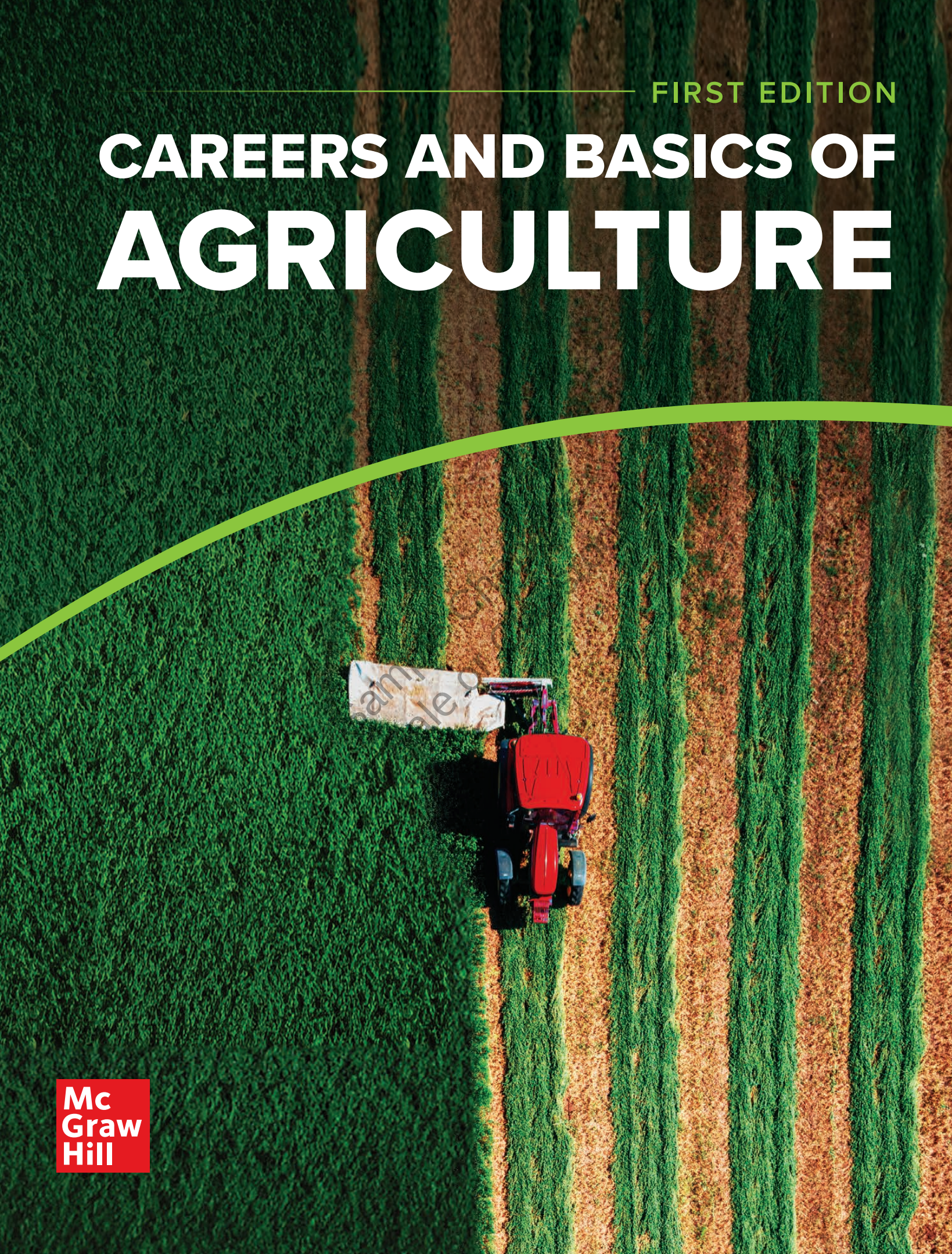
FIRST EDITION

CAREERS AND BASICS OF AGRICULTURE



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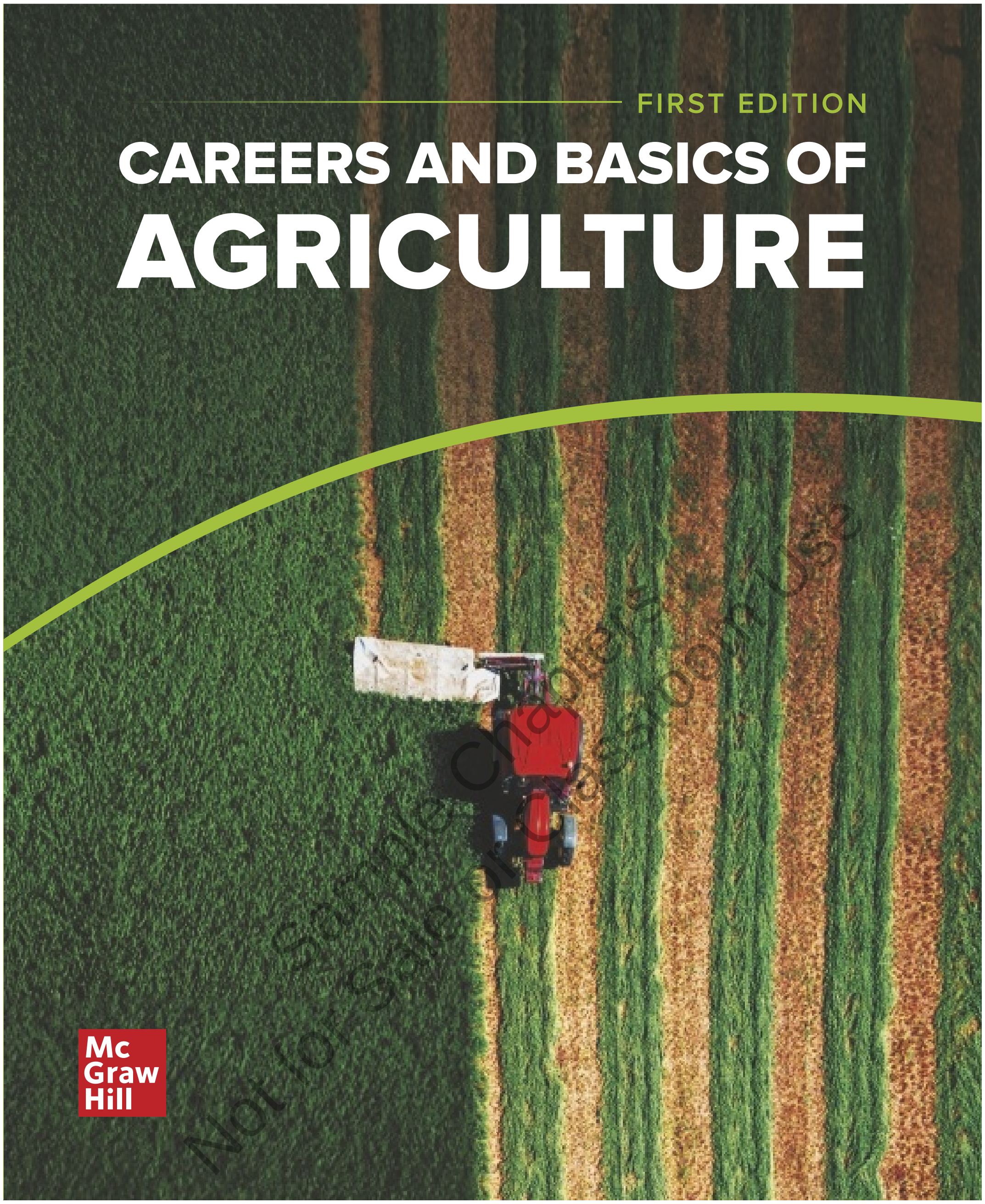

Student Edition Sampler

Mc Graw Hill

Bothell, WA • Chicago, IL • Columbus, OH • New York, NY

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Careers and Basics in Agriculture – Built for Career Success!

Supports AFNR, SAE, and FFA Goals: Content supports the National AFNR standards and helps prepare students for a successful Supervised Agricultural Experience (SAE) and National FFA Organization agriculture and leadership activities.

Provides Active, Career-Connected Learning: Real-world examples, career spotlights, and hands-on activities inspire students to develop critical skills for the agricultural workforce, including communication, leadership, and problem-solving.

Highlights the Broader Impact of Agriculture: Emphasis on global food needs, resource conservation, and economic development, connects students to the vital role agriculture plays in the world.

A Student Edition Built on the Science of Learning

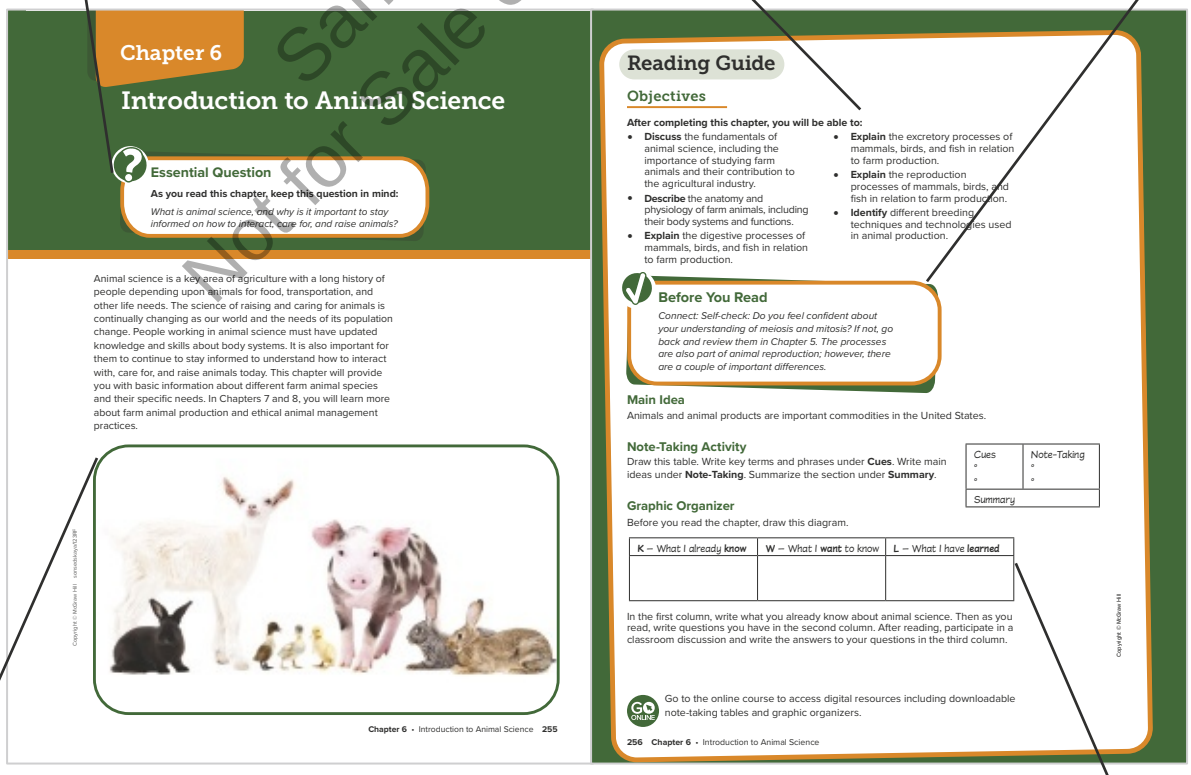
Students effectively gain the knowledge and skills they will use in their careers through the benefit of proven instructional design.

Clear and Engaging Introductions

Essential Questions frame the content so students can **predict and structure their learning**.

Objectives provide **learning intentions and success criteria** so students know where they are going in their learning.

Before You Read **activates prior knowledge, spirals instruction,** and **connects concepts** from previous chapters.



Chapter 6

Introduction to Animal Science

Essential Question

As you read this chapter, keep this question in mind:

What is animal science, and why is it important to stay informed on how to interact, care for, and raise animals?

Animal science is a key area of agriculture with a long history of people depending upon animals for food, transportation, and other life needs. The science of raising and caring for animals is continually changing as our world and the needs of its population change. People working in animal science must have updated knowledge and skills about body systems. It is also important for them to continue to stay informed to understand how to interact with, care for, and raise animals today. This chapter will provide you with basic information about different farm animal species and their specific needs. In Chapters 7 and 8, you will learn more about farm animal production and ethical animal management practices.

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Reading Guide

Objectives

After completing this chapter, you will be able to:

- **Discuss** the fundamentals of animal science, including the importance of studying farm animals and their contribution to the agricultural industry.
- **Describe** the anatomy and physiology of farm animals, including their body systems and functions.
- **Explain** the digestive processes of mammals, birds, and fish in relation to farm production.
- **Explain** the excretory processes of mammals, birds, and fish in relation to farm production.
- **Explain** the reproduction processes of mammals, birds, and fish in relation to farm production.
- **Identify** different breeding techniques and technologies used in animal production.

Before You Read

Connect: Self-check: Do you feel confident about your understanding of meiosis and mitosis? If not, go back and review them in Chapter 5. The processes are also part of animal reproduction; however, there are a couple of important differences.

Main Idea

Animals and animal products are important commodities in the United States.

Note-Taking Activity

Draw this table. Write key terms and phrases under **Cues**. Write main ideas under **Note-Taking**. Summarize the section under **Summary**.

Cues	Note-Taking
◦ ◦	◦ ◦
Summary	

Graphic Organizer

Before you read the chapter, draw this diagram.

K – What I *already* **know**	W – What I **want** to know	L – What I have **learned**

In the first column, write what you already know about animal science. Then as you read, write questions you have in the second column. After reading, participate in a classroom discussion and write the answers to your questions in the third column.

Go to the online course to access digital resources including downloadable note-taking tables and graphic organizers.

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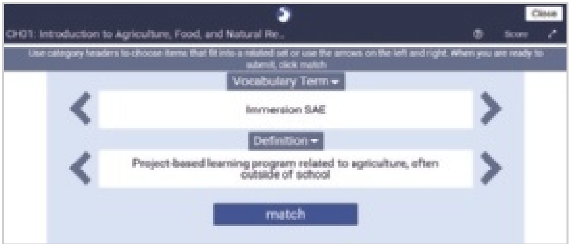
Motivating real-world relevance is introduced and sustained throughout each chapter.

Writing promotes deeper processing, so the **Note-Taking Activity** and **Graphic Organizer** guide students.

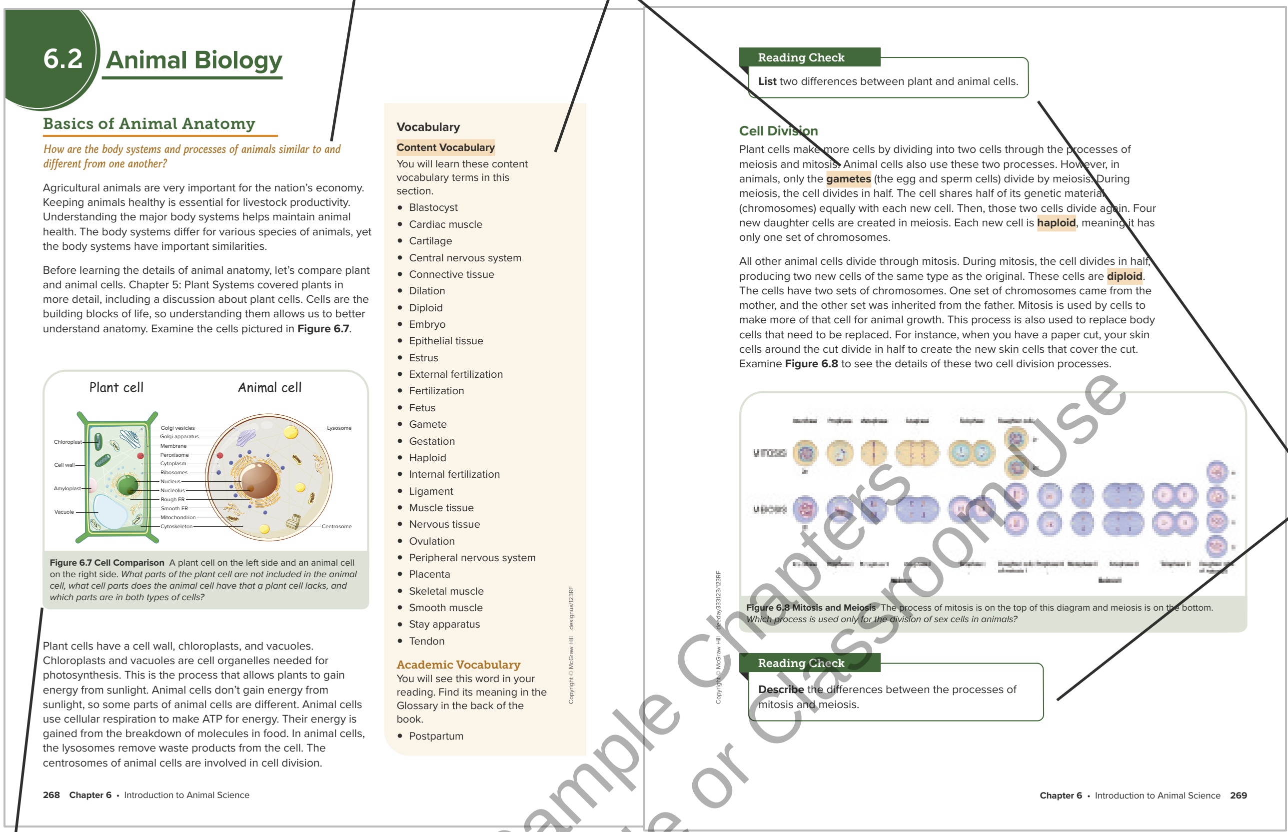
A Design Painstakingly Focused on Learning



Each section's introductory question helps students **hypothesize what they will learn and drives curiosity**.

Essential vocabulary is introduced early, contextually defined in the narrative, and reinforced in digital activities.

Section labelling, clean page design, and visual white space provide an **engaging and unintimidating learning experience**.



6.2 Animal Biology

Basics of Animal Anatomy

How are the body systems and processes of animals similar to and different from one another?

Agricultural animals are very important for the nation's economy. Keeping animals healthy is essential for livestock productivity. Understanding the major body systems helps maintain animal health. The body systems differ for various species of animals, yet the body systems have important similarities.

Before learning the details of animal anatomy, let's compare plant and animal cells. Chapter 5: Plant Systems covered plants in more detail, including a discussion about plant cells. Cells are the building blocks of life, so understanding them allows us to better understand anatomy. Examine the cells pictured in **Figure 6.7**.

Figure 6.7 Cell Comparison A plant cell on the left side and an animal cell on the right side. *What parts of the plant cell are not included in the animal cell, what cell parts does the animal cell have that a plant cell lacks, and which parts are in both types of cells?*

Plant cells have a cell wall, chloroplasts, and vacuoles. Chloroplasts and vacuoles are cell organelles needed for photosynthesis. This is the process that allows plants to gain energy from sunlight. Animal cells don't gain energy from sunlight, so some parts of animal cells are different. Animal cells use cellular respiration to make ATP for energy. Their energy is gained from the breakdown of molecules in food. In animal cells, the lysosomes remove waste products from the cell. The centrosomes of animal cells are involved in cell division.

Vocabulary

Content Vocabulary

You will learn these content vocabulary terms in this section.

- Blastocyst
- Cardiac muscle
- Cartilage
- Central nervous system
- Connective tissue
- Dilation
- Diploid
- Embryo
- Epithelial tissue
- Estrus
- External fertilization
- Fertilization
- Fetus
- Gamete
- Gestation
- Haploid
- Internal fertilization
- Ligament
- Muscle tissue
- Nervous tissue
- Ovulation
- Peripheral nervous system
- Placenta
- Skeletal muscle
- Smooth muscle
- Stay apparatus
- Tendon

Academic Vocabulary

You will see this word in your reading. Find its meaning in the Glossary in the back of the book.

- Postpartum

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Reading Check

List two differences between plant and animal cells.

Cell Division

Plant cells make more cells by dividing into two cells through the processes of meiosis and mitosis. Animal cells also use these two processes. However, in animals, only the **gametes** (the egg and sperm cells) divide by meiosis. During meiosis, the cell divides in half. The cell shares half of its genetic material (chromosomes) equally with each new cell. Then, those two cells divide again. Four new daughter cells are created in meiosis. Each new cell is **haploid**, meaning it has only one set of chromosomes.

All other animal cells divide through mitosis. During mitosis, the cell divides in half, producing two new cells of the same type as the original. These cells are **diploid**. The cells have two sets of chromosomes. One set of chromosomes came from the mother, and the other set was inherited from the father. Mitosis is used by cells to make more of that cell for animal growth. This process is also used to replace body cells that need to be replaced. For instance, when you have a paper cut, your skin cells around the cut divide in half to create the new skin cells that cover the cut. Examine **Figure 6.8** to see the details of these two cell division processes.

Figure 6.8 Mitosis and Meiosis The process of mitosis is on the top of this diagram and meiosis is on the bottom. *Which process is used only for the division of sex cells in animals?*

Reading Check

Describe the differences between the processes of mitosis and meiosis.

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Reading Checks provide **regular retrieval practice, encouraging student engagement**.

A question after each image caption provides **active cognitive engagement**.

Visual Elements for Every Learner

Complex concepts are **easier to learn when presented visually**.

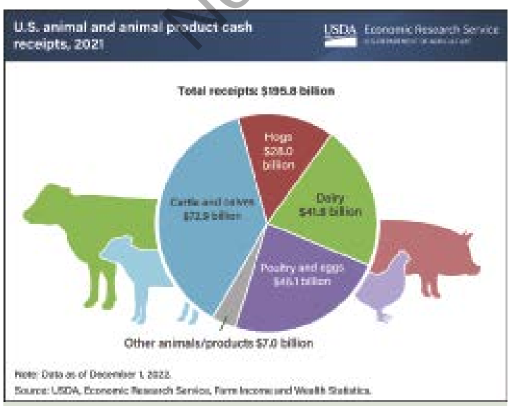


Figure 6.1 Livestock Income Nationally The agricultural industry brings income to the United States. *What are some animals/products that might be included in the $7.0 billion section of the chart?*

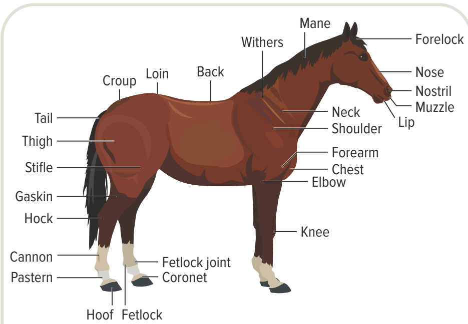


Figure 6.9 Mammal External Anatomy The horse's skeleton lends itself to use for riding and driving by people. *What parts are similar on this four-legged mammal to a human, even if the parts aren't labelled?*

Illustrations with clear labelling **support student retention**.

Each visual element is well labelled and explained with a question to **activate learning**.

Visual Elements for Every Learner (cont.)

Charts organize information visually, **reducing cognitive load**.

Agribusiness The business side of agriculture, including sales and marketing	**Agricultural Education** Teaching and training others about agriculture	**Agriculture Technology** Using technology to improve farming and food production	**Animal Science/Industry** Raising and caring for animals for food or other services or products
Biotechnology Using science to improve plant production, animal production, and agricultural processes	**Environmental Science** Studying and protecting natural resources and the environment	**Food Processing and Products** Turning raw agriculture into food and other goods	**Natural Resources** Managing and protecting resources like water, soil, forests, and minerals
Plant Science Growing and studying plants for food, fuel, and other uses	**Power, Technical, & Structural Systems** Designing & maintaining equipment & structures used in agriculture	**Skilled Trades** Specialized jobs that require technical skills and training	**Sustainability** Finding ways to farm and produce food while protecting the environment

Figure 13.1 Sectors in the Agricultural Industry These are the main sectors in the agricultural industry. *Which two sectors are you most interested in learning more about?*

Figure 6.35 A Cow with her Newborn Calf This cow is cleaning her newborn. *What phase of birth is the cow in?*

Up-to-date images bring **relevancy and real-life connection**.

Figure 3.5 Members Participating in an FFA Event These students are showing sheep that they have raised for their SAE project. *What are three ways that these students are demonstrating the FFA Code of Ethics?*

Review, Practice, and Assessment to Ensure Understanding

Each section's review prompts ensure students **retrieve and explain key concepts**.

3.1 Agricultural Leadership and Organizations Review

After You Read

1. **Describe** the role of extracurricular agricultural organizations in personal and professional development.
2. **Summarize** the history of the FFA and how the FFA is structured.
3. **Identify** the importance of the FFA creed and the meaning of the symbols in the FFA emblem.
4. **Explain** how the FFA code of ethics is related to good citizenship, including stewardship, advocacy, and community leadership.
5. **Evaluate** the importance and value of FFA citizenship skills, Program of Activities, agendas, minutes, constitution, and bylaws.
6. **Create** a fictional POA that includes a title, quality standards, target completion date, estimated budget, 3 SMART goals, and an intended outcome.
7. **Discuss** the role of agricultural organizations like FFA in formulating public policy.
8. **Evaluate** the importance and value of developing career skills.
9. **Interpret** the interaction of the three components of agricultural education (classroom/laboratory instruction, supervised agricultural experience (SAE), and participation in student leadership organizations).

Online Explorations

Research an FFA leadership role that may be a good fit for you.

Assessments delivered online or printed ensure **spaced practice** and **application of the learned material**.

Chapter Reviews provide succinct concept summaries for students to ensure they have **retained essential knowledge and skills**.

Chapter 3 Review

Chapter Summary

Section 3.1

- Leadership in agricultural organizations is shared across central or top decisionmakers, support staff with specific responsibilities beneath the decisionmakers, and the broader group of employees who make the day-to-day operations of the organization possible.
- Leaders in agricultural organizations are responsible for balancing the needs of their workers and the needs of their organization.
- There are many different extracurricular agricultural organizations, including the FFA, 4H, Block and Bridle, AETE, and others.
- Every agricultural leader's success is unique to them. However, successful leaders often share similar skills. Some of these skills include innovation, ethical leadership, self-awareness, self-motivation, and continuous learning.

Section 3.2

- There are specific leadership skills that can benefit agricultural professionals. These skills include effective communication, decision-making, and problem-solving.
- Effective agricultural leaders are committed to continuing their own professional development throughout their careers. Self-awareness, self-motivation, and continuous learning are crucial parts of keeping this learning going over the long term.
- Goal setting is a necessary part of achieving success. Goals help move a person towards their ambitions in smaller, manageable pieces, instead of in one overwhelming mass. SMART goals are a great way to develop goals that are manageable in size. SMART goals are specific, measurable, achievable, relevant, and time bound. Smaller achievements via completion of these goals make the attainment of much larger goals more possible.
- Leaders are responsible for taking on the ethical responsibilities that come with overseeing others' welfare, access to work, and day-to-day quality of life. Ethical leadership includes practicing integrity, accountability, and social responsibility.

Section 3.3

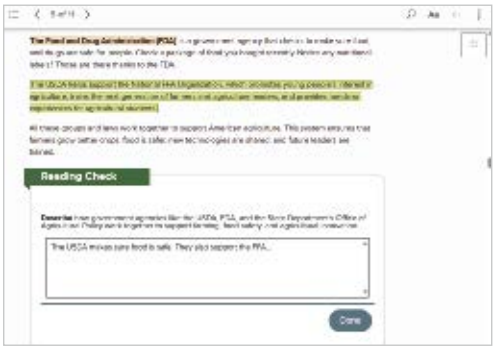
- Personal communication skills are crucial to successful leadership. They can also improve personal relationships in non-professional life. Active listening, verbal and non-verbal communication, and the capacity to adapt communication styles to different audiences are all important personal communication skills.
- Professional communication is conducted via many different forms in agribusiness. Forms of professional communication include written communication, public speaking, and persuasive communication techniques (including speaking and writing).
- Conflict resolution is part of every leader's life, particularly those in the agricultural professions. Conflict resolution skills include negotiation, mediation, and collaboration techniques, as well as the ability to understand when to use each skill.

Engagement and Time-Saving That Only Online Resources Can Deliver

Students and teachers benefit from how these online tools advance learning. All in one place, the resources are easy to access and easy to use.

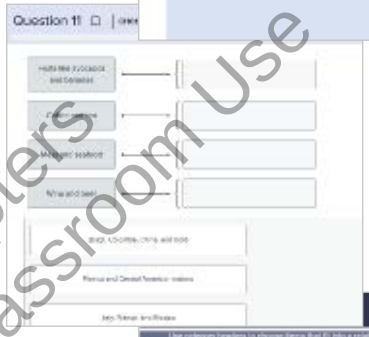
Learning, Personalized for Impact

Students engage in **personalized learning** with **SmartBook**. Integrated assessments point students to the content they need to review for **subject mastery**.



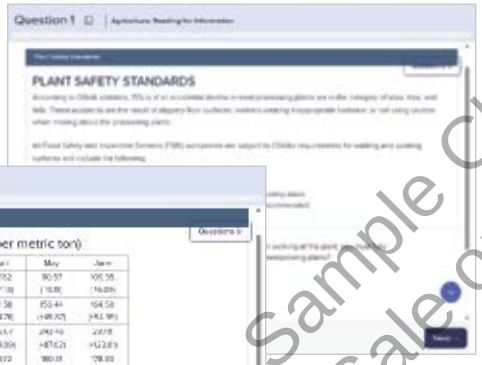
Rich Assessment to Ensure Understanding

Auto-graded vocabulary, extension activities, and **assessments** save teachers time and give students opportunities to assess their learning.



Academic and Visual Literacy Connections

Special assessments ask students to apply **mathematics**, **reading**, and **visual literacy** to the agricultural industry.

