was recognized. People began to realize they had little knowledge about agriculture. Most of the knowledge about growing plants and animals had been obtained through trial and error. Most of the ideas about agricultural production had no real scientific basis. To solve this problem, Congress passed the Hatch Act in 1872, which authorized the establishment of **experiment stations** in states with Land Grant colleges. The purpose was to create new knowledge through a systematic process of scientific investigation (**FIGURE 2–16**). These experiment stations

Source: USDA, Agricultural Research Service (ARS). Photo by Stephen Ausmus.

FIGURE 2–16
Experiment stations provide research on new and better ways of production.

THE NATIONAL FFA ORGANIZATION

The National FFA is an organization for students studying the science and technology of agricultural education in school. This organization is active in all 50 states, the Virgin Islands, and Puerto Rico. Over 650,000 students participate in activities and programs sponsored by the FFA.

This organization began in 1928 when students studying agriculture met in Kansas City for the purpose of establishing a national association. Prior to this, many states had created similar organizations for rural young people. The state organizations began to compete in livestock judging and looked for a place to hold a national competition. The American Royal in Kansas City agreed to host the event. This brought the students together for the first time, and they decided there was a need for a national organization. In 1928, the Future Farmers of America, or FFA, came into existence.

The FFA was patterned after the Future Farmers of Virginia. This state association was developed by Henry Groseclose, Walter Newman, Edmund Magill, and Harry Sanders. They saw the need to give rural youth opportunities to develop social graces and leadership skills. Ceremonies for the FFA were designed after the ceremonies of the Freemasons, and the awards were patterned after those of the Boy Scouts.

The FFA has passed many milestones since 1928. In 1965, the FFA merged with the New Farmers of America (NFA). The