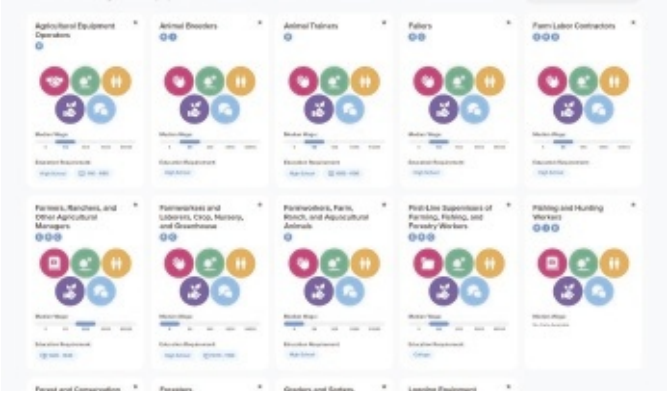


Developing Professional Skills at Every Turn

Students learn and practice soft skills using a **Soft Skills SmartBook**, **assessments**, **project-based learning**, and **simulations**.

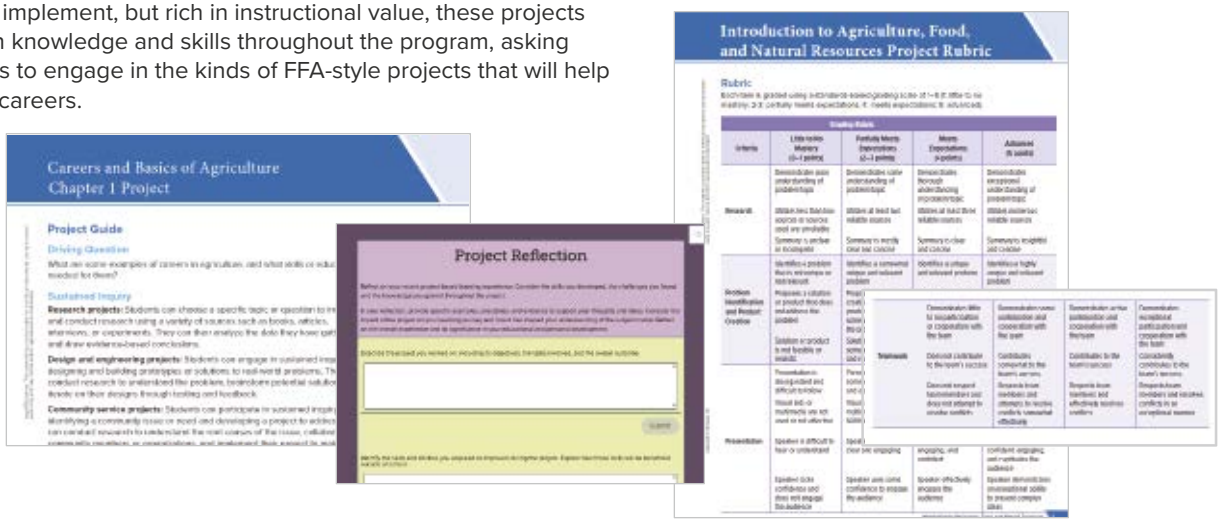
Exploring the Latest Careers

Students explore agricultural careers with updated data from O*NET in the **Career Center**.



Project-Based Learning for Immersive Learning

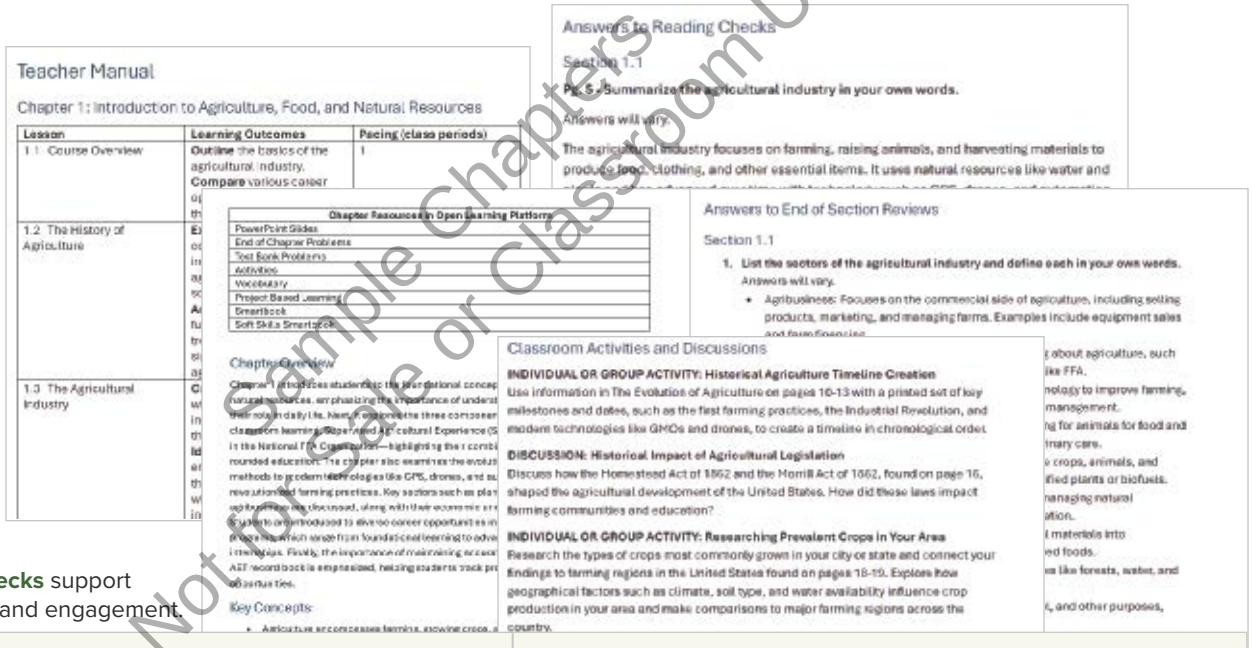
Easy to implement, but rich in instructional value, these projects draw on knowledge and skills throughout the program, asking students to engage in the kinds of FFA-style projects that will help in their careers.



Teaching Support to Ensure Success

Whether coming from industry or a biology classroom, teachers will be prepared and ready with rich support provided at every turn.

A complete **Teacher Manual** provides pacing, activities, concept overviews, and full explanations of section review questions in the student edition.



Robust **presentation decks** support classroom discussions and engagement.

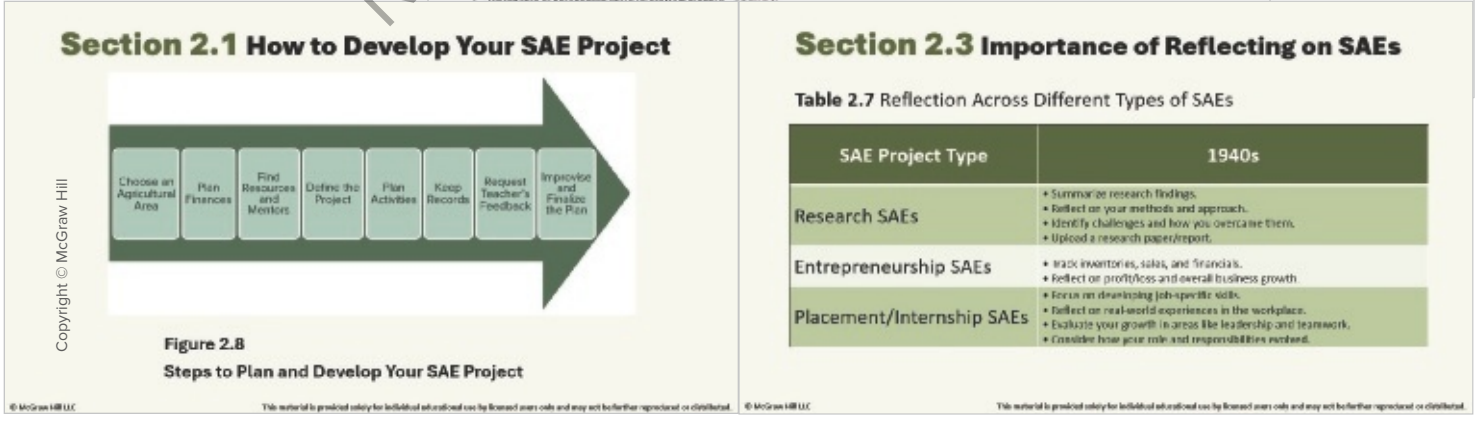


Table of Contents

Careers and Basics of Agriculture

Chapter 3

Agricultural Leadership and Communication

Essential Question

As you read this chapter, keep this question in mind:

What are the roles and responsibilities of agricultural leaders?

Building a successful career in agriculture doesn't just begin when you graduate from school and begin looking for a job. It begins while you are in school. It is important that while you are still a student, you participate in extracurricular activities related to agricultural skills and education. This will help you improve your agricultural knowledge. It will also help you learn a lot of other important things that might not seem related to your field at first. Some of the additional abilities you can develop while engaging in extracurricular agricultural education programs include

- ethical leadership;
- good decision-making;
- community building;
- financial management;
- goal setting;
- effective communication.

Over the course of this chapter, you will learn about what makes a good agricultural leader and how strong communication skills can have a positive impact on agricultural professionals.

Reading Guide

Objectives

After completing this chapter, you will be able to:

- **Examine** leadership in agricultural organizations, including the role and responsibilities of leaders and the benefits for skill enhancement and networking opportunities.
- **Identify** extracurricular organizations in agriculture, such as the National FFA Organization, and describe their roles in the industry.
- **Analyze** case studies of successful agricultural leaders, identifying their leadership traits, strategies, and contributions to the industry.
- **Develop** leadership skills specific to agriculture, including effective communication, decision-making, and problem-solving abilities.
- **Discover** the importance of personal development in agriculture, including self-awareness, self-motivation, and continuous learning.
- **Explore** the process of goal setting and achievement in an agricultural context, understanding how to set SMART goals and create action plans.
- **Identify** the ethical responsibilities of leaders in agriculture, including integrity, accountability, and social responsibility.
- **Demonstrate** personal communication skills, including active listening, verbal and nonverbal communication, and adapting communication styles to different audiences.
- **Explore** professional communication in agribusiness.
- **Outline** strategies for conflict resolution in agricultural settings.

Before you Read

Connect: Consider how extracurricular activities can enhance your SAE project.

Main Idea

Meeting with agricultural leaders and organizations is an excellent way to develop social, networking, and career-related skills. These leaders have a responsibility to provide ethical leadership, stewardship, and advocate for those they serve.

Note-Taking Activity

Draw this table. Write key terms and phrases under **Cues**. Write main ideas under **Note-Taking**. Summarize the section under **Summary**.

Cues ° °	Note-Taking ° °
Summary	

Graphic Organizer

Before you read the chapter, draw this diagram.

K – What I already **know**	W – What I **want** to know	L – What I have **learned**

In the first column, write what you already know about leadership and communication. Then, as you read, write your questions in the second column. After reading, participate in a classroom discussion and write the answers to your questions in the third column.

GO ONLINE Go to the online course to access digital resources including downloadable note-taking tables and graphic organizers.

3.1 Leadership in Agricultural Organizations

Overview of the National FFA Organization

What are the roles and responsibilities of agricultural leaders?

Being a successful student in agricultural education involves more than just classroom learning. It requires more than hands-on experience, too. It is important to practice doing parts of the agricultural job or jobs you would like to have in the future. But an equally important part of preparing for those jobs is developing specific professional and life skills—especially leadership skills.

Agricultural Extracurriculars, Education, and Leadership

A great way to build professional and life skills in the field of agriculture is by participating in **extracurricular** opportunities within agriculture. These can be community-based activities or groups, school clubs, or efforts hosted by larger organizations. One of the most well-known extracurricular organizations in American agricultural education is the **National FFA Organization (FFA)**.

Each student in an agricultural education program is required to have an SAE project. SAEs give FFA members the chance to build practical skills in their chosen agricultural field(s), while developing leadership, problem-solving, and other additional important career readiness skills. Some examples of SAE projects include volunteering at a local food processing plant, leading the creation of a community garden, growing and selling chicken eggs, creating compost for a school, or conducting a research project and presentation about the impact of rising temperatures on dairy production.

Reading Check

How can participating in extracurricular organizations benefit you personally?

The History of the National FFA Organization

The National FFA Organization started as two groups: the Future Farmers of Virginia and the New Farmers of Virginia. These groups were started separately in the 1920s at different colleges, and each became popular nationally. Their organizational structures were

Vocabulary

Content Vocabulary

You will learn these content vocabulary terms in this section.

- 4H
- Agricultural Education Division of the Association for Career and Technical Education (AETE)
- American Farm Bureau Federation
- Animal and Plant Health Inspection Service (APHIS)
- Block and Bridle
- Career Development Event (CDE)
- Collegiate FFA
- Crop Science Society of America (CSSA)
- Farm Service Agency (FSA)
- FFA Advisor
- FFA Chaplain
- FFA Historian
- FFA Parliamentarian
- FFA President
- FFA Reporter
- FFA Secretary
- FFA Sentinel
- FFA Treasurer
- FFA Vice President
- Food and Agriculture Organization of the United Nations (FAO)
- Food and Drug Administration (FDA)
- Future Farmers of America (FFA)
- Leadership development event (LDE)
- National Association of Agricultural Educators (NAAE)
- National FFA Organization (FFA)
- National Professional Agricultural Student Organization (National PAS)
- New Farmers of America (NFA)

different, but they were both instrumental in training students for future agricultural careers.

The Future Farmers of Virginia group was started at Virginia Tech University in 1925 for White male agricultural students. This is the organization that became **Future Farmers of America (FFA)** in 1928. Its official **creed**, or set of guiding principles, was created in 1930.

In 1927, the New Farmers of Virginia group was started at Virginia State University to promote leadership skills in African American male agricultural students. In 1935, the **New Farmers of America (NFA)** became its own national organization and was based at the Tuskegee Institute in Alabama. The NFA was heavily influenced by the ideas and teachings of Booker T. Washington, a civil rights leader and author. A statue of him is shown in **Figure 3.1**.

Over the decades since the FFA's official founding for young men, some young women had found ways to participate in the FFA because their chapters were open to it. But there were limits. Some could not compete in competitions or earn certifications through their chapters. Others could not receive credit for participation at their high schools and colleges. Some programs even created a "FFA Sweetheart" title for women who wanted to get involved. This pushed these interested students away from shared studies and activities and positioned them as symbolic or "non-members".

In 1942, Dorothy Gilson-Baker became the first female member of an FFA on record. She was part of the Port Royal, Pennsylvania chapter, and participated in a broad range of activities both on her family's farm and with her FFA peers, winning an annual award in carpentry at the age of 17. Gilson-Baker's name was not, however, added to the national FFA records at the time, meaning she has never been recognized as an official member of the organization.

In 1965, the FFA merged with the NFA resulting in the end of NFA. This was due to the Civil Rights Act of 1964 which mandated the end of segregation. The merger reflects the influence of the social movement of the 1960s.

It was not until 1969 that members of the FFA from Michigan and California successfully raised a motion to remove the requirement of being "male" for FFA members. Females were then officially welcomed into

- Program of Activities (POA)
- Speaking Development Event (SDE)
- The American Society of Agricultural and Biological Engineers (ASABE)
- The Food Safety and Inspection Service (FSIS)
- The National Sustainable Agriculture Coalition (NSAC)
- United States Department of Agriculture (USDA)

Academic Vocabulary

You will see these words in your reading. Find their meaning in the Glossary in the back of the book.

- Advocacy
- Agenda
- Bylaws
- Chief Executive Officer (CEO)
- Code of Ethics
- Company president
- Constitution
- Creed
- Emblem
- Extracurricular
- Federal charter
- Minutes
- Mission statement
- Motto
- Networking
- Skill
- Stewardship
- Vision statement

Figure 3.1 Booker T. Washington The FFA has been helping to provide agricultural education to students since 1925 but began with two organizations. *What two groups eventually led to the current National FFA Organization?*

the organization at all levels. Some of the many young females who have since participated in FFA work include:

- Anita Decker and Patricia Krowicki, the first female delegates to attend a National FFA Convention in 1969 (pictured in **Figure 3.2**)
- Julie Smiley, the first female member to serve at the national level of FFA, (as the western region vice president, in 1976
- Jan Eberly, elected the first female national FFA president in 1982
- Karlene Lindow, the first female member to be named American Star Farmer by the National FFA in 2002

Figure 3.2 Anita Decker and Patricia Krowicki Attending a National FFA Convention Today, women are welcomed as delegates and participants in all chapters of FFA at both the local and national levels. *How might access to FFA provide advantages to female agricultural students?*

In 1988, the FFA changed its name to the National FFA Organization (keeping the acronym FFA), to better reflect the growing diversity in agriculture. In the same year, the organization began to allow younger students in Grades 7 and 8 to join as members. Today, people of all different identities, backgrounds, and agricultural skillsets participate in local FFA chapters and the National FFA Organization. The days of participants being required to be of a specific race, gender, or type of agriculturalist are behind us.

FFA is made up of thousands of local student chapters and led by one national organizing body. There are chapters in all 50 states, Puerto Rico, and the U.S. Virgin Islands. FFA continues to support students who are pursuing futures in agricultural fields or other fields. However, where the original FFA chapters were focused on specifically farming professionals and researchers, the organization's support has expanded. Now, "agricultural education" and "agricultural professions" have much broader definitions. Careers and courses of study have changed over time. For example, you could be a chemistry student as an adult who is interested in developing new strains of plants, which would be an agricultural course of study towards an agricultural profession. FFA's focus on helping students develop personal, leadership, and career-focused skills has remained the same at its heart, but the resources, approaches and opportunities it can offer have grown. Ask the agriculture teacher who is teaching the course you're currently taking. They can help you become an FFA member.

The FFA Creed

The FFA creed was written by Erwin Milton, or E.M., Tiffany in 1928. Tiffany (pictured in **Figure 3.3**) was a professor of agriculture at the University of Wisconsin. While some of his students prepared to give presentations about projects they had completed with FFA, Tiffany wanted them to have a simple summary of the FFA's mission and beliefs. The summary statement he wrote became the FFA Creed and was adopted at the Third National FFA Convention in 1930. While it was revised at the 38th and 63rd Conventions, it is still in use today. Each of the FFA Creed's five paragraphs focuses on a promise that members are expected to make and keep while being part of the FFA.

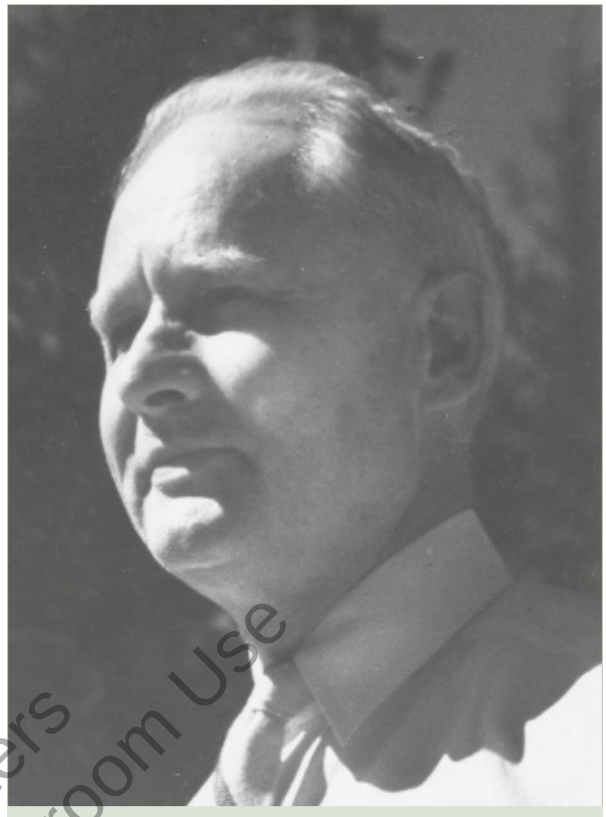


Figure 3.3 Erwin Milton Tiffany E.M. Tiffany developed the FFA Creed in 1928. *What is one way students can follow the FFA Creed?*

The FFA Creed, By E.M. Tiffany

I believe in the future of agriculture, with a faith born not of words but of deeds – achievements won by the present and past generations of agriculturists; in the promise of better days through better ways, even as the better things we now enjoy have come to us from the struggles of former years.

I believe that to live and work on a good farm, or to be engaged in other agricultural pursuits, is pleasant as well as challenging; for I know the joys and discomforts of agricultural life and hold an inborn fondness for those associations which, even in hours of discouragement, I cannot deny.

I believe in leadership from ourselves and respect from others. I believe in my own ability to work efficiently and think clearly, with such knowledge and skill as I can secure, and in the ability of progressive agriculturists to serve our own and the public interest in producing and marketing the product of our toil.

I believe in less dependence on begging and more power in bargaining; in the life abundant and enough honest wealth to help make it so–for others as well as myself; in less need for charity and more of it when needed; in being happy myself and playing square with those whose happiness depends upon me.

I believe that American agriculture can and will hold true to the best traditions of our national life and that I can exert an influence in my home and community which will stand solid for my part in that inspiring task.

The FFA Emblem

The FFA has an **emblem**, or symbol, as shown in **Figure 3.4**. It is made of five symbols put together. The National FFA Emblem dates to 1926, when agriculturalist Henry Groseclose was developing the Future Farmers of Virginia **constitution** and **bylaws**. While reviewing some agricultural documents from Denmark, Groseclose found an image of an owl perched on top of a spade. From there, he worked with R.W. Cline, a graduate student at Virginia Polytechnic Institute, to develop the image, resulting in the FFA emblem we see today.

Figure 3.4 The FFA Emblem This image features the emblem of the FFA. *What are the five symbols that make up the emblem?*

The Emblem consists of five symbols, along with the words "Agriculture Education" and "FFA," to tell the history, goals, and vision of the organization. Together, these symbols represent the FFA's history and goals.

- The first symbol is a cross-section of an ear of corn. This provides the foundation of the emblem because corn can be found in every state and province in America, and it represents unity.
- The second symbol is the rising sun. The rising sun represents progress, growth and learning and holds a promise that tomorrow will bring a new day glowing with opportunity.
- The third symbol is a plow, representing labor and tillage of the soil, the backbone of agriculture and the historic foundation of our country's strength that is needed for farming.
- The fourth symbol is an owl, representing the knowledge and wisdom it takes to be successful in the agricultural industry.
- The fifth symbol is an eagle. The eagle is the national symbol of the United States. The eagle represents the FFA's commitment to the country, the freedom of the Nation, and new horizons in the future of Agriculture.

The different major FFA Officer positions are also represented by each of the parts of the emblem, called station markers. The president is matched with the rising sun, the vice president with the plow, the secretary with the ear of corn, the treasurer with the emblem of Washington, and the reporter with the Flag.

The FFA Motto, Vision, and Code of Ethics

The FFA was created to prepare agricultural students for jobs in agriculture. Today, the organization focuses on developing leadership skills through agricultural education. Participants can go on to have successful careers even if they don't work in agriculture.

The Vision Statement: *Growing the next generation of leaders who will change the world.*

The vision statement states the overall goal of the FFA. It explains that the organization intends to promote positive change by educating tomorrow's leaders.

The Mission Statement: *Make a positive difference in students' lives by developing their potential for premier leadership, personal growth, and career success through agricultural education.*

The mission statement states the purpose of the FFA. It is a guiding idea that explains the core values of the FFA, and all FFA activities are intended to align with the mission statement.

The Motto: *Learning to do, doing to learn, earning to live, living to serve.*

The motto lists the core values of the FFA and states that members are expected to conduct themselves according to these principles.

The FFA asks all members to commit to the **Code of Ethics**. The code focuses on personal professionalism, growth, and a commitment to making the world a better place through **stewardship** (leadership or organizational responsibility), **advocacy** (fighting to bring awareness and support to specific issues), and community leadership. See **Figure 3.5** as an example of students at an FFA event. The Code is made up of eleven expectations:

1. Develop my potential for premier leadership, personal growth, and career success.
2. Make a positive difference in the lives of others.
3. Dress neatly and appropriately for the occasion.
4. Respect the rights of others and their property.
5. Be courteous, honest, and fair with others.
6. Communicate in an appropriate, purposeful, and positive manner.
7. Demonstrate good sportsmanship by being modest in winning and generous in defeat.
8. Make myself aware of FFA programs and activities and be an active participant.
9. Conduct and value a supervised agricultural experience program.
10. Strive to establish and enhance my skills through agricultural education to enter a successful career.
11. Appreciate and promote diversity in our organization.

To help FFA members follow this Code of Ethics, every chapter of FFA is responsible for organizing an annual **Program of Activities (POA)**. This is an annual series of fifteen or more activities that FFA chapters organize in order to reach a common goal.

The Importance of POAs

A chapter of FFA can choose its own set of activities to do each year. Each activity should be part of a larger project or goal. The **FFA Advisor** and FFA Officers create the POA and are responsible for following through with the activities in each area. The FFA Advisor is the person who teaches FFA members about leadership and

Figure 3.5 Members Participating in an FFA Event These students are showing sheep that they have raised for their SAE project. *What are three ways that these students are demonstrating the FFA Code of Ethics?*

who is an agricultural teacher. The FFA Advisor and the FFA Officers are also responsible for educating their FFA members about the chapter goals and activities. There are three subject areas, or divisions, that the activities can fall under. These are:

1. Growing leaders,
2. Building communities
3. Strengthening agriculture

Each division has five quality standards. These standards are specific skill areas that activities address. Some quality standards include:

1. Leadership
2. Citizenship
3. Environment
4. Safety

There is no official POA template, but all POAs should outline the goals an FFA chapter has set across the three subject areas. To create a POA, five activities are chosen for each of the three divisions. The different quality standards that each activity involves should be identified. The estimated amount of money and time needed for each activity, as well as the people who must be involved, should be included, too. **Table 3.1** shows what an example activity page from a POA could look like.

Table 3.1 Example Page from POA

Activity Title:	
POA Division:	**Quality Standards:**
Committee Chair:	**Committee Members:**
Target Completion Date:	**Estimated Budget:**
SMART Goal #1	
SMART Goal #2	
SMART Goal #3	
Activity Outcome	

Source: National FFA Organization

Example activities for a POA include:

- Guiding tours at a livestock show
- Arrange a guest speaker from the agricultural industry
- Running an annual FFA fundraiser
- Doing a community service project
- Holding an FFA recruitment event for younger students

A Constitution, a Set of Bylaws, and a Federal Charter

The FFA has three official documents: a constitution, a set of bylaws, and a **federal charter**. These documents help guide numerous aspects of FFA operations. Each FFA chapter has its own FFA constitution and bylaws that are voted upon by the

FFA members and FFA advisors. They are then approved by FFA at the state level. The constitution and bylaws are voted upon by the State FFA Officers of the chapter and submitted to the State FFA Advisor. If there are any amendments, they can be voted upon by the FFA Officers. They can all be viewed on FFA's official website.

The **constitution** explains the objectives of the FFA. It also lists how the organization is coordinated and funded:

- The expectations of participants
- The structure of FFA chapters
- How leadership should be organized
- What dues should be paid each year

The **bylaws** explain protocols and procedures:

- Behavioral expectations for all members
- The processes for choosing leadership
- The roles and responsibilities of leadership
- How to establish new chapters

The **federal charter** is proof of the FFA's importance to education and leadership development in the United States and provides legal stability to the organization. The charter represents the federal government's promise to support the FFA if it meets certain expectations. These expectations are:

- Making sure the FFA helps its participants develop specific skill sets
- Completing certain goals and activities
- Following organization rules

The charter is an example of how an agricultural organization can play a role in public policy. The FFA responds to guidance from the federal government. The government learns from and consults with the FFA. Not all FFA chapters are required to be chartered when they begin operations, BUT they DO have to be in the process of applying to be chartered. In other words, a chapter can only continue operating long-term if it is chartered. Some schools pay for all students in agricultural classes to become FFA members; however, many require individual students to pay an affiliation, or membership, fee.

FFA chapters meet at least once a month, either in-person or virtually, depending on the needs of the chapter. During these meetings, chapter members can hear about and report on recent events, prepare for upcoming events, receive financial updates, and work on skill building with their peers. These meetings help each chapter strengthen its community. Students can also attend leadership events or the yearly National FFA Convention and Expo as seen in **Figure 3.6**.

Figure 3.6 Members Attend an FFA Event FFA chapters hold regular meetings and events so that all members can stay informed. *Why is FFA chapter meeting attendance important?*

Agendas, or outlines of topics for a meeting, are prepared for each one by the chapter secretary. **Minutes**, or detailed notes about everything that happens during a meeting, are written during each one, also by the chapter secretary. This helps others review the events of a meeting and allows members and leaders to hold each other accountable for their work. For example, absent participants can review chapter meeting minutes that they missed. Or future FFA members can review past meeting minutes to understand how specific issues were addressed by others.

Reading Check

State the FFA Motto.

Other Agricultural Education Organizations for Students

The FFA is not the only organization available to students who are working toward futures in agricultural professions. There are several youth-oriented groups that help students build skills and confidence as they compare and explore career opportunities in agriscience, production, and other agricultural fields. **Table 3.2** lists several of these organizations, along with a brief overview of the focus of each.

Table 3.2 Other Agricultural Education Organizations for Students

Other Agricultural Organizations for High School Students	Details
4H	4H is a youth development organization in both the United States and Canada. Membership is open to youth between the ages of 5 and grade 12. Participants are mentored and complete hands-on projects in fields like agriculture, science, and health. 4H activities are intended to help participants develop leadership, communication, record-keeping, citizenship, and social skills.
Agricultural Education Division of the Association for Career and Technical Education (AETE)	AETE is an organization that serves agricultural educators at the K-12, post-secondary, and adult learning levels. The goal of the organization is to help teachers support students so that they are successful in finding future work in agricultural or natural resource system fields.
National Professional Agricultural Student Organization (National PAS)	The National PAS is a nationwide, student-led organization that connects agricultural students with networking opportunities, skill development, and employment experience.
Block and Bridle	Block and Bridle is a collegiate-level organization that supports students specifically interested in working in animal agriculture and sciences.
Collegiate FFA	Collegiate FFA is made up of chapters that are affiliated with colleges and universities. Professionalism and networking are emphasized as students complete volunteer and service-based projects.

American Agricultural Education Organizations

Many organizations across the United States and the world support agriculture by supporting agricultural education. **Table 3.3** lists several of these organizations. It also gives short summaries of what each one does and whether their target members are adults or young people.

Table 3.3 American Agricultural Education Organizations

Organization Name	Purpose	Membership
Agricultural Education Division of the Association for Career and Technical Education	The largest national education association focused on preparing people for careers	Adults
American Association for Agricultural Education	A national association focused on teaching, studying, and applying learning processes in agriculture	Adults
National FFA Alumni Association	A membership organization that works at the local, regional, state, national, and global levels to provide networking and skill development opportunities for alumni of the National FFA Organization	Adults
Leadership Executives of Agricultural Education and FFA Development	A national network of professional developers specializing in agricultural education and FFA programming resources	Adults
Minorities in Agriculture Natural Resources and Related Sciences	A national society focused on supporting agricultural and scientific professionals of all racial and ethnic backgrounds	Adults
National Association of Agricultural Educators	A federation of agricultural educator associations focused on bringing agricultural education to the global community	Adults
National Association of Supervisors of Agricultural Education	An organization focused on career education and community building for agricultural professionals	Adults
National Farm and Ranch Business Management Education Association	An organization providing farm and ranch management education across the country	Adults
National Professional Agricultural Student Organization	A student-led national association that offers young people opportunities for skill building in the agricultural sector	Youth

Reading Check

Identify one agricultural organization that is open to college students who are enrolled in an agricultural program.

Agricultural Agencies

Agencies in the United States and across the world are responsible for safety, health, and innovation in agricultural practices. In **Table 3.4**, some of these agencies and their activities are listed.

Table 3.4 Agricultural Agencies

Agency	Description
United States Department of Agriculture (USDA)	The USDA is a department of the federal government that oversees grants and offers other support for agricultural professionals and organizations. It contains several sub-departments, including the **Animal and Plant Health Inspection Service (APHIS)**, the **Farm Service Agency (FSA)**, and the **Food Safety and Inspection Service (FSIS)**.
American Farm Bureau Federation	The American Farm Bureau Federation is a nationwide membership organization for farmers, ranchers, and people living and working in rural communities. It advocates for these groups at the state and governmental levels.
Food and Agriculture Organization of the United Nations (FAO)	The FAO is an agency that is part of the United Nations. It focuses on food availability and sustainability across the world.
Food and Drug Administration (FDA)	The FDA is responsible for the safety inspection of accurate labeling of food products not regulated by the USDA, such as produce and plant-derived foods.
The National Sustainable Agriculture Coalition (NSAC)	The NSAC is a national network of agricultural professionals who advocate for policy reforms. These reforms are focused on sustainability, particularly for agriculture, food systems, natural resources, and rural communities.
The American Society of Agricultural and Biological Engineers (ASABE)	The ASABE is a group of biological, food, and agricultural engineers who work to create advanced technological advancements in sustainability for food and natural resources.
Crop Science Society of America (CSSA)	The CSSA is a professional organization that conducts and shares research into crop sciences across the United States.

Reading Check

List 3 federal subdepartments that are part of the USDA.

Leadership Roles and Responsibilities

What is the relationship between organizations and leadership?

Good leadership is essential to the success of any corporation, government, or organization. Leadership is about guiding others to success and taking responsibility for their development. Different responsibilities, and different types of leadership, are shared by multiple people. Corporations, public organizations (like non-profits or charities), and governments all have different leadership structures.

Leadership Roles in the FFA

The FFA is a public organization with its national leadership shared by three groups: one group of adult administrators, one group of FFA alumni officers, and one group of college student officers. At the state level, leadership is also shared across adult administrators (often agricultural teachers or professionals), college student officers, and a group of FFA (youth) officers. For local FFA chapters, adult administrators and

high school student officers share leadership responsibilities. At the national level, the three leadership groups make decisions for all chapters of the FFA. There is then a team responsible for sharing that information with the chapters. FFA chapters, meanwhile, are each led by three executive officers who are students (either college or high school, depending on the chapter level). These three officers are the **FFA president**, **FFA vice president**, and **FFA secretary**. They oversee additional officers, as well as specific committees. The FFA president is the highest seat of power within FFA elected leadership. The FFA vice president is second-in-command to the chapter president. The FFA secretary is the chapter officer who is in charge of creating an agenda and responsible for writing meeting notes. The other FFA officers are:

- **FFA treasurer**: the chairperson of a chapter's earnings and savings committee; receives and deposits funds (including membership dues), issues receipts, maintains accurate financial records, presents financial reports
- **FFA reporter**: the photographer of a chapter; takes pictures of events and members, helps with newsletters and media releases
- **FFA sentinel**: the person in charge of welcoming visitors to a chapter; responsible for maintaining meeting rooms and equipment, makes sure the meeting environment is comfortable
- **FFA advisor**: the person who teaches FFA members about leadership (usually an agriculture classroom teacher); plans instruction, advises and mentors students
- **FFA historian**: the person who takes notes and makes presentations about a chapter and its history; keeps a chapter scrapbook, helps with newsletters and media releases
- **FFA parliamentarian**: the person who connects the leading officers with the member governing committee; ensures that chapters and meetings follow parliamentary procedures, makes sure all members are heard and majority rules
- **FFA chaplain**: the person who oversees a chapter's ceremonies; provides moral support and spiritual guidance, leads prayers at events and meetings

Figure 3.7 shows student officers in the FFA.

The officers oversee committees. Committees are made up of chapter members, with each committee having a different responsibility or sets of responsibilities to manage. To learn more about specific leadership positions or how a chapter functions, reference the Official FFA Manual.

Figure 3.7 FFA Student Officers These students have taken on leadership roles in the FFA. *Why are youth officers an important part of the FFA?*

Reading Check

List the executive and additional officers in an FFA chapter.

The Responsibilities of Leadership

Whether you are in a public organization, a corporation, or an office of government, leadership shares some common characteristics. Being in a leadership role means being a good citizen by responsibly managing and supporting others. Leaders must make decisions for the good of their entire organization. They must also provide feedback to employees and respond to feedback from employees. Leadership delegates work and promote collaboration between employees. They must organize, communicate, motivate, and mediate for employees, too. Leadership positions are divided between driving an organization toward the future and supporting the daily needs of the people that keep it going. You will learn more about being an effective, ethical leader later in this chapter.

Reading Check

List five leadership responsibilities.

Participating in Competitions and Events

How can participation in competitions and events positively impact FFA members?

Participating in a local FFA chapter means that participants must meet both that chapter's requirements and the FFA's requirements. FFA encourages students to enter competitions while they are with their local chapters and contribute to events, too. That participation is added to students' AET account or their agriculture record book.

Competitions, Events, and the FFA

Participation in events and competitions offers students more than just something to do. Each competition that a student enters is an opportunity for **skill**-building, **networking**, and sharing their work with others. For example, entering an agriscience fair means a student must not only develop a science experiment to conduct, but prepare a presentation to give about it at the fair, and speak with agricultural professionals and judges who are present at the competition.

There are three categories of FFA competitive events:

- **Career Development Events (CDEs)** help students develop career-specific and evaluation skills.
- **Leadership Development Events (LDEs)** promote soft skills development to help students be better prepared for the workplace.
- **Speaking Development Events (SDEs)** support the development of public speaking and advocacy skills (**Figure 3.8**).

Figure 3.8 Members Participate in an FFA Event These FFA members are presenting their research findings in an agriscience fair contest. *How are these students building skills that help them prepare for a future career?*

A variety of skills can be built through participating in these events and competitions. For example, an agriscience fair offers participants the opportunity to work on speaking development, leadership, and career development. Perhaps a student can become more skilled in applying chemical equations, preparing a report, engaging in critical reflection, or doing project planning. Additionally, maybe they get better at explaining their work to strangers and creating professional bonds with others through their work. Every individual competition and event that FFA members compete in offers an opportunity for growth. All of these skills are important in real life and developing them prepares you for success in a future career.

Reading Check

Explain why participating in FFA competitions is a valuable part of agricultural education.

FFA Events

The FFA offers a broad range of events to FFA students. There is something for every type of agricultural interest or career path. **Table 3.5** shows the range of events planned by the FFA for 2025.

Table 3.5 FFA Events

Type of Event	Event	Significance
Career Development Events	Agricultural Technology & Mechanical Systems	A team event with an individual component; teams work to solve a multi-system problem and prepare a report; individuals take a written exam that tests their knowledge of the five agricultural technology and mechanical areas: compact equipment, electricity, environment and natural resources, machinery and equipment, and structures
	Agronomy	A team event with an individual component; teams evaluate an agronomic scenario then develop a crop management plan that includes crop selection, production, problem-solving and marketing; individuals take a written exam that tests their knowledge of plant identification, soil type identification and analysis, commodity quality, pest management, equipment knowledge, and a provided agronomic issue important to crop production
	Dairy Cattle Evaluation & Management	A team event with an individual component; teams are given a dairy farm management scenario with problems that they must find solutions to; individuals take a general knowledge exam, evaluate and select six dairy animal classes, and provide oral reasons for their selections
	Employment Skills	An individual event; students submit a cover letter and resume, complete an application, participate in telephone and face-to-face interviews, and engage in a networking activity
	Environmental & Natural Resources	A team event where students encounter real-life scenarios involving environmental threats (events are not postponed because of inclement weather); students complete written statements and oral presentations that demonstrate their knowledge of GPS navigation, soil science, water management, and wildlife conservation

Type of Event	Event	Significance
	Farm & Agribusiness Management	A team event with an individual component; team members collaborate to analyze a problem and present a written or oral report about their solution; individuals also complete a written activity
	Floriculture	A team event with individual components; team members work together to complete a floriculture assignment; individuals complete an exam (including an identification of plant materials and equipment), a problem-solving exercise, a practicum, a job interview, and a floral arrangement
	Food Science & Technology	A team event with individual components; teams design a new food product or change an existing product based on a provided scenario then complete a food safety and sanitation activity; individuals take an exam and complete problem solving and food safety practicums
	Forestry	A team event with individual components; teams use forestry skills and tools to respond to a problem-based scenario and deliver a presentation about a national or regional forestry issue; individuals take a forestry knowledge exam, are tested on tree identification and measurement, and complete practicums
	Horse Evaluation	An individual event with a team component; individuals evaluate and rank horses based on breed characteristics, conformation and performance then defend their decisions orally; team members work together to solve a problem-based scenario
	Livestock Evaluation	A team event; students work in teams to rank market and breeding classes of beef, hogs, and sheep, then defend their ranking orally
	Meats Evaluation & Technology	A team event; team members evaluate quality and yield grade beef carcasses, identify meat cuts and orally defend rankings
	Milk Quality & Products	An individual event with team components; individuals identify and evaluate milk flavor and dairy products, take the California Mastitis Test, Bacterial Culture Test, and Quality Milk Production and Milk Marketing Test, and complete a problem-solving activity; teams deliver a presentation based on a given scenario then determine producer milk acceptability based on several provided parameters
	Nursery/Landscape	A team and individual components event; team members work together to complete a skills-based challenge; individuals take a general knowledge exam, are tested on their ability to identify plants, plant diseases, pests, and beneficial insects, complete a landscape design cost estimate, participate in a mock customer service activity, and demonstrate their ability to pot or propagate plants

Type of Event	Event	Significance
	Poultry Evaluation	An individual event with a team component; individuals evaluate and rank poultry and poultry products then orally defend their rankings and complete a written exam; team members work together to answer questions about a current event in the poultry industry
	Veterinary Science	An individual event with a team component; individuals take general knowledge, math, and identification exams then complete eight six-minute practicums; team members collaborate, using information from their practicums, to analyze a scenario then orally present their evaluations and answer questions
Speaking Development Events	Creed Speaking	An individual event; students must accurately present the FFA creed within a given amount of time, students also answer questions about the Creed
	Agricultural Sales	A team event with an individual component; teams develop a sales plan based on an example product, product information, and customer profiles; individuals take a written exam that tests their knowledge of agricultural sales
	Agricultural Communications	A team event where students create a media communications plan and package that includes a feature story, and a related magazine layout design, broadcast production piece, and social media plan
	Extemporaneous Public Speaking	An individual event; students randomly draw speaking order, draw three topics from 18 choices, select one of the three topics to speak about, then take 30 minutes to prepare their speech; students present a four to six-minute speech to a panel of judges then answer questions related to their topic for five minutes
	Marketing Plan	A team event; teams of three research and present a marketing plan that solves a problem with an agricultural service or product (the team is allowed to recruit as many additional students as needed to complete research)
	Prepared Public Speaking	An individual event; students prepare and submit a speech manuscript prior to the event; during the event, students present a 6-to-8-minute speech that follows the format of their submitted manuscript then answer questions about their topic for five minutes
Leadership Development Events	Conduct of Chapter Meetings and Parliamentary Procedure	A team event where students are each assigned an officer part; students must memorize and perform the opening and closing ceremony then perform multiple motions of parliamentary procedure on a given main motion
	Agricultural Issues Forum	A team event where students research a current issue in agriculture, develop a research manuscript, and present the problem with solutions to multiple industry professionals

Source: National FFA Organization

Case Studies of Successful Agricultural Leaders

What does successful leadership look like in agriculture?

It's easy to assume that leaders in agriculture focus solely on farming, growing crops, or raising livestock. In reality, agricultural leaders work across a wide range of fields, from education and technology to policy and business. Altogether, the various areas of work and study that make up the agricultural profession are referred to as AFNR, or Agriculture, Food, and Natural Resources, as introduced in Chapter 2: Supervised Agricultural Experience (SAE) Program. Leaders in AFNR are innovators who come up with new solutions to existing problems or find unique ways to improve productivity or quality, such as the drone shown in **Figure 3.9**. They are self-motivated and use their leadership abilities to inspire others, enact change, and successfully complete projects.

Figure 3.9 A Drone Sprays Chemicals on a Crop Agricultural innovations such as this drone provide new ways to complete common tasks. *What other agricultural innovations can you think of?*

Agricultural Leaders and Their Successes

There are many leadership opportunities in the multiple sectors of the agricultural industry, as introduced in Chapter 1: Introduction to Agriculture, Food, and Natural Resources. The following examples of successful leaders are from a few of the sectors within the agricultural industry.

- **Plant Systems (approaches to growing plants sustainably and healthily over the long term)**: Alice Waters has promoted healthy and sustainable plant systems for over fifty years. Starting out as the co-owner of a restaurant that only used seasonal and local ingredients, she went on to create gardens that provided schools and prisons with food, work opportunities for former inmates, and education programs for children about healthy eating. She has created a series of lessons about sustainable gardening and farming.
- **Animal Systems (creating ways to make the lives that livestock live better, safer, and cleaner)**: Temple Grandin has worked in animal science since the 1980s to study and promote both the humane killing of animals for meat consumption and the humane treatment of animals on large livestock farms and ranches. She is an active advocate for improved treatment of animals being raised for use, either as food or as labor. You will learn more about Temple Grandin in Chapter 6: Introduction to Animal Science.
- **Food Products and Processing (canning, jarring, preserving, and changing the chemical makeup of foods so that they can be shipped over distances and saved for later safely)**: Joe Pezzini became the **company president** and **CEO** of Ocean Mist Farms, a food processing company, after working in California fields and produce packing for decades. He has worked to alter how fruits and vegetables can be safely packaged and shipped on a mass scale. He was the first chairperson of the California

Leafy Green Products Handler Marketing Agreement (LGMA), a group tasked with promoting and ensuring public safety by providing resources for food processing companies and implementing government supervised food processing audits.

- **Power, Structural, and Technical Systems (electricity, irrigation, and other supporting systems that help improve efficiency, productivity, and environmental protections within agricultural practices)**: Frank Maconachy currently serves as the CEO of Ramsay Highlander Inc., where he leads the development of automated harvesting and plowing machines that reduce the need for manual labor in crop harvesting. Currently, he is working on remotely controlled harvesters that can be directed simultaneously from a single smartphone and self-propelled crop sensors that compile data to give farmers a single report on the condition of their fields and plants.
- **Biotechnology Systems (growth, change, and evolution of agriculture and the systems around it, such as plant strain development and long-distance farming technology)**: Dean Banks, currently CEO of Indigo Ag, is committed to creating sustainable processes, technology, and systems for both the produce and meat industries. He focuses on bringing robotics, artificial intelligence systems, and chemical development programs into daily agricultural processing.
- **Environmental Science Systems (making agricultural practices more sustainable and safer for the environment)**: Tom Mulholland leads a land rescue and revival program in Pittsburgh, Pennsylvania. He helps the city turn unused lots into gardens, community spaces, playgrounds, and other multi-use spaces that can also help combat climate change. By developing greener, tree-filled areas within the city, more harmful pollutants can be cleaned out of the city's air.
- **Natural Resource Systems (improving accessibility of different natural resources in different places)**: Joe Del Bosque of Del Bosque Farms focuses on fighting for water management in areas affected by drought. He defends the needs of not only farmers but also their laborers and other people who depend on the work that farms offer in drought-ridden areas. He frequently speaks at events that bring together Latino leaders, farmers, and workers to raise awareness about agricultural water requirements, restrictions, and management techniques.
- **Agribusiness (the practice of buying and selling products and services related to agriculture)**: Molly Ball, of the FFA, oversees the major fundraising that keeps the FFA going every year. She also is active in involving employees, alumni, and chapters in ongoing programming, to promote long-term agricultural professional growth.

Reading Check

Describe the role of one of the agricultural leaders in making positive change as described above.

3.1 Agricultural Leadership and Organizations Review

After You Read

1. **Describe** the role of extracurricular agricultural organizations in personal and professional development.
2. **Summarize** the history of the FFA and how the FFA is structured.
3. **Identify** the importance of the FFA creed and the meaning of the symbols in the FFA emblem.
4. **Explain** how the FFA code of ethics is related to good citizenship, including stewardship, advocacy, and community leadership.
5. **Evaluate** the importance and value of FFA citizenship skills, Program of Activities, agendas, minutes, constitution, and bylaws.
6. **Create** a fictional POA that includes a title, quality standards, target completion date, estimated budget, 3 SMART goals, and an intended outcome.
7. **Discuss** the role of agricultural organizations like FFA in formulating public policy.
8. **Evaluate** the importance and value of developing career skills.
9. **Interpret** the interaction of the three components of agricultural education (classroom/laboratory instruction, supervised agricultural experience (SAE), and participation in student leadership organizations).

Online Explorations

Research an FFA leadership role that may be a good fit for you.

3.2 Personal Development in Agriculture

Developing Leadership Skills

What makes a good agricultural leader?

Strong leadership requires many different skills. Being a good team builder is not enough. Leaders must also excel at communication. Whether they are delivering a message to the public (such as the student in **Figure 3.10**), trying to inspire their staff, or supporting individual employees, leaders must relay information in engaging and understandable ways. In the agricultural industry, leaders must communicate effectively with people of varying skill levels, interests, and responsibilities to keep progress moving in a positive direction.

Leadership Skills

Leaders also need to be confident critical thinkers and decision-makers. As the world evolves with new technologies and shifting demands, leaders in the agricultural industry must assess what needs are emerging, what strategies are effective, and what changes are necessary to increase their impact. They must be confident in their decision-making abilities and work hard to take as much information into consideration before choosing the next best step. Adaptability is also important. In agriculture, things change all the time. Weather, transportation, and availability of materials and labor are just a few factors that can make or break a day in agricultural work. Just as critical thinking and decision-making are crucial to managing these changes, adaptability is essential, too. Being able to respond quickly with well-informed decisions sets great leaders apart.

Integrity and **self-awareness** are also essential qualities of effective leadership. Making ethical decisions that minimize harm to people, animals, environments, and resources can be challenging. Within the agricultural industry, this means considering not only what a leader's organization, colleagues, or employees need, but also what the earth and its natural resources need. Striking a

Vocabulary

Academic Vocabulary

You will see these words in your reading. Find their meaning in the Glossary in the back of the book.

- Accountability
- Achievable
- Active listening
- Continuous learning
- Empathy
- Ethical
- Integrity
- Measurable
- Relevant
- Respect
- Self-awareness
- Self-motivation
- Social responsibility
- Specific
- Time-bound

Figure 3.10 An FFA Member Leads a Meeting This student is delivering a message to an audience. *What leadership skill is he showing?*

balance between meeting the needs of businesses and people while acting sustainably requires constant work, which is why self-awareness is also so critical. Leaders must be tuned into themselves and their own limits. If they understand when they need to ask for help or when they are overwhelmed, they are putting the needs of the people, places, and things that depend on them ahead of themselves, practicing integrity.

Reading Check

List five skills of a good leader.

Personal Development in Agriculture

Personal development in any profession is an ongoing process. Once a person achieves a goal, they should set new ones to continue growing, both personally and professionally. Four key factors help people work on their personal development. The first is self-awareness. Just as successful leaders need to be aware of themselves, their limits, and their needs, individuals at any level of work or any stage of life need self-awareness, too. Self-awareness helps people understand what they want, what is working and not working in their lives, and what help they need. Self-awareness is closely connected to the second factor, being able to work well with others. Working with others to accomplish goals and objectives is an essential ability that is developed through practice and experience.

Similarly, **self-motivation** plays a key role in helping people move forward. Reminding themselves of their goals can keep them focused and help them grow as individuals. Pursuing **continuous learning** is a specific action that individuals can take to support their self-awareness and motivation. By seeking out new things to learn, ways to improve in their chosen professions, and approaches to life, individuals can continue to develop themselves over time. Reaching goals is one of the outcomes of dedication, motivation, and focus. **Figure 3.11** shows an FFA student's conversation with a livestock judge at an FFA dairy show.

Figure 3.11 A Student Talking to a Livestock Judge at an FFA Dairy Show This student focused on a goal and worked hard to reach that goal. *What personal development skills likely kept this student focused on his goal?*

Reading Check

Define self-awareness, self-motivation, and continuous learning.

Developing Leadership Skills

The development of leadership skills does not have to begin in adulthood. Students of all ages can work on leadership skills. Participating in the FFA offers an excellent opportunity to do so. The FFA Handbook lists traits that are specific to good leaders and is a great resource to reference. **Table 3.6** shows how students in the FFA can develop their leadership skills.

Table 3.6 Leadership Skills and the FFA

Leadership Skill	How the FFA Helps Develop the Skill
Active Listening	Paying attention to how their FFA chapter works and what is being discussed in the chapter so that they can find a way to contribute as a member
Participation	Participating in conferences/workshops, attending events, playing an active role in FFA projects, picking up new skills, meeting new people
Active Community Member	Building relationships with neighbors and fellow community members, practicing getting to know people of all ages and backgrounds and understanding their needs and wants in the community
Decision Making	Becoming comfortable with making choices in all sorts of situations, preparing for more significant decision-making needs in the future
Public Speaking	Developing skills in discussion and disagreement and presenting
Collaboration With Others	Working together with different people with different skill sets and interests and figuring out how to support and lead them to accomplish organizational goals and objectives
Taking On Leadership Roles	Practicing leading in different contexts, with different people

Reading Check

List the ways you can develop leadership skills.

Goal Setting and Achievement

What is the relationship between goal setting and earning achievements?

Setting goals is an essential part of not only self-motivation but also overall personal development and pursuit of success. By setting goals, people put their futures in motion. Articulating what they want to do or become, and how they plan to reach that point, gives individuals a clear path to follow. As a result, there is a greater chance of achieving their goals. The achievement of one goal can inspire individuals to set and pursue another, moving them further into the futures they want for themselves.

Setting SMART Goals

SMART goals were introduced in Chapter 2: Supervised Agricultural Experience (SAE) Program. The title stands for the words "specific," "measurable," "achievable," "relevant," and "time bound." Each of these words represents an aspect of strong goal setting. When goals are set with SMART as a guide, they become articulated and detailed, increasing the chances of those goals being achieved (**Figure 3.12**).

Figure 3.12 FFA Member Uses a Computer Program to Monitor His SAE Goals This student has set a herd management goal, and he checks the status of his herd regularly. *How can careful monitoring help a person achieve their goals?*

For example, a student could have the goal of going to more community events in their hometown. It is hard to figure out what "more" means because the term is not specific enough. When would the student know they have arrived at their goal? What would inspire them to keep working toward it? Making the goal more **specific** makes it easier for the student to know what they are working toward and to experience achieving it. For example, a more specific goal could be going to one community event in their town every month during this school year.

Measurable goals are goals that can be tracked. Seeing progress toward a goal helps people keep working toward that goal. For example, the goal of making more money from an egg business could be made more measurable if it included a way, or ways, for the goal-setter to know they are improving. A more measurable version of this goal could be making $200 more from selling eggs to neighbors than they did last year.

Setting **achievable** goals is what helps make goal-setting effective. If goals that are impossible or very hard are set, it is difficult to build a path towards achieving them. But if a simpler goal is set that can be achieved, a series of these goals can be set over time, resulting in the achievement of the unachievable goal. The more achievable a goal is, the more likely it is to be achieved. For example, instead of a recent graduate wanting to own 1000 head of cattle before they are twenty-five, a more achievable version could be wanting to own fifty.

Relevant goals are the goals that are connected to where a goal-setter is in their life. A high school student's relevant goals are not the same as a middle schooler's goals or the goals of a plant breeder throughout their career. A person must set a goal for themselves that makes sense for where they are in their life at that moment and what skills they already have that make the pursuit of that goal possible. If a student in the FFA sets a goal for themselves to develop an original strain of corn before graduating from high school, that goal is not entirely relevant. They do not have the technology, time, resources, or perhaps even knowledge to create a whole new type of corn. However, they could set the goal to study the history of corn development over the last five years, and practice cross-pollinating different types of corn each summer until the end of high school. This version of the goal can be worked on while the student is still at this point in their life. And perhaps one day, the first version of their goal will be more relevant and achievable for them (**Figure 3.13**).

Figure 3.13 A Young Woman Smiles While Standing in a Corn Field A goal is much more likely to be accomplished if it is relevant to the individual who sets the goal. *What goal do you have that is relevant to you? How does your goal differ from your friends' or family members' goals?*

Finally, setting a **time-bound** goal is necessary for a goal's success. In each of the previous examples of goals, there is an element of timing, or a time limit. Whether a goal is set for next month, next school year, or three years from now, there must be an amount of time within which it is pursued. This helps keep goal-setters on track. A goal with a deadline helps to push people to work toward it before they run out of time.

Reading Check

Explain why goal setting is important.

SMART Goals and the Supervised Agricultural Experience (SAE)

SAE projects are a crucial part of the FFA experience for participants. Through SAE projects, FFA members can explore possible fields of study or types of jobs in the agricultural industry. Setting goals while participating in an SAE can help students make the most of these experiences. **Table 3.7** shows some examples of SAE projects that use the SMART method and those that do not use the SMART method of goal setting.

Table 3.7 SAE Nonspecific Goals versus SMART Goals

SAE Project	Nonspecific Goal	SMART Goal
An Internship	Completing an internship before the end of high school	Applying for an internship at a local organization that is related to the student's future field of interest, and designing an independent project to complete by the end of the internship
Practicing Financial Independence	Selling homegrown flowers at school before Valentine's Day to save up as much money as possible	Getting permission to then selling individual flowers for $1 each during the school lunch hour and saving the money in an account that earns interest
Conducting an Independent Research Project	Using research already done for a school project and adding onto it for the independent project	Choosing a specific problem to solve within the student's field of interest, and completing it in a set amount of time agreed upon with an advisor
Learning How to Fundraise	Go door-to-door asking for donations from neighbors for the local horse rescue organization	Meeting with the horse rescue organization's leadership team to learn about what they need help with, and then organizing a neighborhood yard sale with proceeds being donated to the organization

Reading Check

Write a SMART goal for your SAE project.

Ethical Responsibilities in Leadership

What is the importance of being an ethical leader?

Being an ethical leader in agriculture means constantly working to treat all employees fairly, communicating honestly with people impacted by or invested in the business, and accepting failings and shortcomings when they occur. An unethical agricultural leader denies employees' concerns, avoids being transparent with business partners about issues that have come up, and otherwise refuses to recognize both the negatives and the positives. This can cause long-term harm to people and businesses at different levels.

Defining Ethical Leadership

Being an **ethical** leader in the agricultural industry requires more than knowing the difference between right and wrong. Ethical leadership requires a leader to consider what is best for the workplace and its people. Unfortunately, this is not an easy balance. Trying to keep an agricultural organization financially profitable and moving toward a long-term, successful future does not guarantee financial protections for employees or long-term employment.

For example, a poultry processing facility may need to fire staff from their jobs because of a reduction in the number of birds successfully produced by farmers that year. Or a biofuel company may need to change its organizational structure to improve cash flow. Other times, new leadership might clash with pre-existing leaders, resulting in employees having negative experiences in the workplace, or even leaving their jobs entirely. It can be very difficult to balance doing the right thing for a business and doing the right thing for its employees.

An ethical leader must also exhibit and promote other ethical and legal standards by setting a good example. Appropriate work habits and adherence to an organization's policies are part of a leader's responsibilities. It is important for a leader to set high standards and do their best to achieve and maintain those standards themselves. This also applies to legal standards, including following government and agricultural industry regulations, understanding and implementing safety protocols, and respecting employees' rights. Students can be recognized through awards for demonstrating ethical leadership (**Figure 3.14**).

Figure 3.14 USDA Deputy Secretary Krysta Harden Presents Awards to Outstanding FFA Members These students were honored for the achievements of youth in agricultural education and leadership. *Why is being an ethical leader an important part of an FFA experience?*

Reading Check

Summarize why it is important to be an ethical leader.

Traits of an Ethical Leader

There are a variety of different characteristics that help make an agricultural leader ethical, both as a people leader and as a business leader. A few of these traits, and examples of them in action, are described in **Table 3.8**.

Table 3.8 Traits of an Ethical Leader

Characteristic	Description	Example
Honesty	Telling the truth even when the truth is not the easier choice, or the more financially attractive choice	Being open about the state of a commercial farm to investors, even when it is a hard or negative truth
Fairness	Fighting to give everyone equal favor, instead of giving privileges to some people or businesses over others	Giving two equally skilled mechanics the opportunity to apply for a promotion, even though one has not been at the company for as long as the other
Accountability	Taking ownership of failures, mistakes, and responsibilities	Apologizing to an employee for speaking unprofessionally to them regarding a mistake they made while inventorying supplies
Integrity	Being honest and standing by one's beliefs, even when things are hard	Refusing to collaborate with a very wealthy business partner because their business does not align with the organization's beliefs about treating animals ethically

Characteristic	Description	Example
Being Transparent	Communicating openly about both the good and the bad to help promote understanding, not intimidate people	Answering an employee honestly when they ask if there will be layoffs for their marketing department in the next financial quarter
Having Empathy	Understanding that all actions impact other people, and putting oneself in others' shoes to understand those impacts	Giving critical feedback without attacking or intimidating the person receiving the feedback
Having Social Responsibility	Making decisions for the organization that help improve conditions at the local, regional, state, national, and global levels.	Promoting sustainable farming practices, offering employees financial incentives to incorporate more sustainable practices into their personal lives, donating a portion of the organization's profit to a local nonprofit organization annually
Showing Respect	Understanding that different people have different experiences and understandings and come from different backgrounds. Working to collaborate compassionately across these differences	Offering employees a flexible schedule if they need to arrive early or late because their kids need to be taken to or from school, offering cultural and religious paid time off, bringing regular professional development educators in to keep all employees updated on best interpersonal practices
Being Patient	Accepting the differences in workstyle and personality between themselves and others, and find ways to work across those differences instead of forcing one way of doing things	Building installation timelines that take into consideration one team member's attention to detail requiring two days of reviewing instead of one, in exchange for a high caliber of work
Being Curious	Seeking to understand how the workplace and its people function, to help all parties succeed	When a shift manager and a rendering plant employee are not getting along, meeting with each person to better understand how they could be better supported by the other party

Reading Check

List the characteristics of an ethical leader.

3.2 Ethical Leadership Review

After You Read

1. **Explain** the importance of personal development in agriculture, including self-awareness, self-motivation, and continuous learning.
2. **Describe** how you can participate in self-awareness, self-motivation, and continuous learning.
3. **Evaluate** how goal setting can benefit you.
4. **Create** a SMART goal related to solving a leadership-related problem.
5. **Describe** the characteristics of an ethical leader.
6. **Explain** why ethical leadership is important.
7. **Identify** ways that you can be an ethical leader at school, in the FFA, and in your personal relationships.
8. **Explain** how opportunities in leadership, citizenship, and career skills are related to personal development.

Online Explorations

Research the SMART goal that you wrote earlier and identify what was missing to make your goal more specific, measurable, achievable, relevant, and time bound.

3.3 Effective Communication in Agriculture

Personal Communication Skills

Why are personal communication skills important?

Personal communication skills are essential to all aspects of life. Being able to exchange information, thoughts, and feelings with others is important in the workplace and daily life. The more confident an individual is in sharing with others, listening to others, and learning from others, the more fulfilling their relationships will be, both with others and with themselves.

Personal Communication Skills

Personal communication skills help make success in professional settings possible. The ability to have conversations in which everyone feels listened to and recognized for points they make shows people in the workplace that someone is a dependable listener, thinker, and collaborator. A person can use different forms of body language to show openness and compassion while engaging in personal communication. Some of these forms of body language include:

- **Gestures**: using the body to make a point, such as raising an arm or waving a hand
- **Eye contact**: looking into the eyes of the person or people who are speaking to show active listening
- **Facial expression**: using your face to respond compassionately, which can include smiling, raising eyebrows, and furrowing your brow
- **Posture**: positioning your body openly with your shoulders back and gaze turned towards the people you are speaking with
- **Personal space**: standing or sitting close enough to someone to hear one another, but not so close that you are touching, and you do not come up with alternative ways to have physical contact with one another
- **Personal appearance**: wearing clean and neat clothes, having bathed recently, and making sure your face is easily visible to others (i.e., no sunglasses indoors, or hats pulled low over your face)

Body language can be used to show people in the workplace that someone takes their work seriously and can be trusted. These skill sets improve the odds of an employee being trusted to meet with people outside of an organization or with important projects. The better someone's personal communication skills are, the more comfortable people are working with them.

Vocabulary

Content Vocabulary

You will learn these content vocabulary terms in this section.

- Agenda/Order of Business
- Appeals
- Debriefing
- Document
- Evidence-based
- Fair debate
- Incidental motions
- Majority rule
- Minutes and reports
- Motions and amended motions
- Nonverbal communication
- Presentation slides
- Professional communication
- Quorum
- Rebuttal
- Spreadsheet
- Verbal communication
- Voice projection
- Voting

Academic Vocabulary

You will see these words in your reading. Find their meaning in the Glossary in the back of the book.

- Accommodating
- Anecdotes
- Audience questioning
- Avoiding
- Call to action
- Collaborating
- Competing
- Compromising
- Ethos
- Eye contact
- Facial expression
- Gesture
- Inclusive language
- Logos
- Pathos
- Personal appearance
- Personal space
- Posture
- Repetition
- Rhetorical questions

See **Figure 3.15** for an example of FFA member demonstrating communication skills.

Figure 3.15 FFA Member Demonstrates Communication Skills
This FFA member has great personal communication skills. *List 3 communication skills that he is using to present a professional attitude.*

Reading Check

List three reasons why it is important to develop personal communication skills.

Communication Cues

Personal communication skills range from simple to complex and incorporate a wide range of communication cues. These skills include:

- **Active Listening**: listening to speakers to understand them, not to argue with, react to, or speak over them
- **Verbal Communication**: using clarity, tone, and articulation to convey ideas in ways that are warm and accessible while also easily understood, with room for questioning
- **Nonverbal Communication**: using gestures, eye contact, facial expressions, posture, personal space, and general appearance to demonstrate interest and commitment, taking a situation seriously as in **Figure 3.16**
- **Communicating With Clarity**: sharing intentions when communicating so that others do not have to second-guess those intentions and feel comfortable asking for more information, as well as communicating their own needs
- **Acting With Accountability**: being willing to recognize mistakes, counterarguments, and negatives as part of the communication process

Figure 3.16 A Businessman Is Communicating with an FFA Member
Nonverbal communication can be just as effective as verbal communication. *What does this man's gesture communicate?*

Reading Check

List at least three examples of both verbal and nonverbal communication cues.

Adapting Personal Communication Skills

Using personal communication skills depends on the environment a person is in and the people there, too. With friends, an individual might both talk and listen and make a point of focusing on multiple different people or just a few throughout the event. They might sit comfortably, wearing comfortable clothes. At work, wearing more professional

clothing and focusing on active listening might be more important. In a large group setting, such as in school or at work, taking turns speaking and being mindful of the tone being used is helpful. No matter where a person is, there are ways they can successfully use personal communication to show their interests.

Reading Check

Summarize how personal communication skills affect interactions with others.

Professional Communication in Agribusiness

What are the different professional communication skills that can be used in agribusiness?

Personal communication skills can be split into two categories: casual and professional. There is some overlap between the two, especially when you are working with a team of people who you are familiar with, but how the skills are used depends heavily on the context.

Professional and Casual Communication

If you are meeting with a loan officer to secure a loan for a new agribusiness venture, you will want to be cordial, but professional. **Professional communication** includes written communication, public speaking, and persuasion without engaging in slang, overt friendliness, or other conduct that sends a message of "we are friends" or "this is a conversation over coffee." Often, professional communication is part of a person's effort to achieve a business goal, like securing a loan. Professional goals include making money, making professional connections, or getting a job. How a person communicates must demonstrate the seriousness of their intentions.

Conversely, casual communication can send the message that "we are friends," or at least that "we know each other and are communicating outside of the context of working or doing a professional project." The goal of these forms of communication is to build relationships, as opposed to "getting something" from someone or something else. For example, you are likely to communicate casually with your FFA event team members when you're not participating in a competitive event. Likewise, in agribusiness, people often develop friendly relationships outside of work. However, their casual communication is left at the door when they enter their workplace. Students can learn communication skills through teambuilding activities, such as the one shown in **Figure 3.17**.

Figure 3.17 FFA Members Work on Teamwork Skills These students are participating in a team building event at an FFA convention. *Describe one way that they may be communicating casually and one way that they are communicating professionally.*

Professional communication is important to agribusiness because of the many different people, organizations, products and/or services that are involved. To grow and sell rice for restaurants to use, for example, a rice farmer must communicate in a variety of ways. If the farmer works in the paddies where their rice grows themselves, they will have to communicate effectively with other people they are paying to work in the paddies, and to harvest and prepare the rice. If the farmer does not work directly in the paddies, they must communicate even more effectively to be sure that their workers are supported and given the guidance they need to succeed while working with the rice. Following growth and gathering, the rice farmer then has to arrange for it to be packaged for the restaurants that will use it, evaluated for food safety, and shipped to the restaurants. This requires communication via email, over the phone, and face-to-face to make sure things happen on time. And throughout these processes, the rice farmer must also be a good communicator with the restaurants ordering the rice, and perhaps even reaching out to new restaurants to build new working relationships with them. At all times, this rice farmer must be professional, available, willing to hear feedback and provide hands-on support, and make adjustments when people ask for them. The success of this single rice farm depends in part on how good the farmer is at professional communication.

Agribusinesses also depend on professional communications when it comes to protecting themselves, their customers, and their products. Agribusinesses are required to stay up to date on regulatory laws and standards for whatever goods or services they produce. The decision-making groups that create or change these regulations must publicly share any changes made, give agricultural professionals access to the official documents so that they can update their business practices, and keep their businesses running.

If agribusiness owners need protection or help, they have to communicate exactly what they need, why, and when, so that higher-up decision makers can respond effectively. Issues such as disease outbreaks for livestock, contamination of a specific food product, or other threats to customers, business, and animal safety must be swiftly shared and regularly updated to limit the number of parties harmed by the issue. Agribusinesses certainly need to engage in professional communication between staff and teams to operate. But professional communication is also needed between agribusinesses and the groups they work with, do business with, and are regulated by. The better communication is between all levels of agribusiness, from one producer to the top-most government official, the safer and more productive agribusiness will be.

Reading Check

List the three parts of professional communication.

Forms of Professional Communication

Professional communication exists in both written and oral forms. Using both helps an agribusiness professional to make a positive and lasting impact, either with a singular coworker or with many listeners at a professional presentation they are

giving. **Table 3.9** includes some examples of each of these two forms of communication.

Table 3.9 Types of Professional Communication

Professional Written Communication	Professional Oral Communication
Letters	Presentations
Emails	Speeches
Memos	Meetings
Proposals	Phone calls
Reports	Professional conversations
Inter-office messaging (Microsoft Teams, Google Chat, etc.)	Recorded talks

Professional written communication should be used to ensure that a permanent copy of something exists. Letters, emails, proposals, and reports ensure that a record of a conversation, plan, or idea exists and can be shared widely. Memos and inter-office messaging can be used to exchange quick conversations between coworkers, but because they are on record and kept by the workplace, they should be kept professional and brief.

Professional oral communication in agribusiness organizations should convey ideas, thoughts, and plans on a broad scale. This could include communication such as presentations, meetings, recorded talks, and speeches. Phone calls and professional conversations are forms of oral communication that add a personal element to professional exchanges, encouraging relationships to develop between coworkers, peers, and businesspeople to better pursue their goals or find others to collaborate with.

Reading Check

List three types of written professional communication and three types of oral professional communication used in agribusiness. Then, give three examples that incorporate both written and oral professional communication.

Professional Communication Tools

Computer technology has expanded modes of professional communication in ways that have permanently changed how people work with and for one another in agribusiness. **Table 3.10** lists a range of these communication tools and examples of them as they are used in workplaces.

Table 3.10 Professional Communication Tools

Type of Communication Tool	Description	Example
Presentation slides	Computer-based slideshow programs that can support a spoken presentation	PowerPoint, Google Slides
Document	Writing programs	Word, Pages, Docs
Spreadsheet	Numbers and data-tracking programs	Sheets, Excel
Design Platform	Document design programs to make word-based reports and public documents attractive	Adobe Design Suite, Canva, Figma
Video Conferencing	Online programs that allow people to speak to each other in one space across geographies and time zones.	Teams, Zoom, Webex, Google Meet
Shared Online Drive or Work Platform	Internet-based workspaces that allow employees to work on the same documents and projects at the same time without sending them back and forth.	Drive, SharePoint, iCloud
File Compressor	Internet-based services that can send many files at once from one person to another.	WeTransfer, Box, Dropbox
Learning Management System	Learning platforms online where information, instruction, and professional development can take place.	Canvas, Blackboard, iSpring

Before the expansion of computerized communication tools, there were foundational tools used in professional environments that were crucial to the development of the technologically based approaches used today in agriculture. Examples of these non-computerized modes of communication, listed earlier in this chapter, include memo sharing, giving oral presentations (**Figure 3.18**), writing letters, and creating reports.

Each of these communication approaches, and many other non-computerized tools, are still in use today, just with a technological twist added.

Figure 3.18 FFA Presenters at an Agriscience Fair This student is using a presentation tool to share information with an adult. *How can using technology enhance communication?*

Reading Check

Describe how documents, spreadsheets, slideshows, video conferences, and learning management systems are used to share information in agribusiness organizations.

Using Persuasive Speaking

Persuasive speaking can be used in agribusiness settings to persuade others to understand, agree, or collaborate with them. Persuasive speaking focuses on the positives of a topic. If someone wants to convince someone else that an idea is a good one, that they should accept a job offer, or any number of other things, persuasive speaking can contribute to the final decision. But persuasive speaking can be harmful if used to communicate only the positives of something and not the negatives, to mislead someone else, or to pressure someone who does not want to be convinced or pressured. It is only appropriate to use persuasive speaking when introducing something one wants to convince others of and explaining that conviction. **Table 3.11** gives some examples of persuasive speaking techniques.

Table 3.11 Examples of Persuasive Speaking Techniques

Persuasive Speaking Technique	Description
Ethos, Pathos, Logos	Drawing on a group's belief system, common goal, or emotions to drive interest
Rhetorical Questions	Asking questions that the speaker then immediately answers for themselves or knows that listeners cannot answer
Anecdotes	Offering stories in support of a larger argument
Repetition	Returning to the topic or issue in new ways over and over again
Inclusive Language	Using terms like "we," "equal," and "together" to draw people and their investment together
Audience Questioning	Inviting questions from listeners to involve them in the point being made
Call to Action	Inspiring listeners with a goal or need that must be met, inviting them to pursue that goal or meet that need

Sometimes professionals in the agriculture business must use persuasive speaking during important meetings, as shown in **Figure 3.19**.

Reading Check

Identify a time when you spoke persuasively. Share what you spoke about and whether you successfully persuaded your listener with a classmate.

Figure 3.19 A Professional Speaks During a Meeting This speaker is attempting to persuade his listeners. *List two persuasive techniques that he may be using.*

Evidence-Based Arguments

An **evidence-based** argument is focused on delivering one specific point. Evidence, details, and supporting arguments are added to make the central argument more appealing. Acknowledging counter-opinions may be supportive if they can be addressed in favor of the essay's point. Individual elements of the central point must be described and supported by evidence. In written form, an evidence-based argument works best when it is structured similarly to the outline below:

1. Introductory paragraph
   - Overview of the topic being discussed in the essay
   - The problem that the argument is addressing
   - How the argument will be addressed in the essay (also known as the thesis statement)
2. Body paragraph
   - The first element of the argument
   - Evidence supporting the element
   - Discussion of how the element relates to the larger argument
   - Identifying counterarguments for the element
   - Conclusion about this element of the argument
3. Repeat as many body paragraphs as needed until the argument has been addressed.
4. Conclusion paragraph
   - Restate the argument
   - Summarize the points made about the argument
   - State why the argument has been proven

Here is an example body paragraph from an evidence-based argumentative essay about the importance of rotating crops so that corn never grows in the same field two years in a row:

> Rotating crops on a farm so that corn never grows in the same field two years in a row makes a farm more financially successful over the long term. Corn is a crop that is incredibly hard on the soil and makes it too unhealthy to support the growth of any produce. Corn does not have an equal exchange of nutrients with the soil while it grows. It only takes out those nutrients, leaving the earth weakened. Moving the location of a corn field every growing season makes sure that all the nutrients in an area of soil are not removed. Instead, each former corn field has the chance to recover from the strain of growing the crop. The field can be left to lie fallow for a year, meaning it does not have to support the growth of any crop. This allows the earth to rejuvenate, thanks to bugs, decaying matter such as leaves, and fertilizers. A new crop that is not corn, such as soybeans or wheat, can then be planted during the following season, introducing additional nutrients to the soil. While this does require more work from farmers due to moving crop locations on a regular basis, the larger positive impacts cannot be denied. By using the rotation method, a farm can grow corn every year, as well as other crops, without exhausting the soil. The farm can sell more produce and earn more income over time.

Reading Check

List the elements of an argumentative text.

Strategies for Conflict Resolution

What is conflict resolution?

Conflict resolution is the practice of creating responses to issues that help everyone impacted by those issues. For example, conflict resolution between two students who are fighting over a marker involves making sure that both students are seen, heard, and helped. Possible resolutions, following a conversation with the two students, could be:

- Timed exchanges of the marker
- Removal of the marker altogether in favor of another color that is found in two markers instead of one
- Switching from markers to crayons

Conflict Resolution in Professional Settings

Conflict resolution can be used in all sorts of professional contexts. Below are examples of common forms of conflict resolution:

- **Collaborating**: coming together to find an alternative that meets the needs of everyone involved
- **Competing**: creating two different alternatives to determine which one works best
- **Accommodating**: allowing one perspective or approach to win out over the other, or contribute significantly more to the resolution
- **Compromising**: finding a combined resolution that meets some of each of the involved people's needs

Notably, there are also times when **avoiding** may be the best technique for conflict resolution, particularly if someone is in danger or needs a break to clear their mind. For example, a combine operator who has been working to harvest a field for several hours may resist taking a break. This could cause them to unintentionally become a safety hazard. A resolution must be found, or the situation could escalate.

Most conflicts, like this, cannot be resolved by avoiding them. However, if the situation were different, avoidance may be successful. Two team members who can't agree on a solution to a problem may become increasingly frustrated with one another. This conflict would benefit from a pause, and temporary avoidance can be a great way to ensure that a resolution is found when all involved are in a better frame of mind. There are many ways to practice conflict resolution, as seen in

Figure 3.20. Whatever the outcome is, it is important that active listening and effective communication (including nonverbal communication) are used during conflict resolution to achieve the best resolution for everyone.

Reading Check

List five types of conflict resolution.

Figure 3.20 Two People Practice Conflict Resolution
These people have found a way that works for them to solve a conflict. *What is a different way to solve a conflict that may work in a professional setting?*

Parliamentary Procedure

Parliamentary procedure is a form of governmental operations based on public discussions, debates, and decision-making. It is used to create laws, revise laws, and find solutions to hard questions facing the people that parliament represents. In the context of an FFA chapter, parliamentary procedure is used to make decisions about chapter business, chapter events, and issues the chapter faces. FFA parliamentary members in a chapter represent all members of that FFA chapter.

Gray's Parliamentary Guide for FFA includes Robert's Rules of Order, which are used when participating in an FFA meeting or parliamentary procedure. Robert's Rules of Order outlines procedures for how to conduct meetings and make decisions in a group. It ensures fairness, order, and the efficient use of time during the introduction of motions, debating, and voting. The rules also protect the rights of the majority while also safeguarding the rights of minority and absent members.

Motions are key to parliamentary procedure. They are proposals made to initiate an activity or event or to express an opinion in a formal way. FFA parliamentary procedure includes five different types of motions as shown in **Table 3.12**. When a team of FFA members are engaged in competitive parliamentary procedure, individuals earn points based on how well they deliver and defend motions. The team's overall score is then calculated based on each member's performance.

When not in a competition setting, motions are still incredibly important. A good debate, or a poor debate, is shaped by its motions. During an FFA chapter's parliamentary session, members are responsible for adhering to the expectations surrounding different types of motions. At a practical level, motions keep parliamentary procedure moving forward productively.

The issues that members want to address are laid out via motions and then organized in order of priority and addressed, either then or during a later meeting. But in terms of skill-building and preparing members for agricultural professions, motions are also key. By delivering, defending, and debating motions, FFA members practice the processes of research, oral presentation preparation and delivery, and effectively defending an argument. Each of these skills are among some of the key skills for future professionals. Reference Gray's Parliamentary Guide for FFA for an in-depth step-by-step guide and to work through practice examples.

Table 3.12 Examples of Motions

Motion Category	Explanation	Types of Motion	Example
Main	A main motion proposes new business. It is used to bring attention to a specific topic that requires discussion and a vote. Only one main motion can be debated at a time.	*The central motion being raised during a session.*	The chair makes a motion to discuss that FFA jackets must be ordered for new chapter members. The motion is discussed, and a vote is called, but interrupted by a privileged motion.
Privileged	A privileged motion is used to deal with urgent or extremely important matters. All other motions are put aside so that a privileged motion can be addressed. A privileged motion may also be used to request a break or handle an emergency.	- Fix the time with which to adjourn - Adjourn - Recess - Raise a question of privilege - Call for orders of the day	Funds are missing from the proceeds of an FFA benefit auction. A privileged motion is made to address this topic first.
Incidental	**Incidental motions** deal with procedural questions or are called to handle something unexpected.	- Appeal - Division of the assembly - Division of a question - Objection to the consideration of a question - Parliamentary inquiry - Point of order - Request for information - Suspend the rules - Withdraw a motion	An objection is made that jackets should not be ordered until the missing funds are located. An incidental motion is made to table the main motion.
Unclassified	Unclassified motions cannot be classified as main, privileged, incidental, or subsidiary motions, but are used to insert an idea or reconsider a previous question.	*Unique motions that expand on ideas or questions already in play during a session.*	A vote has been taken to order the jackets, but the vote is rescinded after the incidental motion has been made. An unclassified motion is made to vote on the jackets at a later time.
Subsidiary	A subsidiary motion is used to bring attention back to a main or privileged motion.	- Lay on the table - Previous question - Limit or extend limits of debate - Postpone to a certain time, or definitely - Commit or refer - Amend - Postpone indefinitely	A subsidiary motion is made that the problem of the missing funds should be referred to a committee who will research possibilities for how the money was mismanaged.

Parliamentary procedure is a process of give and take, with motions connecting each different event of the procedure to the next. It's like driving through a city: a driver takes specific turns based on what route makes the most sense, where there is less traffic, and what they know is safe. Parliamentary procedure moves from one motion to the next via motions. Each one offers the parliament the chance to consider what the best next step is—stop the current debate? Introduce a new idea? Extend the time needed for the debate? Members decide together whether a motion should be seen through or changed.

Some motions require at least one other member's support in order to move forward with it. Some motions are debatable, while others are not. Some motions can be amended, and some can be reconsidered. And different ratios of voting results are required for different motions. For example, the motion to lay a motion on the table requires a majority vote of support from all attending members. The motion calls for orders of the day, however, requires no vote, just demand. Throughout parliamentary procedure, engagement with other members present to collaboratively make decisions is necessary. One individual cannot decide on their own. The group must consider, debate, and vote whether it all happens during one session or is spread across several sessions.

There are additional characteristics of effective FFA parliamentary procedure to take into consideration. Understanding these characteristics, such as how to speak, what sorts of presentations to give, and expectations for behavior during procedure, can help FFA members contribute effectively. Understanding these components also gives members opportunities to improve their professional communication skills. These additional aspects of FFA parliamentary procedure include:

- **Quorum**: the number of parliamentary members that must be in the room for parliamentary proceedings to start
- **Agenda/Order of Business**: the outline of ceremonies, topics to be covered, and decisions to be made during a parliamentary gathering
- **Fair Debate**: a debate that allows all contributors to an argument to speak in turn and defend their points
- **Voice Projection**: Speaking loudly and clearly so that everyone in attendance can hear what you are saying
- **Appeals**: counterpoints to motions or requests for changes to be made
- **Rebuttal**: an argument that goes against the argument that has just been made
- **Voting**: members choosing whether to agree or disagree with a motion
- **Majority Rule**: whatever outcome most people in parliament vote for becomes the winning outcome
- **Minutes and Reports**: carefully kept notes on every topic covered and event that occurs during a meeting, and a sharing out of those minutes in report form after the fact

Reading Check

Explain the difference between main motions, subsidiary motions, and incidental motions.

Debate Protocol

Debates are not only a central part of FFA operations, but also are a part of many governmental operations around the world. Additionally, debates are used in both professional and casual situations. Debating, or arguing for and against different perspectives on a topic, is a social exercise as well as an element of many workplaces. Debating helps to find answers and establish agreements. Debating helps human beings understand each other, and themselves, through extensive research, discussion, self-expression, and reflection.

Speaking generally, debates are conducted over the course of three stages. First, debaters prepare. They research their topics and points of view and draft what they will say to support those points of view. Second, they conduct the debate, engaging in the exchange of arguments. And third, there is an assessment of outcomes, or **debriefing**, which helps determine who won, who lost, what points were strong, and what points were weak. A decision can then be made regarding the debate's outcome.

There is a three-step procedure to follow when participating in a debate:

1. State your position (I am for/against this motion).
2. State your reasoning.
3. Ask for support in voting for/against the motion.

Details and information on debates specific to FFA are included in the steps to parliamentary debate in Gray's Parliamentary Guide for FFA.

Reading Check

Explain why debriefing is an important element of debate.

Debates and Professional Communication Skills

Debates must be logical, convincing, and realistic. An enormous part of this is the use of effective professional and personal communication skills. By presenting a confident demeanor and using strong oral communication methods (such as speaking clearly, projecting, monitoring speed and tone, etc.), a debater is more likely to find success (**Figure 3.21**).

If a debate is logical, it is not only based on facts but also organized so that it is easy to understand and remember. This helps make individual arguments more convincing. By focusing on sharing evidence, using specific and realistic examples, and delivering in a straightforward way, an audience or a listener will be more likely to be convinced by an argument. Keeping a debate realistic helps to convince people, too. When a debater focuses on what they know is true and explains that truth in an easily understood way that helps an audience keep track of their argument, there is a greater potential for success.

Figure 3.21 FFA Member Speaks at an Event This speaker uses professional communication skills. *List three things that this speaker is doing that will improve the likelihood that he will be successful during a debate.*

For example, an argument for the cancellation of homework could be made based on a debater's knowledge of statistics about how homework impacts a learner's mental health. Evidence that explains that impact and keeps the context of the debater's argument focused on the present-day experiences students have in school would help make the debate successful. Conversely, if a debater argued for the cancellation of homework because it was a waste of time and historically unnecessary for students of previous generations, the lack of specificity and present-day context would make the debate weak.

Reading Check

Explain why it is important to be logical, convincing, and realistic in a debate.

3.3 Effective Communication in Agriculture Review

After You Read

1. **Explain** why personal communication skills are related to citizenship and leadership skills.
2. **List** communication strategies that you can use when effectively participating in classroom discussions and the FFA.
3. **Analyze** why personal communication skills can be a useful tool when working to accomplish organizational (FFA or workplace) goals.
4. **Describe** a time when it would be appropriate to use each type of professional communication (written, oral, combined written and oral).
5. **Write** and deliver a persuasive speech according to the guidelines provided by your teacher. Include a call to action.
6. **Describe** an instance when it would be appropriate to engage in each type of conflict resolution.
7. **Explain** how being logical, convincing, and realistic are interrelated.
8. **Characterize** a fair debate.
9. **Engage** in a mock meeting and demonstrate the use of parliamentary procedures to solve a theoretical problem.
10. **Prepare** for and engage in a classroom debate on a topic selected by your teacher. Present a logical, realistic, and convincing debate on motions.

Online Explorations

Search for videos or articles about FFA parliamentary procedures and take notes on any key points that are presented.

Chapter 3 Review

Chapter Summary

Section 3.1

- Leadership in agricultural organizations is shared across central or top decisionmakers, support staff with specific responsibilities beneath the decisionmakers, and the broader group of employees who make the day-to-day operations of the organization possible.
- Leaders in agricultural organizations are responsible for balancing the needs of their workers and the needs of their organization.
- There are many different extracurricular agricultural organizations, including the FFA, 4H, Block and Bridle, AETE, and others.
- Every agricultural leader's success is unique to them. However, successful leaders often share similar skills. Some of these skills include innovation, ethical leadership, self-awareness, self-motivation, and continuous learning.

Section 3.2

- There are specific leadership skills that can benefit agricultural professionals. These skills include effective communication, decision-making, and problem-solving.
- Effective agricultural leaders are committed to continuing their own professional development throughout their careers. Self-awareness, self-motivation, and continuous learning are crucial parts of keeping this learning going over the long term.
- Goal setting is a necessary part of achieving success. Goals help move a person towards their ambitions in smaller, manageable pieces, instead of in one overwhelming mass. SMART goals are a great way to develop goals that are manageable in size. SMART goals are specific, measurable, achievable, relevant, and time bound. Smaller achievements via completion of these goals make the attainment of much larger goals more possible.
- Leaders are responsible for taking on the ethical responsibilities that come with overseeing others' welfare, access to work, and day-to-day quality of life. Ethical leadership includes practicing integrity, accountability, and social responsibility.

Section 3.3

- Personal communication skills are crucial to successful leadership. They can also improve personal relationships in non-professional life. Active listening, verbal and non-verbal communication, and the capacity to adapt communication styles to different audiences are all important personal communication skills.
- Professional communication is conducted via many different forms in agribusiness. Forms of professional communication include written communication, public speaking, and persuasive communication techniques (including speaking and writing).
- Conflict resolution is part of every leader's life, particularly those in the agricultural professions. Conflict resolution skills include negotiation, mediation, and collaboration techniques, as well as the ability to understand when to use each skill.

Chapter 6

Introduction to Animal Science

Essential Question

As you read this chapter, keep this question in mind:

What is animal science, and why is it important to stay informed on how to interact, care for, and raise animals?

Animal science is a key area of agriculture with a long history of people depending upon animals for food, transportation, and other life needs. The science of raising and caring for animals is continually changing as our world and the needs of its population change. People working in animal science must have updated knowledge and skills about body systems. It is also important for them to continue to stay informed to understand how to interact with, care for, and raise animals today. This chapter will provide you with basic information about different farm animal species and their specific needs. In Chapters 7 and 8, you will learn more about farm animal production and ethical animal management practices.

Reading Guide

Objectives

After completing this chapter, you will be able to:

- **Discuss** the fundamentals of animal science, including the importance of studying farm animals and their contribution to the agricultural industry.
- **Describe** the anatomy and physiology of farm animals, including their body systems and functions.
- **Explain** the digestive processes of mammals, birds, and fish in relation to farm production.
- **Explain** the excretory processes of mammals, birds, and fish in relation to farm production.
- **Explain** the reproduction processes of mammals, birds, and fish in relation to farm production.
- **Identify** different breeding techniques and technologies used in animal production.

Before you Read

Connect: Self-check: Do you feel confident about your understanding of meiosis and mitosis? If not, go back and review them in Chapter 5. The processes are also part of animal reproduction; however, there are a couple of important differences.

Main Idea

Animals and animal products are important commodities in the United States.

Note-Taking Activity

Draw this table. Write key terms and phrases under **Cues**. Write main ideas under **Note-Taking**. Summarize the section under **Summary**.

Cues ◦ ◦	Note-Taking ◦ ◦
Summary	

Graphic Organizer

Before you read the chapter, draw this diagram.

K – What I already **know**	**W** – What I **want** to know	**L** – What I have **learned**

In the first column, write what you already know about animal science. Then as you read, write questions you have in the second column. After reading, participate in a classroom discussion and write the answers to your questions in the third column.

GO ONLINE Go to the online course to access digital resources including downloadable note-taking tables and graphic organizers.

6.1 Introduction to Farm Animals

Animal Science in the United States

Why is animal science important for my state and the United States?

What animal products and **animal byproducts** do you use in your daily life? In Chapter 1: Introduction to Agriculture, Food, and Natural Resources, we learned that animal commodities include animals and the foods they produce. We discovered that animal byproducts benefit people in many ways. Animal products include eggs, honey, and meat. Animal byproducts are non-food parts of the animal, such as hair or wool known as fibers, skin for leather, and manure. Animals in agriculture include typical livestock animals such as cattle, sheep, pigs, goats, and chickens. Other animals in the agriculture industry are those related to **equines**, or horses, donkeys, and mules. People use horses for pleasure riding, for work on farms and ranches with cattle, for therapy, and for business such as horse racing and horse showing. The industry also includes **specialty animals** such as llamas, rabbits, and fish. Specialty animals can be raised for their hair or wool, known as fiber, or for food production. The breeding and raising of **companion animals** are also part of the agriculture industry. Companion animals are kept for pleasure, therapy, service, and support, rather than food or work. **Table 6.1** shows the variety of animals, their products, and byproducts that the United States produces. Can you identify all the types of animals shown in the table?

Vocabulary

Content Vocabulary

You will learn these content vocabulary terms in this section.

- Aquaculture
- Cardiovascular system
- Companion animal
- Digestive system
- Endocrine system
- Equine
- Lymphatic system
- Muscular system
- Nervous system
- Reproductive system
- Respiratory system
- Specialty animal
- Skeletal system
- Urinary system
- Vertical integration

Academic Vocabulary

You will see this word in your reading. Find its meaning in the Glossary in the back of the book.

- Animal byproduct

Table 6.1 Farm Animals, Their Products, and Byproducts of the United States

Domestic Livestock/ Farm Animals of the United States	Image	Animal Products of the United States	Animal Byproducts of the United States
Dairy cattle		Dairy products, veal, organ meat	Leather from the skin, connective tissue used in gelatin, tallow (fat), bones and horns, manure for fertilizer, organs and bodily fluids used in pharmaceutical products

Domestic Livestock/ Farm Animals of the United States	Image	Animal Products of the United States	Animal Byproducts of the United States
Beef cattle		Beef meat, organ meat	Leather from the skin, connective tissue used in gelatin, tallow (fat), bones and horns, manure for fertilizer, organs and bodily fluids used in pharmaceutical products
Swine		Meat	Leather from the skin, insulin used in diabetes treatment, heart valves for human transplant, tissues and bones used in gelatin, fat used in soaps and crayons, blood used in medicines and animal feed
Poultry (chickens, turkeys, ducks, geese, guinea fowl, and quail)		Eggs, meat, giblets	Manure for fertilizer, feathers, organs and blood for animal feed, eggshells for calcium supplements and fertilizer
Sheep		Meat, dairy products	Wool and sheepskin, lanolin, bones and hooves for gelatin and glue
Goats		Meat, dairy products	Mohair and cashmere, leather from the skin, therapy
Equine (horses and mules)			Horses are produced in the United States for recreation, sporting competitions, therapy, and some for transportation or farmwork; hooves for glue, hair for paintbrushes and violin bows, manure for fertilizer, hormones and body fluids used in medications

Domestic Livestock/ Farm Animals of the United States	Image	Animal Products of the United States	Animal Byproducts of the United States
Llamas and alpacas		Meat	Hair for fiber for cloth, hides, antibodies used in medications
Rabbits		Meat	Fur for clothing, manure for fertilizer
Fish or aquaculture		Protein (meat)	Manure for fertilizer, oil, meal made from organs and bones that are used in pet foods
Bees		Honey	Beeswax, pollination

Animal Production in the United States

In 2021, sales of animal products by US farmers earned more than $198.8 billion. The United States produces the most beef and poultry of all countries. The nation is also a top pork, egg, and milk exporter. Agricultural products as exports contributed more than $196 billion to the United States in 2022, with the number rising yearly. Exports of US beef, veal, and dairy products all increased in 2022. States vary in terms of the animal commodities they produce. **Figure 6.1** illustrates the amount of money livestock brought to the nation in 2021.

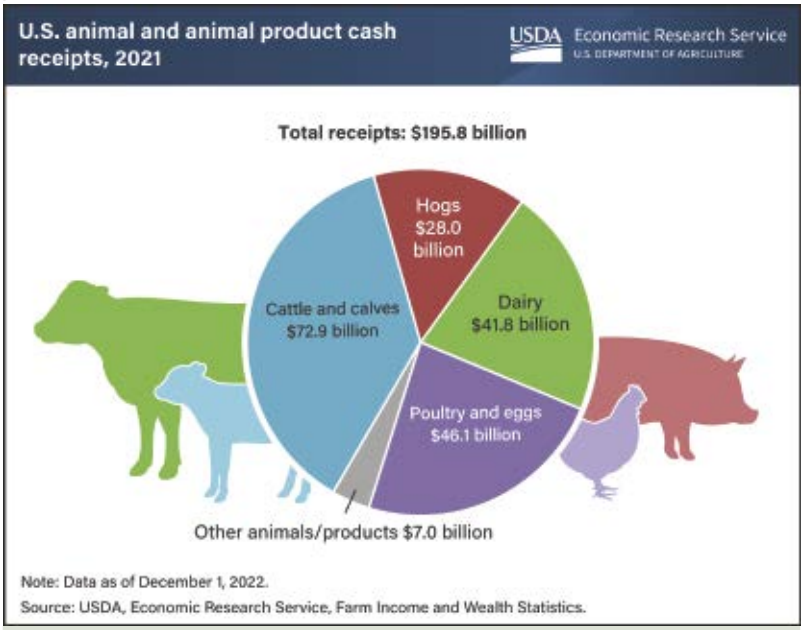


Figure 6.1 Livestock Income Nationally The agricultural industry brings income to the United States. *What are some animals/products that might be included in the $7.0 billion section of the chart?*

Farmers and ranchers often focus on raising just one or two livestock species. They often raise thousands of animals each year. A farmer may raise dairy cows for milk and their calves for veal, or meat from young calves. A different farmer may focus on producing turkeys for Thanksgiving while also raising pigs or sheep. Animals raised for meat that is distributed within the United States or exported to other countries are fed and then sent to slaughter. Other livestock products are also processed and widely distributed.

Some farmers and ranchers focus on specialty livestock production, such as raising bees for honey or pollinating crops and other plants. Over ninety crops in the United States depend upon bees for pollination. If a particular crop location lacks enough bees at pollination time, beekeepers may bring bee hives to that site. Then, the bees go to work, collecting pollen for their hives and pollinating the crops. You can also find people raising fish or rabbits for food or research. Llamas may be grown to use their hair for fiber, for companionship, and as guard animals for herds of other animals, such as sheep. **Figure 6.2** shows a sheep being sheared of its wool, which is known as wool. Its wool is sheared off, collected, cleaned, and then spun into fiber for weaving into scarves, sweaters, etc. People who don't live on farms or ranches may also raise animals for pleasure, for recreation, or for their fiber.

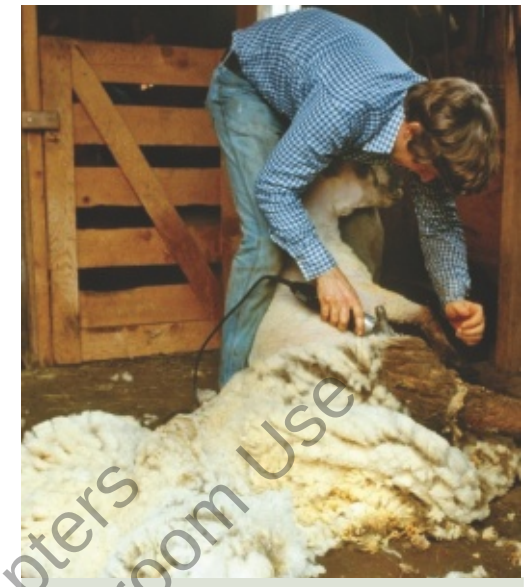


Figure 6.2 Animal Byproducts Sheep provide a source of wool and fiber for clothing. *What jobs help the economy related to raising, trimming, and producing hair and fiber for weaving textiles?*

Animal Production Varies

The types of animal products raised in each state vary. While certain states produce large numbers of certain types of animals, these same animals are also raised throughout the country in smaller numbers. For instance, Wisconsin and Minnesota have the most licensed dairy cattle herds. California, though, produces more dairy products than do either of the other two states. In Texas, the primary commodities are cattle, sheep, goats, and wool. The states in the southeastern United States are the main producers of aquaculture, including fish, crustaceans, and mollusks. Texas, California, and Florida have the most horses.

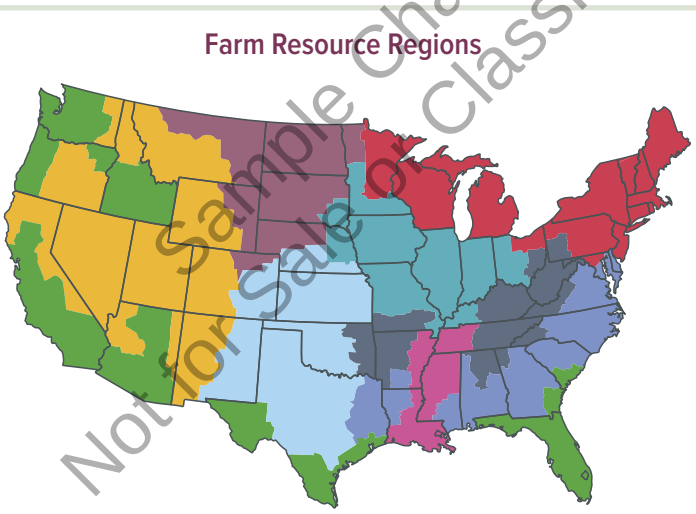
Animals have different needs for food and space. The states well known for specific animal industries are those that can meet the needs of the animal species related to those industries. The natural resources of a state influence the types of animals that can be raised in large herds. For instance, animals such as cattle, horses, sheep, and goats need large amounts of grass, hay, or feed from grain. States with large numbers of these species need to have large spaces for the animals. Those states also must grow and process feed or have food shipped in. For these reasons, large animal herd production is concentrated in the grassy Plains states. Swine and poultry need specific feeds and are often kept in smaller spaces. The states bordering the Mississippi River support many large poultry and swine production facilities, as grain for the animals may be shipped on the river. You'll learn about state-specific information in Chapter 7: Animal Production.

States that have more fertile land can produce more crops for grain and more grass for feed. However, mountainous regions may lack large amounts of land for animal grazing. Therefore, they don't have room for large herds of bigger animals. The

northern plains states have large grasslands and some mountainous areas, so people raise cattle and sheep in different regions. Sheep can eat a wide variety of plants that grow in the mountains, but cattle need large amounts of grass. People may raise small herds or individual animals in areas that can't support large scale production.

Farm animals also have specific environmental temperature needs. Keeping large numbers of animals is difficult in climates that have snowy and cold winters, unless the animals are kept indoors. The Northeastern states have found solutions with warm dairy barns for the cows, keeping cattle together in large buildings as an advantage in the wintertime to keep the cattle warm. On the other hand, when the weather turns hotter and animals are kept together in large buildings, it may be easy for them to overheat. Large scale poultry producers often need to use ventilation, cooling systems, or even air conditioning to keep their flocks comfortable.

Other states that are known for **aquaculture**, or fish production, include adequate bodies of freshwater or saltwater, depending on the fish species' requirements. Hence, the states bordering the oceans or states having more lakes, ponds, and rivers produce more fish. Top fish-producing states include Alaska, Maine, North Carolina, South Carolina, Maryland, and Florida. Alaska produces the most seafood of all the states. **Figure 6.3** illustrates the spread of animal production around the United States. The most common types of animals produced in each region are listed.



- **Basin and Range:** Beef cattle and sheep
- **Northern Great Plains:** Beef cattle, sheep, and dairy cattle
- **Heartland:** Hogs, beef cattle, dairy cattle, poultry, sheep, horses
- **Northern Crescent:** Dairy cattle and hogs
- **Eastern Uplands:** Beef cattle, poultry, and hogs
- **Southern Seaboard:** Poultry, hogs, beef cattle, sheep, goats
- **Mississippi Portal:** Poultry and hogs
- **Prairie Gateway:** Beef cattle
- **Fruitful Rim:** Fish and horses

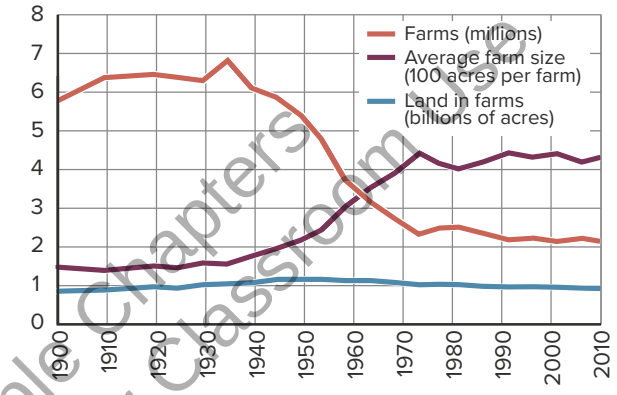
Source: US Department of Agriculture, Economic Research Service, Agricultural Information Bulletin Number 760.

Figure 6.3 Farm Resource Regions Map showing the various areas of animal production in the United States. *What animals are produced in your region?*

The Changing Image of Animal Productions

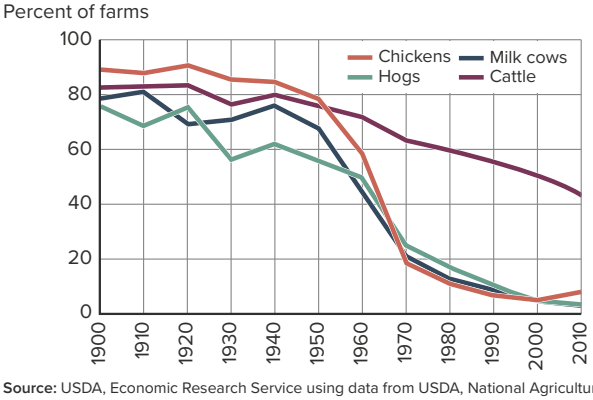
Animal production for food has changed several times over the past century. In the past, farmers often kept small herds of several types of livestock. They raised and then slaughtered the animals for food for themselves and a few other people. However, as the number of people in the nation has increased, the need for more food has also increased. Animal production shifted from the family farms of the past to large production facilities. Different companies and farms owned various parts of the process. This shift in food production led to increased transportation of feed and livestock. Livestock feed is transported over long distances to animal production facilities. When the animals are ready to be butchered, they may be transported by semi-truck and train to a state with food processing facilities. The animal products and by-products are then sent to stores and restaurants. However, companies are realizing that they can control the entire production process more efficiently using the concept of **vertical integration**. Under the new business model of vertical integration, a company raises livestock species. The company also produces livestock feed on huge corporate farms and manages food product preparation, including butchering and transportation to warehouses. **Figure 6.4** shows the number of farms in the United States from 1900 to 2010. **Figure 6.5** shows the percentage of livestock species on farms in the same period. Carefully examine these two graphs.

In Chapter 8: Ethical Considerations and Managing Animal Welfare, you will learn about animal production methods. Issues of animal safety and welfare must be respected and resolved during the gate-to-plate concept of animal production. In the gate-to-plate concept, the process explains the relationship and sequence of a particular food commodity from the time the commodity animal is born to the time the animal is turned into food and other byproducts. The concept also covers the many people, facilities, laws, and transportation elements that are involved in producing the food we eat. Animal production issues related to disease transmission, animal



Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service, Census of Agriculture (through 2022) and Farms and Land in Farms: 2024 Summary (February 2025).

Figure 6.4 Farms, Land in Farms, and Average Acres per Farm, 1900–2010 The number and size of farms in the United States have been changing over time. *What do you notice about the changes in farm size and number of farms since 1920?*



Source: USDA, Economic Research Service using data from USDA, National Agricultural Statistics Service, Census of Agriculture, with data interpolated between Census years.

Figure 6.5 Percent of Selected Livestock on Farms, 1900–2010 The percentages of livestock species have changed over time in the United States. *Which species has changed the most, the least, and how are the numbers changing overall?*

comfort, and waste management are among the key concerns being addressed. People in the agriculture industry are working on methods to solve these issues.

The first issue of large-scale animal production, disease transmission, can arise due to the huge numbers of animals kept together. Diseases may also spread along the transportation route. Scientists try to better identify and track diseases as well as develop vaccines for animal diseases.

Additionally, the comfort of the animals during growth and transportation is a concern for people. More humane care and transportation methods must be used to decrease the stress placed on animals. Stressed animals lose weight, causing decreased egg and milk production. One example of these solutions comes from animal scientist Dr. Temple Grandin. She created cattle facilities and methods that ease stress for cattle during handling, so they lose less weight when being moved from one facility to another or when being handled for veterinary care.

Another issue for large-scale production is the amount of manure produced by thousands of animals kept in small spaces. The waste products must be appropriately managed for human, animal, and environmental health reasons. To manage the quantities of animal waste, some livestock producers spread it as fertilizer on nearby fields. The waste can also be used as biomass for biogas. You'll learn about methods of waste management in Chapter 12: Environmental and Natural Resources.

Companion Animals

Many types of farm animals are kept as **companion animals**. Typical companion animals, or pets, are dogs, cats, rabbits, or hamsters, although horses, cows, goats, pigs, poultry, and sheep can also provide companionship for people. Some are also used as therapy, service, or support animals, and many produce milk, eggs, or fiber in small amounts. Companion animals can also be found on small farms, rural properties, and even in cities. All companion animals require appropriate food, water, and veterinary care. Hooved animals still need to have their feet attended to by farriers or other trained individuals. They may require training to be safe and manageable for their owners. **Figure 6.6** shows a miniature horse that has been trained for riding by small children.

Figure 6.6 A Miniature Horse with a Small Child This miniature horse is fully grown and used for riding by small children. *What advantages and disadvantages would a person have in raising and using companion animals?*

Animal Science

No matter whether animals are kept for food or other product use, or for recreation, companionship, or therapy purposes, the principles of animal science need to be understood by those who want to keep and breed healthy animals. Animal science includes the business and science of caring for domestic farm and specialty animals. All people who raise animals to sell, produce animal products, or provide companionship and recreation must meet the animals' needs. This includes the correct amount of healthy food, water, and safe housing. It is important for people to understand how to care for animals in order to properly maintain both animal and human health. Animal care and safety is the responsibility of farmers and ranchers, with daily care of animals, people who work in large production facilities, and people involved with animal recreation, such as at racetracks. Caring for animals often requires the specialized skills of veterinarians. Farm animals need vaccinations against diseases, protection from parasites, and specific medical treatments. You will learn about specific animal breeds in Chapter 7: Animal Production.

Other roles and jobs in animal science focus on laboratory work or legal work. Animal scientists may work in laboratories and other agricultural facilities to research and develop new vaccines for diseases. They also investigate how to make hardier species adaptable to our changing climate. Other jobs related to animal science may involve drafting laws and regulations for animal care and safety, and the equitable use of the land and water needed for animal production. You will learn about technical skills related to livestock production in Chapter 8: Ethical Considerations and Managing Animal Welfare. Then, Chapter 12: Environmental and Natural Resources covers laws and regulations focusing on the interaction of livestock and the environment.

As you learn more about animal science, you will participate in lab activities. Let's review the Lab Safety Checklist from Chapter 5.

Lab Safety Checklist

- **Proper Supervision**: Do not perform lab activities without an instructor present. It is important to have someone to instruct you, and that person can be a vital resource in case something goes wrong.
- **Dress Appropriately**: Wear Personal Protective Equipment (PPE) when handling different materials in the lab. Animal parts could be treated with chemical preservatives, so be sure to wear gloves, safety goggles, and lab aprons when handling materials.
- **Know the Procedures for an Emergency**: Locate the first aid kit and eye wash station in your lab. Be sure to also note the location of the Poison Control Center phone number and who to call in case of an emergency.
- **Know the Safe Handling of Lab Equipment**: You may be using sharp tools to cut open or dissect animal parts. Handle tools with care and recall the instructions for sharing tools. Inspect glassware for cracks before using it. Use proper techniques for the storage and cleaning of lab equipment.
- **No Tasting**: Food should not be present in the lab. Similarly, do not taste any of the materials you are experimenting with. While you may enjoy eating meat, some animal parts may have been treated with chemicals and may make you very sick.

- **Be Aware of Your Surroundings**: Identify any potential hazards that might be present in the materials you are working with. Keep your area clear and free of obstacles to prevent trips, falls, and other accidents. Roughhousing is never okay in a lab setting.
- **Clean Up**: It is important to clean up your area when you are finished. Never leave an experiment out. Remain in your area until the experiment is complete, then be sure to properly dispose of and/or store all materials when you are finished. Use the Sharps Container and Biohazard Waste containers for their intended purposes.

Consider how the lab safety checklist applies to working with live animals. A major difference you must note is that animals are living creatures who may bite, kick, and scratch due to fear or anger. Your safety and that of the animal must always be considered when working around farm animals. Treat them with compassion and respect, but with safety in mind. Listen carefully to instructions from your teacher or the animal handler for the species in general and a particular animal you may be working with.

- Wear hard-soled shoes that cover your toes and provide support to your ankles; no sandals, Crocs, or backless shoes. Make sure shoes are tied without loose laces to trip upon. Likewise, wear clothing that won't frighten animals by blowing in the wind. Avoid loose clothing, which can get in your way. Be prepared for your clothing and shoes to become dirty. Contain/pull-back long hair so it isn't distracting you or the animals. Goats and horses have been known to sample clothing and people's hair.
- Caution is also needed when using ropes and other equipment. For instance, don't wrap ropes around your hand or any other body part; coil the rope into a figure-eight coil in your hand to lead or hold animals.
- Sick or injured animals may have a larger flight zone due to fear or pain.
- Avoid getting between the animal and a fence or wall. Some animals, such as horses and cows, can kick their back legs out sideways, behind themselves, or forward under their body. Animals can also strike forward with their front legs.
- Many animals bite when frightened or if people move into the animal's personal space.
- Animals with horns can use their horns for protection by butting or trying to hook the horn on people. Loud noises can upset animals, as can large groups of students.
- Some animals dislike being left alone without others of their species. Or the animal may not like to have other animals of their species or other species around them; their likes and dislikes affect how they react to having people nearby.
- Animals and people can also share diseases. So, wash your hands before and after handling animals. Clean your shoes or wear shoe covers after being around animals before returning to school.
- Do not eat or drink around the animals.
- Nicotine in any form may be hazardous to animals. Avoid vaping, smoking, chewing tobacco, or using any drugs around animals.

Reading Check

Define the meaning of animal science and how animals contribute to the agricultural industry.

Animal Science Overview

What aspect of animal science am I going to learn about next?

We've explored the importance of animals to the agriculture industry and how people may raise and keep animals in the United States. The ten major body systems found in animal bodies are listed below. In the next section on animal biology, we will go into more detail about each body system and the anatomical differences between animals.

- The **skeletal system** is the system of bones and joints that gives the body its shape and supports the animal. Animals that have four legs have a different skeletal system than animals that swim or have wings.
- The **muscular system** is made of soft tissue that enables the body to move. The muscles also cushion the internal organs and allow them to do their jobs.
- The **nervous system** consists of the brain, nerves, and spinal cord. It is responsible for sending and receiving messages throughout the body.
- The **cardiovascular system** consists of the heart and blood vessels. These vessels move blood throughout the body, delivering oxygen and removing waste products from the body's parts.
- The **respiratory system** allows the body to breathe. Its organs move oxygen and carbon dioxide in and out of the body.
- The **endocrine system** comprises the tissues responsible for regulating and releasing hormones into the body.
- The **digestive system** is a group of organs that move food into the body and process nutrients from the food.
- The **lymphatic system** is a set of organs and tissues that protect the body from disease and help maintain proper fluid levels.
- The **urinary system** is a group of organs that filter blood. It removes harmful elements and excess liquids from the body.
- The **reproductive system** is a body system that allows males and females to reproduce or mate. Males and females have different reproductive organs.

Reading Check

List the functions of the cardiovascular, endocrine, lymphatic, and urinary systems.

6.1 Introduction to Farm Animals Review

After You Read

1. Make a two-column chart. On the left, **list** the top agricultural animal commodities produced in the United States. On the right, **state** an example of where each commodity is produced in the United States.
2. **Summarize** the importance of studying farm animals, their byproducts, and their contribution to the agricultural industry.
3. **Identify** lab safety procedures that are unique to animal science labs.

Online Explorations

Animal Commodities in Your State

Research which animal commodities are produced in your state and how environmental factors support the production of those commodities. Take notes as you explore reputable sources and then discuss your findings with the class.

6.2 Animal Biology

Basics of Animal Anatomy

How are the body systems and processes of animals similar to and different from one another?

Agricultural animals are very important for the nation's economy. Keeping animals healthy is essential for livestock productivity. Understanding the major body systems helps maintain animal health. The body systems differ for various species of animals, yet the body systems have important similarities.

Before learning the details of animal anatomy, let's compare plant and animal cells. Chapter 5: Plant Systems covered plants in more detail, including a discussion about plant cells. Cells are the building blocks of life, so understanding them allows us to better understand anatomy. Examine the cells pictured in **Figure 6.7**.

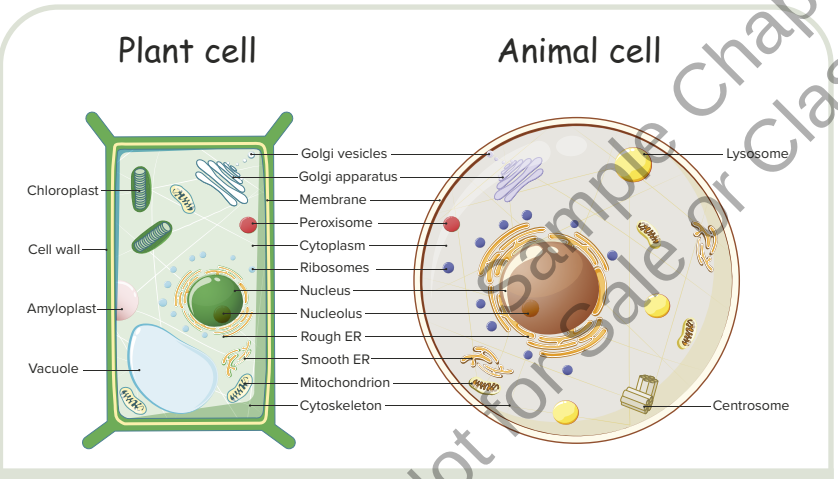


Figure 6.7 Cell Comparison A plant cell on the left side and an animal cell on the right side. *What parts of the plant cell are not included in the animal cell, what cell parts does the animal cell have that a plant cell lacks, and which parts are in both types of cells?*

Plant cells have a cell wall, chloroplasts, and vacuoles. Chloroplasts and vacuoles are cell organelles needed for photosynthesis. This is the process that allows plants to gain energy from sunlight. Animal cells don't gain energy from sunlight, so some parts of animal cells are different. Animal cells use cellular respiration to make ATP for energy. Their energy is gained from the breakdown of molecules in food. In animal cells, the lysosomes remove waste products from the cell. The centrosomes of animal cells are involved in cell division.

Vocabulary

Content Vocabulary

You will learn these content vocabulary terms in this section.

- Blastocyst
- Cardiac muscle
- Cartilage
- Central nervous system
- Connective tissue
- Dilation
- Diploid
- Embryo
- Epithelial tissue
- Estrus
- External fertilization
- Fertilization
- Fetus
- Gamete
- Gestation
- Haploid
- Internal fertilization
- Ligament
- Muscle tissue
- Nervous tissue
- Ovulation
- Peripheral nervous system
- Placenta
- Skeletal muscle
- Smooth muscle
- Stay apparatus
- Tendon

Academic Vocabulary

You will see this word in your reading. Find its meaning in the Glossary in the back of the book.

- Postpartum

Reading Check

List two differences between plant and animal cells.

Cell Division

Plant cells make more cells by dividing into two cells through the processes of meiosis and mitosis. Animal cells also use these two processes. However, in animals, only the **gametes** (the egg and sperm cells) divide by meiosis. During meiosis, the cell divides in half. The cell shares half of its genetic material (chromosomes) equally with each new cell. Then, those two cells divide again. Four new daughter cells are created in meiosis. Each new cell is **haploid**, meaning it has only one set of chromosomes.

All other animal cells divide through mitosis. During mitosis, the cell divides in half, producing two new cells of the same type as the original. These cells are **diploid**. The cells have two sets of chromosomes. One set of chromosomes came from the mother, and the other set was inherited from the father. Mitosis is used by cells to make more of that cell for animal growth. This process is also used to replace body cells that need to be replaced. For instance, when you have a paper cut, your skin cells around the cut divide in half to create the new skin cells that cover the cut. Examine **Figure 6.8** to see the details of these two cell division processes.

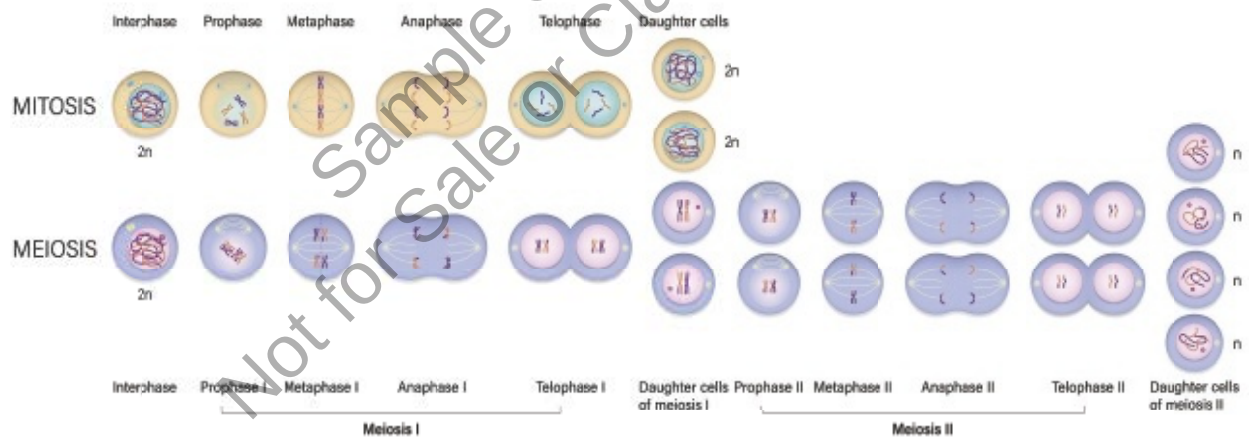


Figure 6.8 Mitosis and Meiosis The process of mitosis is on the top of this diagram and meiosis is on the bottom. *Which process is used only for the division of sex cells in animals?*

Reading Check

Describe the differences between the processes of mitosis and meiosis.

The Role of Tissues in Animal Bodies

Groups of related cells work together to create tissues. Each type of tissue has a common function. Similar tissues then make up organs. Similar organs create systems, such as the digestive system. The organ systems all contribute to the needs of the whole animal.

The body systems are made of four types of tissue. The tissues make up different body systems with specialized jobs in living bodies.

- **Epithelial tissue** makes up the covering and linings of our body. This tissue protects the organs and the body. Examples include your skin and the lining of the digestive system.
- **Connective tissue** connects and supports other tissues and organs. Examples include bones, cartilage, blood, and tendons.
- **Muscle tissue** allows movement of the animal and its internal organs. Examples include the body's muscles and the heart's muscles.
- **Nervous tissue** sends and receives electrical signals throughout the body. This tissue also creates communication between nerves in the body and the brain. Examples include the brain, the spinal cord, and nerves.

Reading Check

List the four types of animal tissues, along with their location.

External Animal Anatomy and Physiology

What differences can be seen in the anatomy and physiology between various animal species?

Let's begin the study of anatomy with the differences between the external parts of mammals, birds, and fish. You can probably name basic features, such as heads, wings, tails, and legs. But how are all mammals alike? How are mammals different from fish and birds?

Mammals have fur or hair and bear live young. Livestock mammals also have four limbs, a tail, a head, a neck of varying length, and a body that encloses most of their internal organs. Note that seagoing mammals, such as whales, have flippers and fins instead of legs. Examine this image of a horse in **Figure 6.9**. Notice that mammals have many of the same body parts as humans do. However, the body parts are in different places on four-legged animals than on two-legged humans. Four-legged

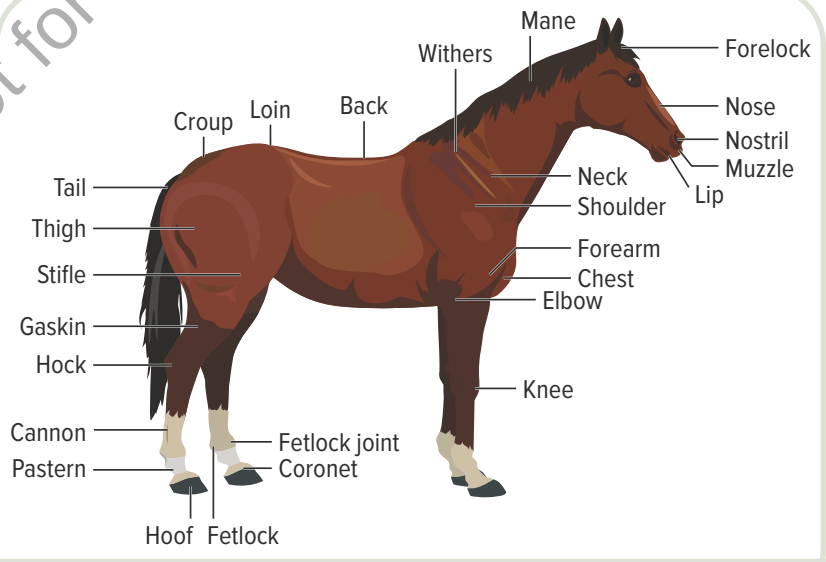


Figure 6.9 Mammal External Anatomy The horse's skeleton lends itself to use for riding and driving by people. *What parts are similar on this four-legged mammal to a human, even if the parts aren't labelled?*

animals also have other external body parts, such as tails and manes, that humans don't have. Their different body parts enabled them to live in the wild.

Next, let's study the external anatomy of birds. The biggest difference in external anatomy from mammals is having wings instead of four legs. Birds have rear legs, but their front legs changed to wings as they evolved over time. Wings in front enable them to fly and they have feathers instead of hair or fur. Birds have ears, although just small openings on the sides of their head without the external parts that we see on mammals. Examine the image of a bird in **Figure 6.10**.

Next, you can analyze the external anatomy of the fish. They are quite different from humans. Their differences allow them to survive in water instead of on land. Fish have some similarities to people; both have eyes, a mouth, and a body. Both fish and humans have skin, although fish have a covering of scales over their skin instead of hair. Over millions of years, fish evolved to live in water, swimming in a very streamlined manner. Look at the external anatomy of the fish in **Figure 6.11**.

As you learn about the different body systems in mammals, birds, and fish, keep the external anatomy of the species in mind. All three types of animals have the same body systems, in some manner, even though their external bodies appear very different from each other.

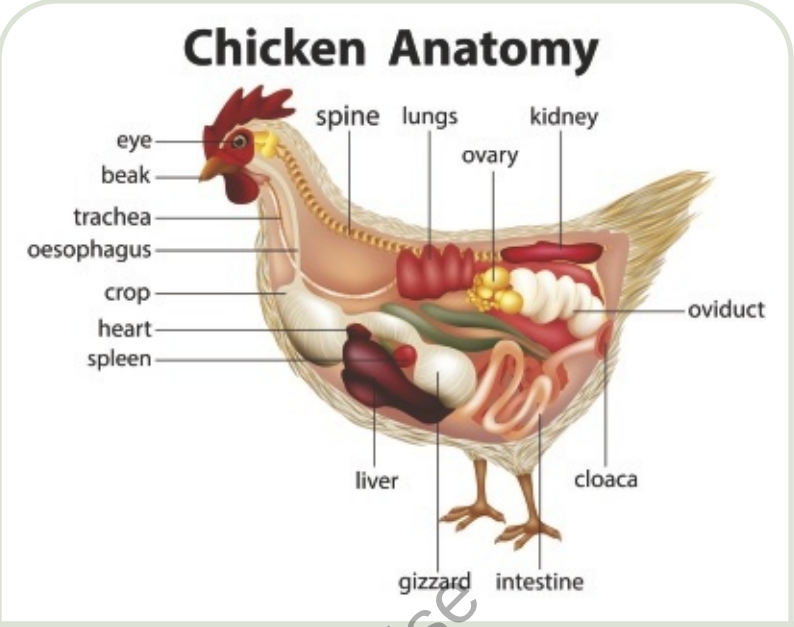


Figure 6.10 Bird External Anatomy The chicken body is adapted to life both on the ground and in the air. *What parts of the bird are similar to human parts, and which parts does the bird have that people do not have?*

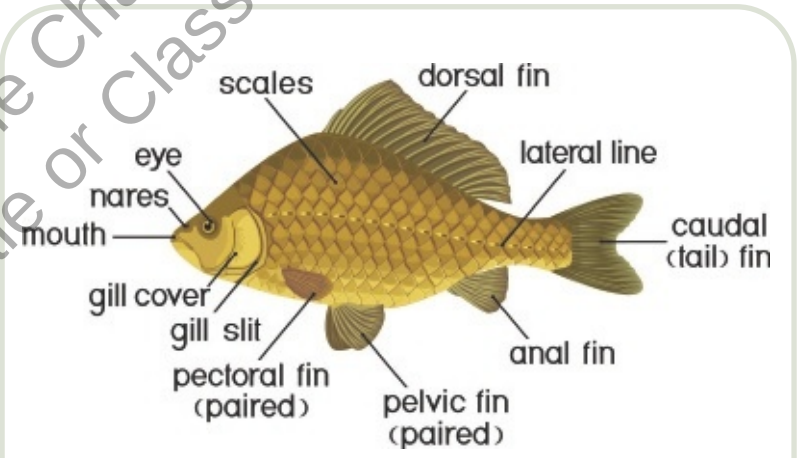


Figure 6.11 Fish External Anatomy Fish anatomy is adapted for its watery environment. *Which body parts of the fish are similar to those of humans, and which are different from those of humans?*

The Skeletal System

The body system of each animal species is unique. The uniqueness comes from the species' skeleton, which has several key roles. The skeletal system is the set of bones and joints that support the animal and protect the internal organs. Most importantly, the skeletal structure creates a framework for that animal's particular shape. Examine the skeletons in **Figure 6.12** to see the way their skeletons provide the framework for the animals we may see in everyday life.

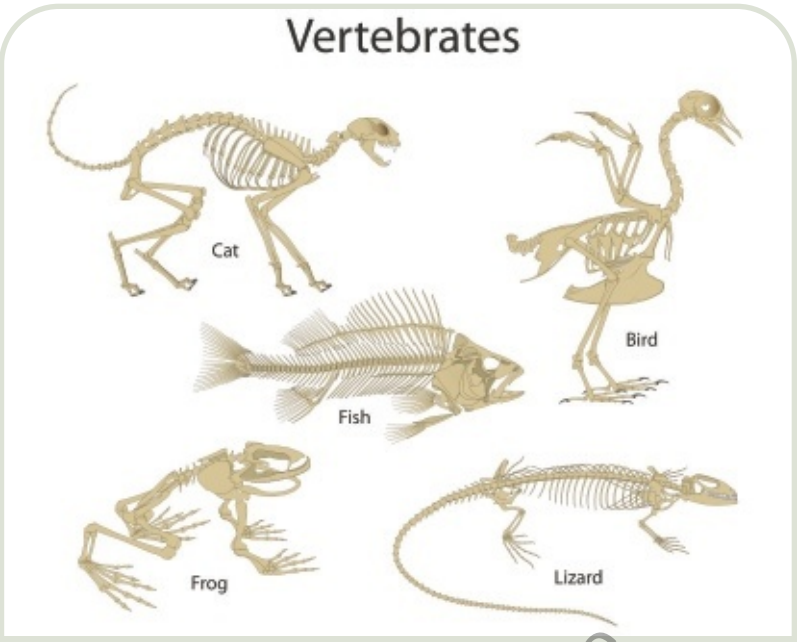


Figure 6.12 Different Animal Skeletons Each species has a unique skeleton that protects vital organs and gives structure to that animal's shape. *What is one difference you can note about the frog skeleton compared to the others?*

The skeleton is made up of bones and joints. The bones attach to the joints with tendons and cartilage to provide the framework for the body. For instance, turkeys have hind legs and wings, while horses have four legs. Pigs also have four legs, but their spines are curved differently from those of horses. Many species have several hundred bones in their skeleton that provide the special shape of a species.

The bones are generally stiff to provide a structure for the animal. The hard outer layer of the bones is made of calcium. Both the hard outer and inner layers of the bones are made of cells. The middle of the bone, known as the marrow, is soft and spongy. The marrow produces red blood cells and disease-fighting immune cells. It also stores iron, which is needed for red blood cell creation. Strong bones are extremely important for animals. A broken bone can mean suffering and even death for the animal if it can't stand to eat or defend itself. How difficult would you find walking if you couldn't bend your knees or ankles? If you have been in a cast for a broken leg, you have had this experience. Bones connect to joints. The joints allow the animal to move. The joints' tendons, ligaments, and cartilage are stretchy, like a rubber band. Animal bodies have specific types of joints that allow the body to move and bend in specific ways.

Gently feel your elbow joint with your opposite hand as you bend and straighten your arm. Try the action with your wrist joint, too. What kinds of movement do you feel in your elbow and wrist joints? Some joints can move only back and forth, such as your elbow. Other joints like those in your wrists are made of multiple bone and joint connections and have more movement. The joint arrangement allows them to twist, move up and down, or move back and forth. Animals also have different types of joints that serve different purposes.

Most animals have skulls, backbones made of vertebrae, ribs, and some forms of appendages. The appendages could be legs, fins, or wings. The tails of most animals are made of more vertebrae, continuing from their backbones. Even

horses, with their long tail hairs, have tailbones that extend more than a foot from the top of the tail. The tails are under the animals' voluntary control. This allows animals to swish insects from their bodies, or to show anticipation of food, or to show anger and fear. The tails also help the animals balance, especially while running.

The skeleton is adapted to meet the unique needs of each species. For instance, cows and horses need to be able to support their heavy weight on land. So, their skeleton is rigid with bones that are very heavy to push against gravity. Animals that are herbivores (plant eaters) developed as prey animals. Their skeletal systems may have long legs to evade predators with speed. Prey animals may also have horns and hard hooves to protect them from predators. Prey animals also have eyes on the sides of their skulls, allowing them to see nearly 360 degrees around their bodies to watch for predators. Herbivores also have teeth and jaws adapted to biting off and then chewing tough grasses and hay or grinding grain. Examine the skeleton of the cow in **Figure 6.13**.

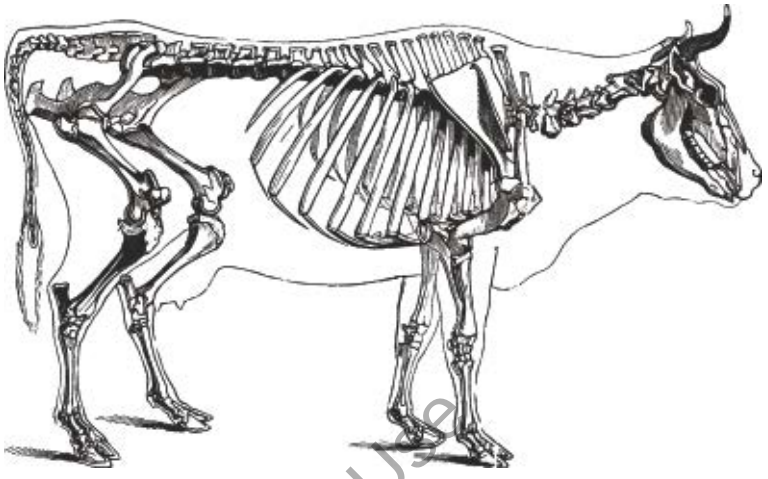


Figure 6.13 Mammal Skeleton Notice how big the bones of cows must be to support their weight on land. *What bones and body parts of the cow can you identify?*

Carnivores, such as cats, eat meat. Carnivores have skeletons adapted for running and jumping onto prey. They may also have sharp teeth, designed to slice into their food, and claws that help hold their prey. Carnivores' eyes are set on the front of their faces, so they can better track running prey animals.

Fish, on the other hand, need to be able to swim smoothly through the water. Fish skeletons are lightweight so they can swim easily. Their skeleton is streamlined to glide smoothly through the water. Fish have fins for steering and propulsion in water, instead of legs or wings. Most fish have internal skeletons just as those in mammals and birds, however, some crustaceans, such as shrimp and crabs, have exoskeletons. This means their skeletal structure is on the outside of their bodies. The exoskeleton protects the animals, like wearing a coat of armor. A fish skeleton is shown in **Figure 6.14**.

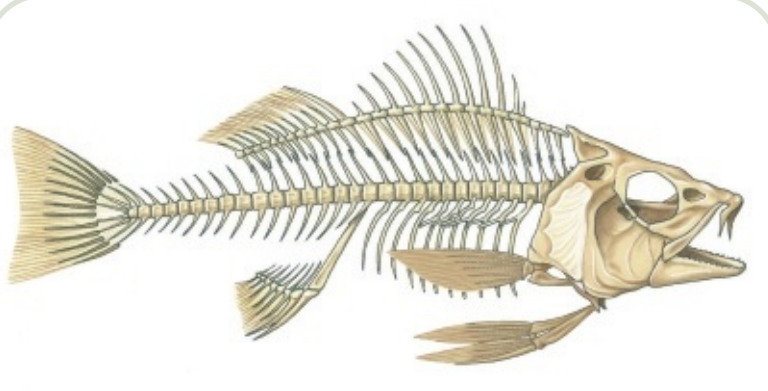


Figure 6.14 Fish Skeleton The bones of fish must be lightweight to ease swimming. *Which bones of the fish can you identify?*

Bird skeletons are adapted for flight, and they have wings instead of forelegs. Birds' hollow bones are lightweight and enable birds to fly. Many of our domestic poultry have been bred to reduce the size and strength of their wings. This keeps the poultry from flying away. Birds also have hind legs that allow them to walk on the ground. Some birds have sharp beaks to catch food, such as insects, or crack open seeds for food. They have sharp claws to help the birds hold onto a perch above the ground for safety or to protect themselves. They also have fewer bones than mammals**. Figure 6.15** shows a chicken skeleton. As you examine the skeleton, think about chicken bones you may have seen in food, such as wings or fried chicken.

Figure 6.15 Poultry Skeleton The chicken bones are lightweight and able to support flight. *Which bones of the chicken skeleton can you identify?*

Most of the animals discussed above have similar bone structures. For instance, birds, fish, and mammals have bones like our forearms. Birds have forearms in their wings, while fish have them in their fins. In mammals, the forearm is part of the foreleg. Now, go back to the figures you just examined and analyze the skeletons to see which bones are in similar or different positions in the various animals.

Some types of animals have horns coming from their heads. Cattle are examples of animals that can grow horns, but not all types of cattle have horns. Most male and female cattle, goats, and sheep are born with the genetic trait to grow horns. The horns grow naturally from the skull at a special location known as the horn bud. Some breeds, such as Polled Hereford and Aberdeen, have been developed without the genetic trait of horns. Breeds without horns are known as 'polled'. Horns that remain on animals can cause problems for people, the animal itself, and other animals. For example, horns that remain on cattle may get caught on fencing. Some animals, especially bulls (intact male cattle) and rams (intact male sheep), can be aggressive towards people and other animals. Their horns make them even more dangerous since the males can gore or ram people or other animals. The injuries can cause severe damage or even death. Also, horns continue growing as the animal matures, and the growth requires blood flow. Horns can also grow inward, turning towards the eye or the skull. Removing the horns allows the animal to use its nutrition for more productive means of gaining weight or supporting a calf.

To dehorn, or remove the horns, farmers or veterinarians cut or burn the horn bud on young animals to stop the horn bud from creating the horns. Removing the horns in young animals and using pain medication such as lidocaine reduces the pain from the horn removal. A strong sedative is also given to reduce the animal's stress and make the procedure easier for the handler. Dehorning has many advantages for people and for the animal, especially if the animal does not need horns for protection from predators.

Reading Check

Describe the main purpose of the skeletal system.

The Muscular System

The muscular system has the job of helping the animal's body with internal and external movements. The movement includes walking, digesting food, and pumping blood. The muscular system also helps provide the animal with its shape. Breeds of animals within species can vary in muscular development depending on their special uses. For example, a Quarter horse has short, powerful muscles that provide quick bursts of speed. The Arabian horse has longer, leaner muscles designed for longer distance running. The Shire draft horse has powerful muscles with the strength to pull large loads on farms.

Animals have similar muscles to those that you have throughout your body. Let's discover the three types of muscle tissues in animal bodies. All muscles are made of cells.

Skeletal muscles help the body with voluntary movements. These muscles provide the power for animals to walk, run, fly, and swim. The muscles also allow animals and people to bite off and chew food. These muscles are attached to the skeleton's bones. Skeletal muscles are under voluntary control. The skeletal muscles take messages from the nervous system and move the bones when walking, chewing, etc. **Figure 6.16** shows the skeletal muscles of a pig.

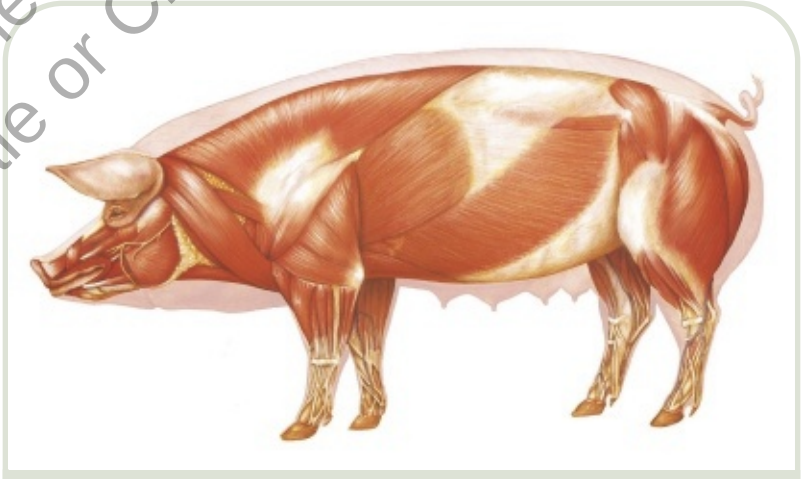
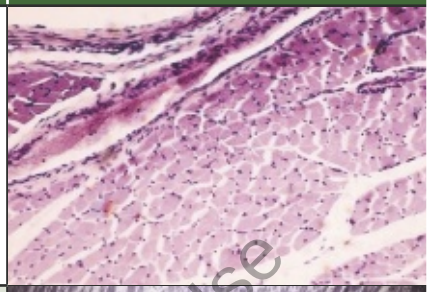
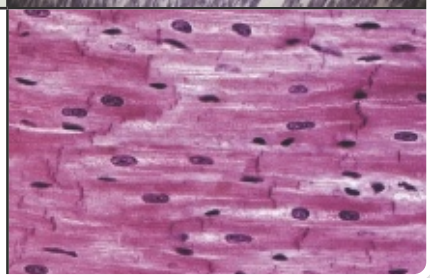


Figure 6.16 Skeletal Muscles A pig's skeletal muscles help it move around its pen. *What types of pork meat might we have from these muscles in this image?*

The **cardiac muscle** has the important job of making the heart work. The cardiac muscle tissue is only found in the heart, and the heart is a muscle. It has a crucial job of pumping blood throughout the whole body, no matter how big the animal's body may be. Muscles, including the heart, are stronger after walking, running, swimming, and flying. It is important to exercise and ensure our animals also get exercise.

Smooth muscles manage involuntary movements. This means the animal or person doesn't have control over the movement. Smooth muscles are responsible for digesting food, helping eyes focus, and making the hairs on animal bodies stand up when they are cold. The muscles are located in the digestive system, in the skin, along the walls of blood vessels, in the eyes, and in the respiratory, urinary, and reproductive systems. **Table 6.2** summarizes the purpose of the different types of muscle tissue with images of each muscle type as shown under a microscope.

Table 6.2 Summary of Muscle Tissue

Type of Muscle Tissue	Purpose of the Tissue	Image under a Microscope
Skeletal Muscle	Provide voluntary movement of the animal such as eating and walking	
Smooth Muscle	Works under the control of the nervous system for digestion and blood flow	
Cardiac Muscle	Found only in the heart with the power to pump blood throughout the body	

Animal bodies have several other important types of tissues that connect bones and muscles. These special tissues are called connective tissues since that is their main job in the body. Many types of connective tissue are stretchy, like rubber bands. **Ligaments** hold the bones together in the skeleton. They are found in the joints, such as holding the bones of the knees together. Strong **tendons** are responsible for attaching muscles to the bones, such as in the legs. The **cartilage tissue** protects and supports the joints in the body. Cartilage tissue also makes up the nose and outer ear parts in animals and people. Cartilage can also be found between the vertebrae of the spine.

Cartilage develops from a specialized cell. These cells produce cartilage, especially in young animals. Young animals are born with more bones than adults of their species. Some of the bones are made of cartilage. The bones are also in smaller sections. The small sections gradually fuse together as the animal grows into adulthood. For instance, the skull is made of several segments that grow together into one complete skull. Smaller bone sections and bones made of cartilage allow the young animal to curl up inside its mother or inside its eggshell. **Figure 6.17** shows an example of cartilage on a bird skeleton.

Figure 6.17 Bird Skeleton with Cartilage The bird has cartilage between the bones of its legs to cushion the joints. *Where else can we find cartilage in animals?*

Have you seen horses standing with their eyes closed? They are napping and can doze off without falling over. Horses can nap while standing because of the arrangement of their leg tendons and ligaments. This system is called the **stay apparatus**. It lets them lock their leg joints so they can stand without tipping over. This handy trick allows animals to rest while also being ready to run if threatened. However, horses need to feel safe enough to lie down and go into a deep sleep at least once a day. The stay apparatus of horse legs is shown in **Figure 6.18**.

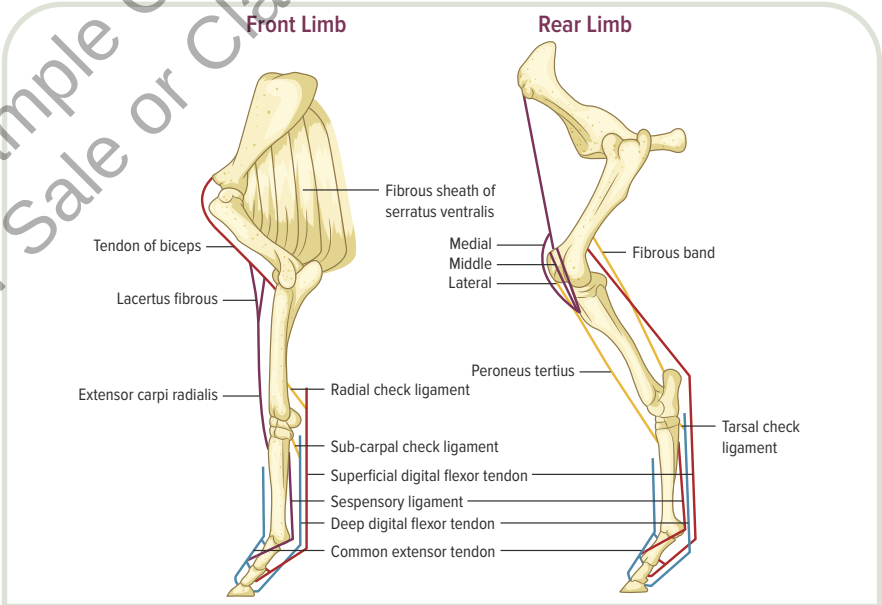


Figure 6.18 A Stay Apparatus The stay apparatus is a complex system of ligaments and tendons in the horse's skeletal structure that locks the limbs in place with the joints stacking directly above each other. *What advantage does the stay apparatus give to a horse?*

Reading Check

Identify the three muscle types and where they are located.

Internal Animal Anatomy and Physiology

What internal differences are there between animal species?

What body system alerts a horse to the fly on its shoulder? What body system tells a sheep that a threat may be nearby? Both answers lie with the nervous system. The nervous system is essential to all animals and humans. This system is made up of the brain, the spinal cord, and all the nerves in the body. Nerves run throughout the body, even to the ends of the feet, the bones in the tail, and the eyes, nose, ears, and mouth. The brain is the control center for the body. The brain collects and sends messages through the spinal cord to nerves in the body.

The Nervous System

The nervous system has several purposes. First, it helps animals regulate body functions such as internal temperature. Then, the five senses detect differences in the animal's body and in the surroundings, sending those messages to the brain. The five senses are hearing, sight, smell, touch, and taste. Animal species have amazing differences in the strength of their senses, like a superpower! For instance, dogs' sense of smell is 10,000 to 100,000 times as powerful as ours. No wonder they can sniff out dangerous chemicals in the environment. Some dogs can even scent disease in people when the dog is trained for this task. All nerves are made of specialized cells. These cells create two parts of the nervous system with differences in fish, birds, and mammals. The two parts of the nervous system are the central nervous system and the peripheral nervous system.

The nervous system is divided into two main parts. The **central nervous system** includes the brain and the spinal cord. Peripheral means at the edge. The **peripheral nervous system** consists of nerves all over the animal's body, from feet or fins to wings to tail to beak, depending on the animal. It includes the nerves connected to the five senses in the body. Examine **Figure 6.19** to analyze the mammal's nervous system.

Figure 6.19 Drawing of the Horse's Nervous System The nervous system is made up of the brain, central nervous system, and peripheral nervous system. *Which of these parts of the nervous system goes through the spine of the horse?*

Nerve impulses, or messages, start in the peripheral nervous system and travel to the central nervous system of the spinal cord and then to the brain. Then the brain sends impulses back along the same nerve pathways. The messages tell the animal's body what to do about the cause of the message. Neurons are specialized nerve cells that transmit messages along the nerve pathway.

For instance, when the nerves in the horse's skin detect a fly, the nerves send the message, or impulse, to the brain. Nerves meet and run through the spinal cord, which is located inside the vertebrae of the spine. The spinal cord is like a main highway for nerves since it goes directly to the brain. The brain processes the message and sends a message back along the nerves. The message might be to twitch the skin to dislodge the fly or to run away if the fly seems dangerous. Nerves move messages at speeds of about 50 meters per second. The message movement is so fast that it seems almost instantaneous. Think about how far 50 meters is, either at your school or on a sidewalk next to a road, and imagine moving that fast in one second.

The brain is the control center of the nervous system. Understanding the brain's main parts helps explain why species act differently from each other. All brains have the same basic parts. But the sizes of the parts, the overall size of the brain, and the shape of the brain vary among species. After all, the brain must fit inside the particular species' skulls. **Figure 6.20** shows an illustration of the brain and nervous system of a cow.

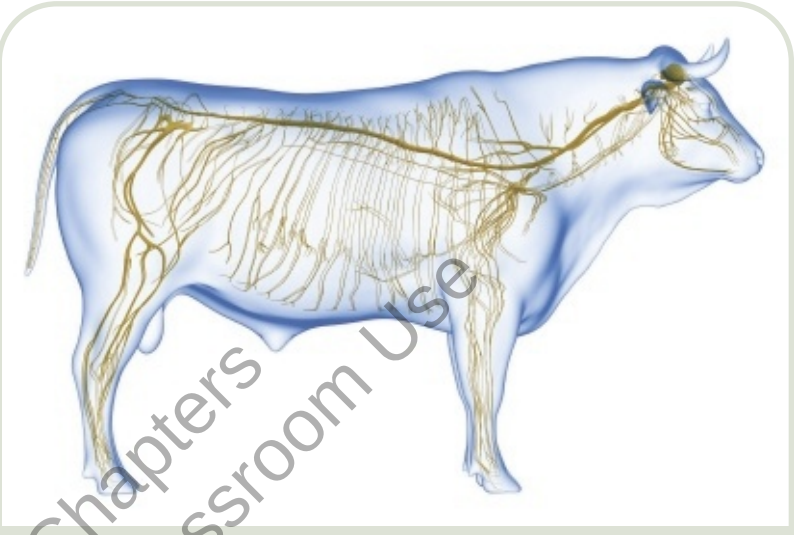


Figure 6.20 Brain and Nervous System of Cattle The illustration shows the complexity of the nervous system of animals. *What path would a message from the nerves in the hind feet take to reach the brain of the animal?*

The main parts of the brain are the same for all animals. The brain has two halves, or hemispheres. They are known as the left and right hemispheres. Each hemisphere specializes in different activities that help animals survive. For instance, the left hemisphere focuses more on helping the animal find food. The right hemisphere involves watching for danger. The hemispheres also give animals left or right-sidedness, just as people are right or left-handed. The two halves are connected by a large bundle of nerves known as the corpus callosum. It sends signals back and forth across the two hemispheres.

The parts of the brain are the same in the right and left hemispheres. The area of the brain nearest the spinal cord is known as the medulla. The medulla is responsible for managing involuntary body actions, such as heart rate and breathing. Moving forward in the brain is the cerebellum. The cerebellum controls coordination and balance. Then, towards the face of the animal is the midbrain. The midbrain controls vision in non-mammals. In mammals, midbrains deal with sensory processing, sleep, and motor control. The cerebrum is located towards the top, or the face of the animal, depending on the species. This part manages memory and learning.

The brains of different species have adapted to the needs of the species. Let's compare the brains of mammals, birds, and fish. The largest area of the brain in many mammals is the cerebrum. Nerves from the eyes, ears, and nose go to the cerebrum with their messages. The large cerebrum helps mammals learn and remember. In birds, the cerebrum is also larger and more important. It controls birds' senses, voluntary movements, and sound production. The optic area is also very important since it manages the important visual functions for birds. The most

dominant part of the fish brain is the cerebellum. This part is responsible for maintaining balance while swimming, managing muscle movements, and sensing external pressure on the fish. Examine **Figure 6.21** to compare the brains of mammals, birds, and fish.

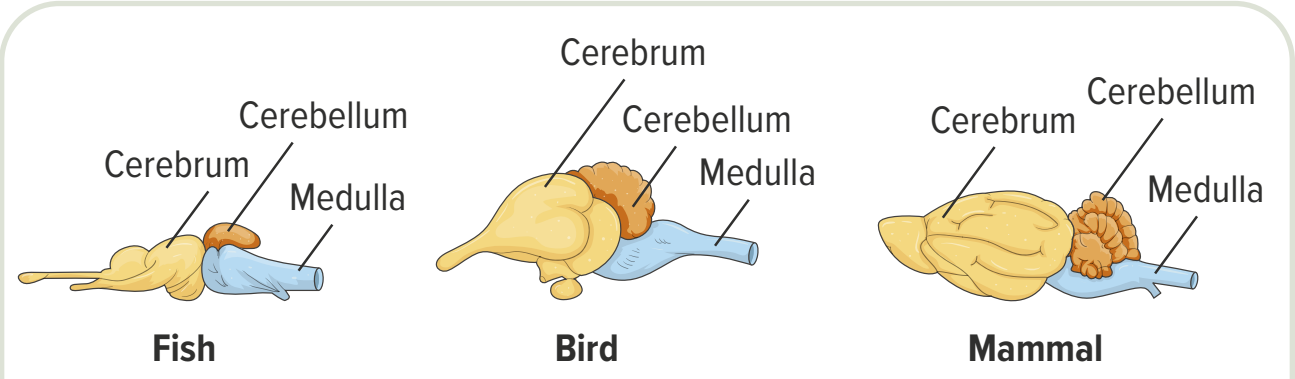


Figure 6.21 Comparison of Nervous Systems in Mammals, Birds, and Fish The brains of different species have evolved to fit the needs of the species for survival. *What does that tell us about the reasons for the different sizes of parts of their brains?*

Which species seems more capable of learning based on its brain, and why? What advantages do birds have due to their brains? You were correct if you said that mammals were the most capable of learning because of their large cerebrum. Birds have advantages with their vision since the optic center of their brain is well-developed. This means birds can see well to hunt and find food, as well as see colors, which is important for mating needs. Both birds and mammals can produce their unique species-related sounds and have more control of their voluntary movement with the larger cerebrums of their species.

Reading Check

Differentiate between the central and peripheral nervous systems.

The Cardiovascular System

Another important body system is the cardiovascular system. This system may also be known as the circulatory system since it circulates blood throughout the body.

This key system ensures that blood moves through the animal's body from the heart to the brain and all other body parts. The heart is the main organ that acts as a pump for blood. The blood is carried away from the heart in arteries and veins, which carry blood back to the heart. The tiny blood vessels we see near the skin are called capillaries.

Blood has several main elements. It is made of red blood cells, which carry oxygen to the body. Then, white blood cells help the body fight off infection and disease. Finally, platelets make the blood clot when the body is injured. So, when you have had a paper cut, the platelets help your cut stop bleeding. As you read earlier, blood is made by the bone marrow, inside the body's bones.

The heart is a muscle. The tightening/releasing cycle of the heart muscle is known as the heartbeat. You can find your heartbeat, or pulse, in your wrist or neck. Gently

press your first two fingers against the blood vessels inside your other wrist or on the side of your neck. You can count your heartbeat for one minute. Don't worry if you can't easily find your heartbeat while sitting still. Many people need to practice finding their heartbeat and counting their beats.

To find the pulse on animals, place your first two fingers against an artery on the animal. Don't use your thumb to take the pulse since thumbs have a pulse. The best location for arteries varies among different species. In general, arteries can more easily be found near the skin's surface on the inside of the legs, under the jaw, or behind the left elbow against the body. Note that the pulse of pigs can only be found by feeling the heart through the pig's skin. Be careful when taking the pulse, as some animals don't like to have pressure on their arteries or hearts. Then, count the number of beats, or pulses, for one minute.

Animal heart rates will vary based on the species, the age of the animal, their excitement or stress level at the specific moment, and the overall health/sickness of the animal. Generally, younger animals have higher pulses. Animals that have been more active will also have higher pulse rates.

Mammals (including people) and birds have a heart with four chambers. Blood moves through each chamber in a particular order. Each chamber has a valve that acts like an automatic door that opens and closes. The valve movement helps the heart pump blood throughout the body. The blood flows to the lungs, where carbon dioxide gas produced by the animal's body is exchanged for new oxygen. Next, blood flows throughout the body. Blood provides oxygen to other body parts and collects carbon dioxide. Then the blood returns to the heart and lungs to repeat the cycle. However, bird hearts are larger for the size of the bird than the hearts of mammals. The heart of the bird also produces more blood flow with each beat compared to the hearts of mammals. This stronger blood flow is crucial for birds to have the oxygen necessary for flight. **Figure 6.22** shows the complexity of the cardiovascular system for mammals and birds, with a diagram of a horse.

Figure 6.22 Horse Cardiovascular System This figure illustrates how the cardiovascular system is placed within the skeleton of a horse. This is similar in complexity to the circulatory system for birds. *Why do you think the blood vessels are larger in the main body parts of the horse and smaller in the legs?*

Since fish live in water and use gills instead of lungs for breathing air, they only have a heart with two chambers. Their pathway for blood and air exchange is less complex than that of mammals and birds. In fish, the blood flows in just one direction. The blood moves from the heart to the gills, then to the brain, in a loop through the fish's body and

back to the heart. See the one-way system of blood flow in **Figure 6.23**.

Now, examine **Table 6.4** to compare the cardiovascular systems of mammals, birds, and fish. The mammal and bird species have more similarities to each other than they do to the fish species.

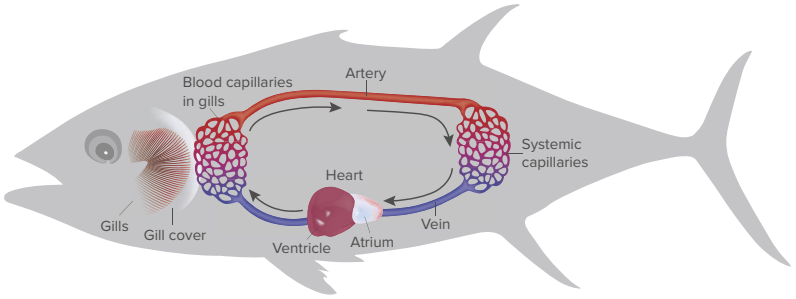


Figure 6.23 Fish Cardiovascular System The fish's cardiovascular system flows in one direction, as shown by the arrows. *How does the one-way blood flow impact the fish in terms of getting oxygen to all body parts?*

Table 6.4 Comparison of Cardiovascular Systems in Mammals, Birds, and Fish

Species	Number of Heart Chambers	Type of System
Mammal	4	Two-way
Bird	4	Two-way
Fish	2	One-way

Horses have long legs and a need for swift movement. To move blood quickly from their hooves to their bodies, horses have a special part at the bottom of their hooves. This V-shaped muscle is known as the 'frog.' **Figure 6.24** shows a diagram of the bottom of a horse hoof. The rounded part at the top of the drawing is the toe, or front, of the hoof. The thick line around the outside of the hoof is the wall, which is harder than your fingernails.

When a horse walks or moves faster, the ground presses on the frog of the hoof. This pressure helps to move blood in the veins back up their legs to their body. However, horses can also have problems with blood circulation in their hooves. The outside of their hooves is very hard, even harder than the outside of our fingernails. So, if the frogs don't move the blood quickly enough, horses can develop a condition known as founder, or laminitis. It is caused by the vasoconstriction (narrowing) of the blood vessels. This is a very painful condition for the horse. Sometimes this causes so much damage to the hoof that the horse is permanently lame. Several possible causes for this condition are related to the feed and grass given to horses, running on pavement, or being given steroids. Horse owners and handlers need to be very aware of laminitis since it can mean extreme pain and permanent lameness, leading to death, for the horse. Horses that are lame without a visible cause need to be seen by a veterinarian quickly to prevent permanent injury.

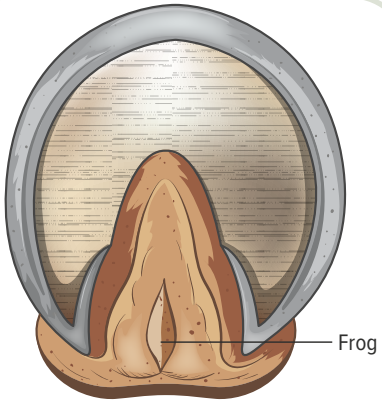


Figure 6.24 Illustration of a Horse's Hoof This is the bottom of the horse's hoof. The frog is the V-shaped muscle at the back of the horse's hoof. How might this muscle help move blood out of the hoof?

Reading Check

Summarize how mammalian, bird, and fish hearts differ.

The Respiratory System

Take a deep breath and feel the air expanding your lungs; then exhale and feel the air leaving your body. The respiratory system is the body system responsible for managing our breathing. The respiratory system is interconnected with the cardiovascular system. Blood carries oxygen and carbon dioxide around the body. We learned that blood in the cardiovascular system picks up oxygen in the lungs and transports it throughout the body. Oxygen is needed by all the organs and muscles, including the brain. The blood also gathers carbon dioxide from the organs and muscles to return to the lungs.

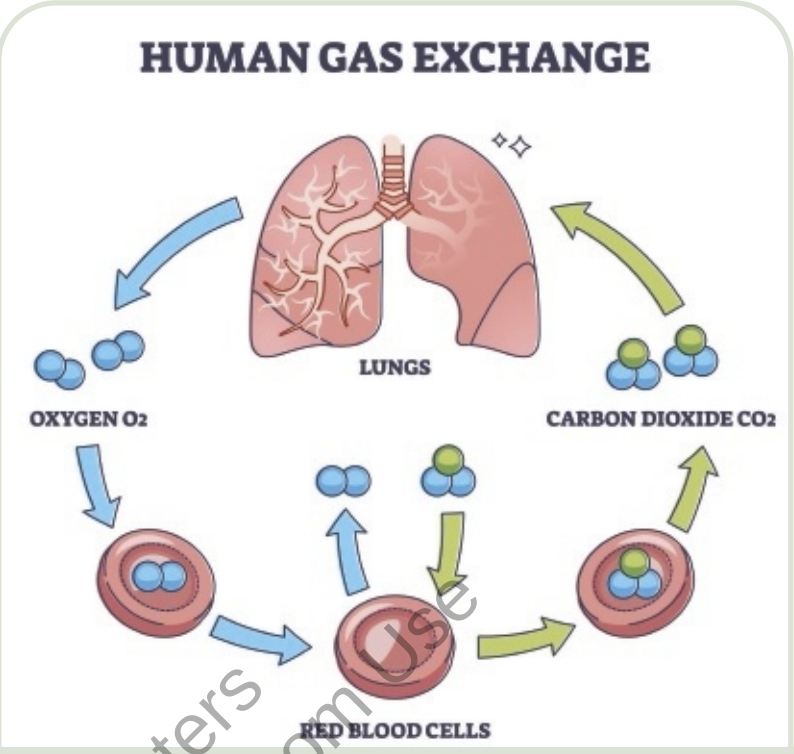


Figure 6.25 Human Gas Exchange When you inhale, you take in oxygen. When you exhale, you release carbon dioxide. *What system works with the respiratory system to keep your body properly oxygenated?*

When animals and people breathe in (inhale), they take in oxygen needed by the muscles and other organs of the body. When animals and people breathe out (exhale), they release carbon dioxide that is not needed by their bodies. **Figure 6.25** illustrates the process of gas exchange.

When inhaling, animals may also breathe in dust and other particles in the air. Tiny hairs known as cilia in the throat catch large particles in the air, preventing some dust and other particles from making their way to the lungs. Smaller particles are captured by mucus in the lungs. The lungs are filled with many small air sacs. These sacs fill with air during inhalation and deflate during exhalation. Respiration in birds and mammals is a two-way movement of inhaling and then exhaling. Respiration is different for fish.

For mammals and birds, the respiratory system comprises the nose, throat (pharynx), and sinuses at the head end. Inside the body, the respiratory system includes the lungs and trachea. The diaphragm is a thick muscle separating the heart and lungs from the digestive system. The differences in animal species cause different shapes for the nose and nasal passages, as well as the length of the throat. These body differences are one reason diseases affect animal species in various ways. For instance, cows have small lungs for their body size. This makes them more affected by changes in the air temperature, making them more prone to pneumonia.

Many mammals can only breathe through their noses. They are known as obligatory nasal breathers, meaning they can't breathe through their mouths. The bodies of horses and other obligate nasal-breathers have a feature that closes off their esophagus (food passageway) from their trachea. That way, they don't inhale food into their lungs.

Many animals, even if they can only breathe through their noses, can open their mouths to pant. Panting helps them release extra heat during very hot days. Panting also decreases an animal's body temperature, such as during exercise or in times of fear or nervous stress. The animals release heat from internal body tissues as the air moves over them. However, panting also evaporates water from their bodies, which must be replaced.

Birds have many of the same body parts as mammals in their respiratory systems: the nose, throat, sinuses, trachea, and lungs. However, birds breathe faster, even at rest, than other animals. So, their respiratory system is adapted to pass more oxygen along faster to their body. Like people, birds can breathe through their mouth and nose. Their lungs are rigid, not flexible like the lungs of mammals. Some of the air is held in air sacs before oxygen and carbon dioxide are processed in the lungs. After leaving the lungs, the air is held in other air sacs. So, with the air sacs, birds have a nearly constant flow of air coming into their lungs. This means that birds' lungs don't inflate and deflate as the lungs of mammals do. The respiratory system of birds is more efficient at supplying continuous oxygen from the air during flight. Fish have very different respiratory systems from those of mammals and birds. After all, fish are adapted to living in water. Instead of taking in oxygen through the nose, fish directly take in oxygen from the water through their gills. The gills lie just behind their mouths. The blood vessels in the gills also release carbon dioxide from the fish into the water. The gills are protected by a thin piece of skin known as the gill cover. The red color of the gills is due to their many blood vessels. The blood vessels carry oxygen to the swim bladder. The oxygen in the swim bladder is absorbed by blood vessels for use in the fish's body. Many fish also use the swim bladder to help them change their depth in the water. The amount of oxygen in the bladder changes when fish want to move to the water's surface. They release oxygen from the bladder when they want to move deeper in water. Examine **Figure 6.26** which shows a dog's respiratory system.

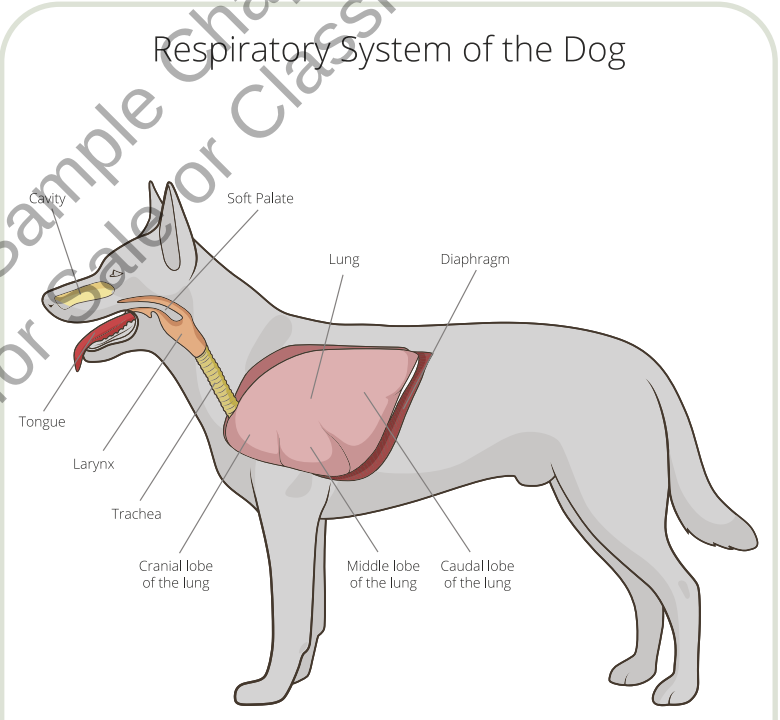


Figure 6.26 Respiratory System of a Mammal The respiratory system of a dog. *What differences can you describe between the parts of the dog's system and those of the birds?*

Reading Check

Differentiate the parts of the respiratory system of mammals and fish by listing the parts in each and telling how each type of animal breathes.

The Endocrine System

Are you hungry or sleepy right now? If you are, part of the feeling comes from the endocrine system. The endocrine system controls the hormones, the chemical messengers that support the growth and regulation of cells and organs. Hormones have an important role in growth, metabolism, and reproduction activities for animals. Hormones signal different organs when it is time for them to become active, such as during puberty. The endocrine system also signals the body when more energy is needed, such as during exercise or during times of growth. These signals may make you feel tired or hungry. Organs involved in the endocrine system include the pituitary gland, the pancreas, and the thyroid gland. The reproductive organs for males (testes) and females (ovaries) are activated by the hormones of the endocrine system at puberty. Blood carries hormones around the body. When hormones are not kept in balance by the endocrine system, an animal may have a disease such as Cushing's Disease or diabetes. **Figure 6.27** illustrates the endocrine system of a pig.

While the endocrine system in mammals has been studied more closely, this system in fish is not as well understood. For fish, just like mammals, the system is responsible for growth and metabolism of energy. However, the endocrine system in fish also manages some elements of their skin color. The system is involved in regulating the pressure of water on their cells, too. This is essential since fish live in water. The fish organs and glands involved with reproduction are not as clearly understood as those of mammals. Some of the activities of the endocrine system in mammals are managed by the nervous system in fish instead. Examine **Figure 6.28** to see the similarities and differences in the mammal and fish endocrine systems.

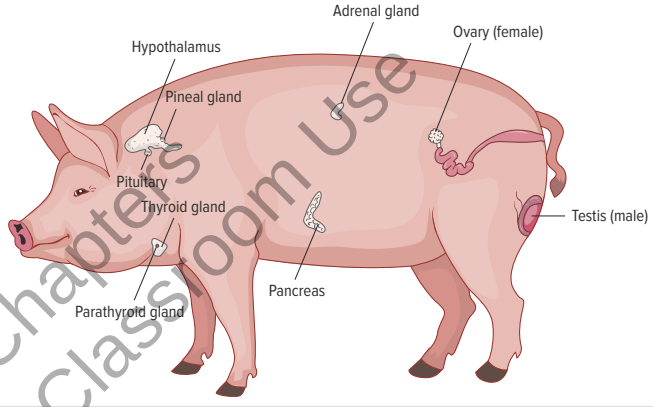


Figure 6.27 Endocrine System The endocrine system of pigs is shown in the illustration. *What will cause the release of hormones in the endocrine system in a pig?*

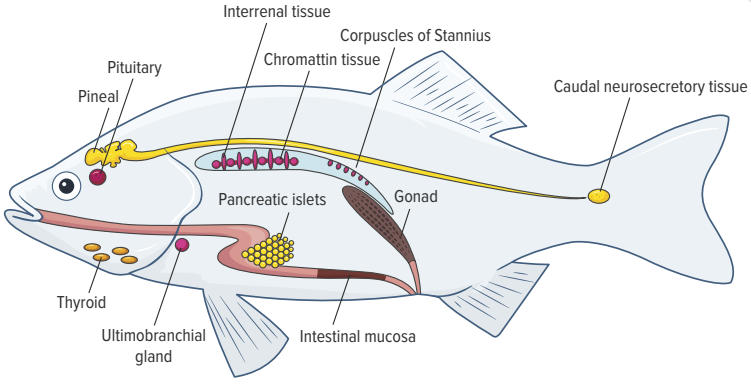


Figure 6.28 Similarities of the Endocrine System While the fish and mammal endocrine systems have a few similarities, they also have differences. *What are the differences in function between the two systems?*

Reading Check

Summarize the purpose of the endocrine system and include a summary of how the endocrine system in fish is different from that of other animals.

The Digestive System

The digestive system is a key system for animal growth, energy, and maintenance. Food moves through the digestive system, which turns the food into nutrients

needed by our bodies. The digestive system has differences depending on the nutrition needed by the species. Animals that eat only plants are herbivores. Examples of herbivores include cows and sheep. They must consume large amounts of grass, hay, and grain to produce the energy their bodies need. Carnivores, such as cats, eat meat. Other carnivores eat non-flesh items too. Dogs fall into this category as they may eat vegetables, fruit, bread, etc. Then, omnivores are animals designed to eat meat and plants. Pigs and chickens are examples of omnivores.

In all animals and people, digestion begins with food taken in by the mouth. Some species chew the food into smaller bits and then swallow it. Horses and pigs fall into this category. Other species, such as chickens and ducks, swallow food without chewing. At that point, specific types of animals have key differences in their digestive systems. While the systems may work differently in various species, all digestive systems have the same purpose: to break down food into nutrients needed by the animal and to remove excess food as waste. However, each species must eat different types of food and have different nutritional requirements because of these differences in their digestive systems. Let's explore the digestive differences of mammals between monogastric, ruminants, small ruminants, and pseudo-ruminants.

Humans are monogastric. Mono means one, so monogastric animals have one stomach. Animals with only one stomach include horses, donkeys, pigs, and rabbits. The digestive process begins with the mouth (lips, tongue, and teeth), which bites or pulls food into the mouth and then breaks food into smaller bits. Next, food moves through the esophagus to the stomach. Stomach acids dissolve the chunks of food into a liquid form. The food passes to the small intestine, where it extracts the nutrients. Enzymes made by the liver, the small intestine, and the pancreas help process food. Nutrients are moved into the bloodstream for use by the body. In horses, the leftover food in the small intestine passes into the cecum part of the large intestine. The cecum ferments leftover grass fiber, taking out more nutrients. The total length of the large intestine of a horse is about 25 feet! Other monogastric animals do not have a cecum in their large intestine; however, the large intestine is responsible for further processing of digested food. The large intestine also has the job of taking water out of the digested food and forming the leftover food into feces (manure or waste), which is removed from the animal via the rectum.

Many animals can regurgitate (vomit) their food if they have a digestive issue. However, horses cannot vomit. They have a very powerful muscle at the first opening of their stomach that prevents food from coming back up the esophagus. If you see a horse with partly chewed food coming from its nostrils or mouth, it has likely choked in its esophagus and coughed the food back up. However, being unable to vomit also means a horse that has eaten something harmful may die, since the food must pass through the digestive system. See **Figure 6.29** for an image of the digestive system of the monogastric horse.

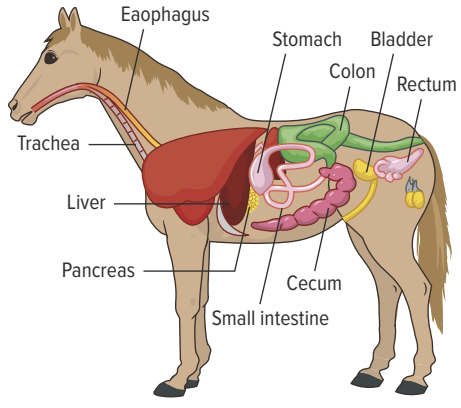


Figure 6.29 Digestive System of a Horse The digestive system takes up much of the internal space of the horse's body. *What parts of the equine digestive system can you identify here?*

Ruminants have a specialized stomach with four compartments that make them more efficient in

processing the food they eat. Examples of ruminants are cows and bison. These animals evolved to eat large amounts of grass or hay, known as forage, to meet their nutritional needs. The mouths of ruminant animals are unique because they don't have upper incisor teeth. Instead, their lips, lower teeth, a rough upper gum area, and tongue pull and tear the grass or hay into their mouth. Then the forage is roughly chewed. The animals eat very rapidly without chewing their food well. The food moves along the esophagus to the stomach, as in monogastric animals. However, the food in ruminants goes to the first stomach compartment, called the rumen. The rumen can hold 40 gallons of food in an adult cow. Tiny microbes in the rumen break down the food into smaller, more digestible chunks. This allows cows to regurgitate (vomit) this food back up so they can "chew their cud" into smaller bits. The animal swallows the food again into the second stomach compartment, the reticulum. Tiny microbes cause the food to ferment, so that the food can remain for 48 hours, as the food is used for energy. The reticulum also collects hard objects, such as nails or wire, that have been eaten by the cow. The liquid portion of the food from the cud being chewed goes to the omasum and abomasum stomach compartments. The omasum has a large surface area to absorb nutrients from the digested food. It also absorbs water from the food. The abomasum has stomach acids, so it's known as the true stomach of ruminants. The small and large intestines are the next pathways for food, just as in the monogastric, with similar purposes. The cecum in ruminants helps to digest fibers, using a special type of bacteria that haven't been digested yet. The cecum also absorbs water. The cecum in ruminants is similar to the appendix in humans. See the image of the cow's digestive system in **Figure 6.30**.

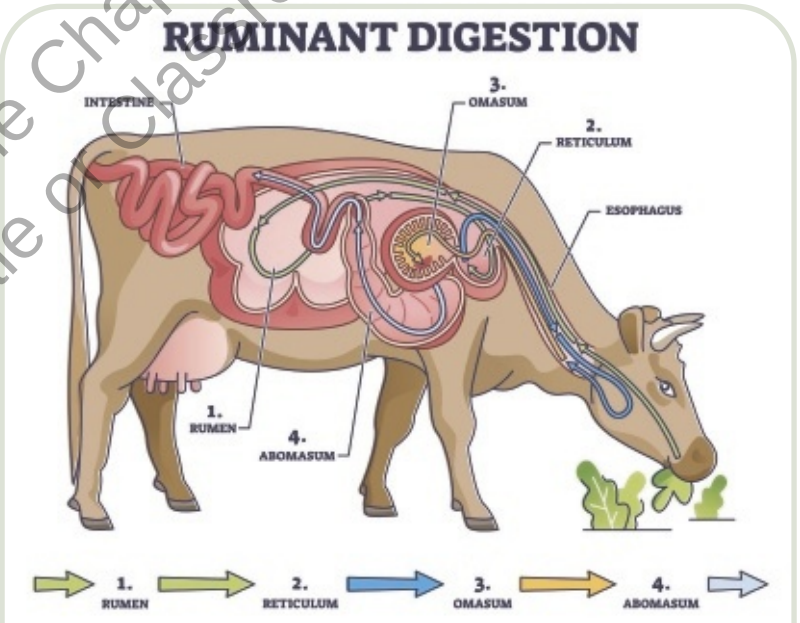


Figure 6.30 Digestive System of a Cow This shows the digestive system of a cow, which is a ruminant. *Can you describe the order of the digestive system as food passes through the four stomach compartments?*

Animals that are known as small ruminants include sheep and goats. They also have four stomach compartments and the same digestive system as large ruminants. However, since they are smaller animals, their digestive system is also proportionately smaller. Cows can digest the fiber in their food more efficiently than sheep and goats. Goats are known as indeterminate ruminants. This means that goats can digest a wider variety of food than other ruminants.

Another group of plant-eating animals is known as pseudo-ruminants. Examples of this type of animal would be alpacas, camels, and llamas. Similar to ruminants, pseudo-ruminants also lack upper front teeth. Instead of having four stomachs like ruminants, these animals only have three stomach compartments. The digestive process of pseudo-ruminants is the same as that of ruminants, but they don't have a rumen stomach. Instead, pseudo-ruminants chew their cud to break down the tough plants into smaller and softer material that their stomachs can digest.

The avian/bird digestive system includes unique structures. Birds tend to quickly eat a lot of food without chewing it, focusing on safety from predators. After the bird picks up and swallows its food (grain, worms, berries, etc.), the food goes down the esophagus to the crop. The crop stores this food with mucus until the bird is in a safe place to digest the food. Then, the food moves into the first of the two stomach halves. The first half, the proventriculus, has stomach acid that begins dissolving the food. Then, the food moves to the second part of the stomach, known as the gizzard, or ventriculus. This stomach provides a mechanical squashing action. Some birds, like chickens, swallow tiny rocks that help grind up the food in the gizzard. From the gizzard or ventriculus, the food is moved into the small intestine to extract nutrients for the body. Then, the food moves to the large intestine to the pair of sacs known as the ceca. They ferment the food and absorb water from it. Leftover food and water are removed via the rectum. Birds have a shorter digestive system than mammals. This reduces the weight birds must lift and carry during flight. Examine the digestive system of the bird in **Figure 6.31**.

Figure 6.31 Bird Anatomy This illustrates the parts of a bird's digestive system as well as other parts of the bird's body. *What parts of the bird's digestive system are also shared as parts in the digestive system of monogastric animals?*

Compare the digestive systems of different farm animals with **Table 6.5**. Find the unique features of different species' digestive systems.

Table 6.5 Comparison of the Digestive Systems of Farm Animals

Type of Digestive System	Monogastric	Ruminants	Small Ruminants	Pseudo-Ruminants	Avians
Examples	horses, donkeys, pigs, rabbits	cows, bison	sheep, goats	alpacas, camels, llamas	chickens, turkeys, geese
Unique Features	1 stomach compartment, have both upper and lower teeth, food is chewed only once in the mouth	4 stomach compartments, chew their cud (food) more than once to process it; lack upper incisor teeth	4 stomach compartments, chew their cud (food) more than once to process it; lack upper incisor teeth	3 stomach compartments, chew their cud (food) more than once to process it; lack upper incisor teeth	No teeth; swallow grit to help digest food in the gizzard; eat large amounts of food, hold food until safe time to digest it in the crop

Reading Check

Describe the four parts of the ruminant stomach and explain how each compartment functions.

The Lymphatic System

The lymphatic system has two main purposes in mammals and birds. First, the lymphatic system collects fluid from other tissues in the body and returns that fluid to the blood vessels. Secondly, this system also produces white blood cells, which help fight disease. The fluid and any other particles it has collected are known as lymph. Lymph passes through lymph nodes. The nodes filter out the particles and germs before the fluid flows into the blood. The particles and germs may cause lymph nodes to swell during an infection or illness. The lymphatic system includes the lymph nodes, the lymphatic vessels, and the spleen. The spleen filters the blood, removing germs and other particles. The spleen also stores extra red blood cells until they are needed to carry more oxygen. See **Figure 6.32** for an image of a cow with the lymph system illustrated.

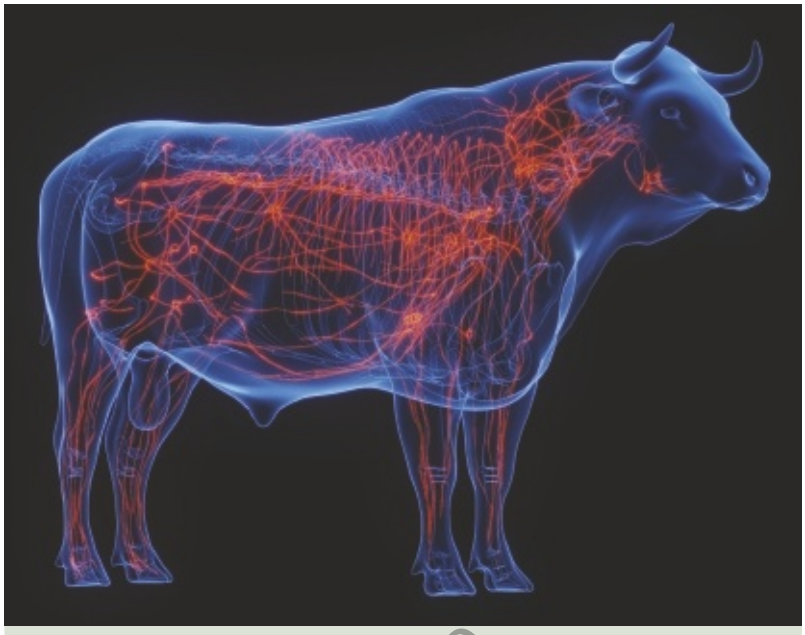


Figure 6.32 Lymph Nodes A model of a cow's lymph system and lymph nodes. The lymph system supports the immune system of animals. *Why might animals have so many more lymph glands in the neck and chest areas?*

In fish, the lymphatic system is part of the circulatory system. Fluid outside the blood vessels is collected by tubes, known as lymph ducts. These ducts return the fluid to the blood vessels. The spleen also filters the blood in fish, just as in mammals and birds.

Reading Check

Summarize the purpose of the lymphatic system.

The Excretory System

All living things need a way to remove liquid and solid waste from their bodies. The excretory system has this responsibility with the support of several other body systems. The large intestine of the digestive system is part of the excretory system. This organ handles solid waste removal. The liver is an accessory part of the excretory system. The liver removes waste products and detoxifies harmful substances during digestion. The urinary system is also part of the excretory system. The urinary system handles the removal of liquid waste and cleans the blood. Those acts help to maintain proper blood pressure and electrolytes in the body. The nervous system controls the urinary system. The brain signals the body when it's safe to release stored wastewater or urine.

The excretory system has a few differences in mammals, birds, and fish. Recall that for mammals, solid waste removal is part of the digestive system. In mammals, the urinary system (for liquid waste) is made of the two kidneys, the ureter, the urinary bladder, and the urethra. Blood pumped from the heart filters through the two

kidneys. The kidneys remove waste products from the blood. The waste, or urine, then moves from the kidneys to the ureters for storage in the urinary bladder. When the bladder is full, the urine is released through the urethra.

The kidneys are generally located near the backs of the animals. Kidneys have slightly different shapes in different species. In cows, the kidneys resemble a head of cauliflower. Horse kidneys resemble a Valentine heart. Dogs' kidneys are kidney-bean shaped. **Figure 6.33** shows a model of a female mammal (dog) urinary system.

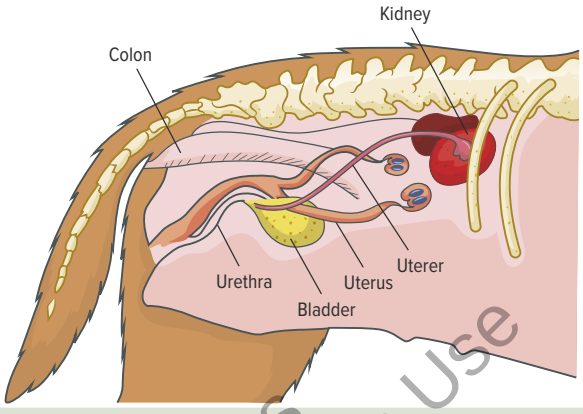


Figure 6.33 Female Mammal Urinary System The main parts of the mammal's urinary system are similar for mammals, no matter their body type. *What is the overall purpose of the urinary system?*

However, in birds, the urinary process doesn't have a separate system. The excretory system handles both the liquid and solid wastes produced by the bird's body. The bird's kidneys are located behind the lungs and resemble a pair of long tubes. Blood is filtered through the kidneys to remove waste products. This creates urine. The liquid waste (urine) moves through the ureters into the cloaca. From there, the urine goes back into the large intestine. The urine mixes with the solid waste from food before being excreted with the manure via the urinary vent.

Fish also have a pair of kidneys, located near their spines. The kidneys filter out particles from the blood. The waste then moves through the urinary tubes to the bladder. Finally, the urine waste is released through the urogenital opening. Since fish are surrounded by water, their bodies absorb more water, so they must urinate more often. Examine the urinary system elements and functions in **Table 6.6**.

Table 6.6 Urinary Systems of Mammals, Birds, and Fish

	Mammals	Birds	Fish
Purpose	Filter the blood of particles, Remove excess water from the body	Filter the blood of particles, Remove excess water from the body	Filter the blood of particles, Remove excess water from the body
Parts	Kidneys Ureters Urinary bladder Urethra	Kidneys Ureters Cloaca Large Intestine Urinary vent	Kidneys Urinary tubes Bladder Urogenital tube

Reading Check

Identify the differences between mammalian and avian urinary systems.

Animal Reproductive Systems

What are the differences in reproductive systems between animal species?

The reproductive systems vary the most between different species. The system has the same role across species: create more of the same animal species through reproduction. **Gestation** is the amount of time between conception and birth, with the length of time different from one animal species to another. Maturation means the time needed before the young animal has grown enough to be ready to reproduce. Let's read about the differences in the reproductive systems of mammals, poultry, and fish.

Mammal Reproduction

Mammal farm animals require both female and male partners to create a new life. The female reproductive organs include:

- Ovaries: produce the eggs
- Uterus: provides an internal space for the young animal to grow during gestation
- **Placenta**: a membrane surrounding the baby animal that provides nutrition for it until the young animal is born
- Mammary glands: produce milk for the baby animal

In male mammals, the sperm (male reproductive cells) are produced by the testes, which lie in the scrotum. The sperm mix with glandular liquid to create the semen. Semen is passed out of the body through the penis.

The time needed for different species to gestate and then to reach maturation, or the age at which they reproduce, varies by species. See **Table 6.7** for specific gestation and maturation times for each species. Some species generally mate and then reproduce in the spring and summer when food is more plentiful, while others can mate and reproduce year-round. However, female animals giving birth in the winter generally benefit from extra shelter and feed. While animals have given birth on their own for thousands of years, people who care for domestic animals prefer to keep a close eye on pregnant animals to ensure they have proper food, water, and medical care during their pregnancy, during the birth process, and while caring for the young animals.

Table 6.7 Gestation and Maturation Times

Species	Gestation Length	Maturation in Females	Maturation in Males
Equine	11 months	14 months	14 months
Llamas	11 months	12 months	36 months
Cows	9 months	11 months	11 months
Pigs	3.5 months (114 days)	6 months	7 months
Sheep	5 months (150 days)	7 months	7 months
Goats	5 months (150 days)	7 months	5 months

Species	Gestation Length	Maturation in Females	Maturation in Males
Dogs and cats	2 months	6-12 months depending on size	6-12 months depending on size
Rabbits	1 month	4-9 months depending on breed	4-9 months depending on breed
Chickens	21 days until hatching	6 months	6 months
Fish	Several weeks depending upon the type of fish	Depends upon the type of fish	Depends upon the type of fish

To reproduce, the female mammal needs to produce eggs (female reproductive cells) from her ovaries. Mammal eggs do not have a hard shell the way that chicken eggshells do. Proestrus occurs first as the body prepares an egg for a possible pregnancy. During **ovulation**, the egg is released from the ovaries. The egg is ready to be fertilized. **Estrus** or 'heat cycle' means the pituitary gland has produced hormones, making her body ready to accept the male animal. If the female animal is not impregnated, the reproductive system returns to normal (anestrus and diestrus phases) until the next heat cycle.

Fertilization occurs if the female animal's egg cell joins with the sperm cell. Then, her body nurtures and grows the young animal in the womb during gestation. An early stage of the new animal is known as a **blastocyst**. This stage occurs at about 5-6 days. Cells begin dividing to form the specific animal, and the placenta is developed, as shown in **Figure 6.34**. Then the new animal moves into the **embryo** stage, which lasts for many weeks or months (depending upon the animal). During the embryo stage, many cell divisions form the various organs and body systems of the new animal. Finally, the new animal becomes a **fetus** until it is born.

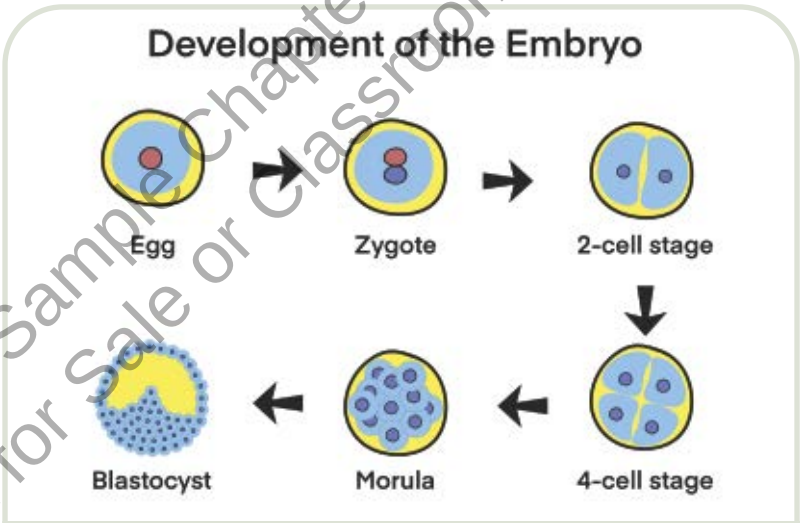


Figure 6.34 Embryo Development The early stages of life in mammals are focused on cell creation. *What is happening with the blastocyst cells?*

Reading Check

Define blastocyst, embryo, and fetus.

In mammals, several factors regulate the gestation and birthing process. These factors include the size of the animal species, the number of young animals produced at birth in the same litter, and the health of the fetus. Larger animal species, such as the horse and cow, take more time to gestate their young inside their mothers and usually produce just one or two babies per year. Smaller species, like pigs and sheep, gestate for fewer months and tend to produce one to eight young at a time.

At birth, the young of farm animals can usually rise, walk, and nurse from their mother within hours after birth. This is an advantage for former prey animals. After all, they had to be able to flee predators soon after birth. The babies are mobile but need their mother to nurse them for nutrition. They can't eat regular grass or hay yet, as their teeth are still developing. Some may try gumming roughage. Farmers often begin weaning piglets, lambs, and calves after two months, when the young can eat specialized food for more growth. Foals (the young of horses) are not usually weaned until they are five or six months old. Their mother's milk production slows, and the foals eat grass and hay easily. Smaller mammals, such as dogs and cats, give birth to young with closed eyes. The young can only crawl, not walk, for the first two to four weeks. They need much care from their mother at this time and for the next few weeks. Puppies and kittens begin the weaning process around four weeks but need several weeks to learn how to eat soft foods.

During the later weeks of gestation, the mother's body is also preparing her mammary glands to produce milk as nutrition for the young. Hormones in the mother's body signal to her uterus that it's time to release the fetus. First, the cervix opens more widely to the environment in the **dilation** phase. The mother animal looks for a quiet, safe space to have her baby. The uterus begins to contract to push the fetus out. The mother animal may lie down or walk around to relieve the discomfort. The umbilical cord has supplied the fetus with nutrients and oxygen throughout gestation. Now, oxygen and nutrients slow and then cease moving through the umbilical cord. In the expulsion phase, the fetus is pushed out into the world with powerful, involuntary contractions of the uterus. The baby animal must begin to breathe on its own and needs to find its mother to nurse for nutrition now. However, if the mother is giving birth to more than one young animal, the expulsion phase will stretch out in time as each young is delivered one by one. The mother is very busy cleaning the afterbirth from each young animal and nudging it to find milk, even while giving birth to siblings. After all the young are born, the mother also has to expel the afterbirth, the used placenta that surrounded the fetus during gestation. The afterbirth is pushed out of the mother's body during the placental phase. The next phase, **postpartum**, means the mother cares for the young animals. She produces milk for them, cleans them, and protects them. **Figure 6.35** shows the care given by a mother cow to her newborn calf.

Figure 6.35 A Cow with her Newborn Calf This cow is cleaning her newborn. *What phase of birth is the cow in?*

Reading Check

Identify what happens during dilation, expulsion, and placental birth.

Poultry Reproduction

Like mammals, poultry also require both male and female interaction to reproduce. However, the major difference is that the young are gestated outside of the mother's body after fertilization. In poultry, the male produces sperm in the testes, which are located inside the bird. The male bird stands on the back of the hen, so that their cloacas touch. The sperm travels from the male cloaca to the hen's cloaca, entering the female bird. Male poultry do not have a penis like male mammals do. However, both mammals and poultry are considered to use **internal fertilization**. Internal fertilization means the egg and sperm join inside the animal to begin a new life.

Female poultry (hens) produce an egg in a single ovary as a yolk, or ovum. Male poultry do not produce eggs. When the yolk moves to the oviduct, the eggshell and egg white are added to the yolk. The oviduct is about 25 inches long inside the hen. To mate, the male bird touches his cloaca to the female cloaca and releases his sperm cells. The sperm travel up the female's oviduct to the yolk. If the sperm enters the tiny, white spot on the yolk, the female reproductive cell, fertilization occurs. The cells begin dividing to create a baby chick. However, the process doesn't completely occur within the hen's body. Most of the development occurs after the egg is laid while the hen incubates the egg, in the nesting process. During incubation, the hen keeps the egg at a certain temperature to promote the development of the chick. If the egg is not kept at the right temperature, the baby bird will not develop. Likewise, if the egg is not fertilized, a baby chick will not develop.

Reading Check

Identify the difference between the female mammal and poultry reproductive systems.

After an egg is released into the oviduct, the female chicken lays her egg, usually one a day. The entire process of producing an egg and laying it takes about 25 hours. Laying an egg occurs whether or not the egg is fertilized. Once an egg is laid, another yolk is released, and the process repeats daily. The hen will try to sit on her nest of eggs until the chicks hatch, if the eggs were fertilized. Since the hen wants to protect her eggs in case a chick is developing within, she may become 'broody.' Broody hens are aggressive towards anyone who tries to take their eggs away. If the eggs are not expected to produce chicks, the hen must be removed from the nest so the eggs can be collected.

The eggs with expected chicks can also be taken away from the mother for the safety of the eggs. Eggs with chicks are very sensitive to temperature and humidity. So, an incubator with heating lights may be needed if the eggs are removed from the hen. Chicken eggs need temperatures between 36.7°C (98°F) and 38.3°C (101°F). Other poultry species may have slightly different temperature needs.

The fertilized chicken egg needs only three weeks for the chick to develop and hatch. Read the six stages of poultry hatching:

1. The egg is laid in the nest. The chick is just a few cells inside the egg with the yolk. The head and backbone are the first body parts to begin developing.

2. After day 2, the heart forms, and blood vessels are created. The heart begins beating.
3. By day 3, buds for the wings, legs, and beak can be seen.
4. From days 7 to 14, the chest cavity encloses the heart. The embryo begins to look like a bird.
5. On day 20, the bird's beak has pierced the shell, and the embryo begins to breathe air. The chick has moved into hatching position inside the egg.
6. Finally, on day 21, the chick pushes its beak and head through the eggshell, forcing its body through the shell. Then, the chick rests while its downy feathers dry.

Fish Reproduction

Fish have a major difference in reproduction from mammals and birds. Fish reproduce externally, instead of the sperm and egg uniting inside the female's body. In **external fertilization**, the egg and sperm join in most fish (including some aquarium species) outside the bodies of the fish. Fish mating is known as spawning. Most fish do require both male and female interaction to spawn sexually. However, there are a few species of fish that reproduce asexually. With asexual reproduction, the female fish produces eggs and all the genes for the young. The baby fish are basically clones of the mother fish.

When fish spawn, many fish come to the same place. They all release their eggs and sperm in the same area of water. With luck, a sperm and egg unite so that fertilization occurs. Since fish don't usually know which offspring are their own, they don't take care of their eggs or the young after hatching. Since fertilization and the development of fish embryos leave so much to chance, fish produce hundreds of eggs and sperm. This increases the chance of baby fish surviving to adulthood.

Fish gestation varies depending on the type of fish. In all fish, eggs are soft, instead of hard like chicken eggs. The fertilized fish eggs hatch into larvae with an egg yolk sac attached. The larvae look different from the adult fish. The larvae use the egg yolk for nutrition as they develop. They go through a metamorphosis, changing to their adult form. Fish eggs can be gestated in different places. For instance, some fish, such as the catfish, use mouthbrooding to carry and hatch the young. Other fish larvae, like salmon, hatch in the water near the spawning site without the parents nearby. Finally, some fish, such as the guppies, fertilize and carry the eggs inside the mother's body until she produces live baby guppies. **Figure 6.36** shows a fish larva.

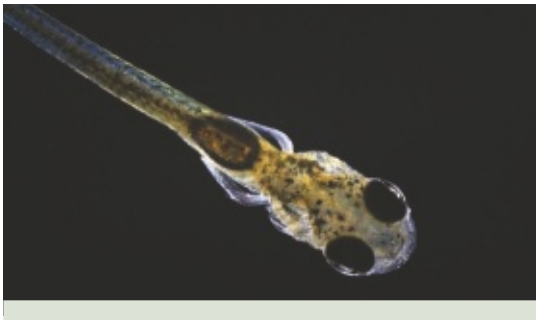


Figure 6.36 Fish Larva This larva will change as it matures into adulthood. *How is it different from an adult fish, and how is it the same as an adult fish?*

Reading Check

Compare and **contrast** fertilization, embryo development, and birth in poultry and fish.

6.2 Animal Biology Review

After You Read

1. **Make** a table that lists and describes the primary functions of the 10 systems in an animal's body.
2. **Describe** differences in the skeletal systems of mammals, birds, and fish.
3. **Explain** what happens during proestrus, estrus, metestrus, and diestrus.
4. **Describe** the fertilization process and explain how it differs in mammals and birds.
5. **Describe** what happens during each of the four phases of mammalian birth.
6. **Describe** the six phases of poultry hatching.

Online Explorations

Sharpen Your Animal Observation Skills

Look for online animal anatomy tutorials or free practice content to sharpen your anatomy and physiology identification skills.

6.3 Animal Breeding and Genetics

Genes and Traits

How do genes and traits impact what offspring will look like?

What makes each animal look like its species, yet also appear unique? Why do some horses have white legs? Why do some cows have curly hair on their faces? The answer to these questions lies in the genes inherited from their parents. Genes are the blueprints or plans that determine what an animal looks like. Genes also affect disease resistance, reproductive ability, and even behavior to some extent. Animals receive genes from their parents. If a gene is dominant, the animal will typically display that trait. So, that means the other gene inherited from the other parent is not dominant and the trait will not be seen in the animal. For instance, the Hampshire pig breed is black with a white band around its middle. The color pattern is dominant, so the piglets generally have that pattern when they are born. You will learn details about animal production for the major farm animal classes in Chapter 7: Animal Production. **Figure 6.37** illustrates some of the traits that are determined by genes of a species.

Figure 6.37 Hampshire Pig The pig inherited its color pattern from its parents. *What traits of the pig might have been determined by the genes it received from its parents?*

Vocabulary

Content Vocabulary

You will learn these content vocabulary terms in this section.

- Accuracy of selection
- Additive genetic variation
- Artificial Insemination (AI)
- Cloning
- Crossbreeding
- Gene targeting
- Generation interval
- Inbreeding
- Pedigree breeding
- Preservation breeding
- Selection intensity
- Selective breeding
- Somatic cell nuclear transfer (SCNT)
- Standard deviation
- Transgenic

Different breeds of animals were intentionally created so that genes for specific traits were inherited consistently throughout generations. People who want to maintain or increase a specific trait in animals select animal parents who have that trait. For example, if a farmer wants to raise cattle that gain weight faster, then the parent cow and bull need to be animals with the trait of efficiently gaining weight. However, some diseases are also inherited through genes, so producers must avoid breeding animals that carry those diseases. For instance, Arabian horses may carry the Lavender Foal disease. This disease limits involuntary and voluntary muscle movements and causes death shortly after birth. The foals are also lavender in color. Breeders of Arabian horses use DNA testing to identify animals with the gene and avoid using them in their breeding programs.

Reading Check

Summarize the relationship between genes and traits.

Animal Breeding Methods

When animals are mated (bred), several breeding methods can be used. Each method has benefits and disadvantages that must be considered. Some methods work better in specific species. Each breeding method has different intentions behind its use, with particular issues. Some methods are used more often with certain species.

In pasture breeding with farm animals (horses, cattle, sheep, goats, llamas), the farmer leaves the male animal with a herd of females in a pasture. The animals are left for several months to a year to mate as female heat cycles occur. Humans may check on the animals, but animals are largely left alone in the pasture. People raising cattle, sheep, or chickens tend to use pasture breeding the most. The method is also popular with people raising animals on organic farms. The offspring of this group may have similar traits since they have the same father. However, there are fewer offspring nationally with the same trait since fewer females are placed in a group. Problems to consider with this method include injury to either male or female animals from the mating. There may also be injury or death from other causes to the animals while they are in the pasture. Farmers may want to consider the unique issues of the method. This includes the unknown breeding dates of the female. There may also be uncertainty about whether the females are even pregnant. Sometimes, male animals may not accept the female who is added to the group after the group is formed. Additionally, the animals can transmit disease among the group since they are in close contact with each other.

The next method is known as natural breeding. This method is commonly used with horses. In this method, the human handlers have more control over the males and females during mating experiences. The handlers bring males and females together in a safe space. A person may observe them for injuries during mating. A handler may quickly remove one of the animals from the setting after they mate. This prevents further chances of injury to either animal. A wider selection of males for mating increases variation among offspring. Differences among the young also increase with the number of females mating with a single male. Using this method, breeders can increase the number of females that a male can cover in a year compared to pasture breeding. While this method can be safer for animals than

pasture breeding, there are possible problems to know about. Problems can include injury to the people handling mating animals. Injury can occur to either male or female animals during mating. This method also takes careful observation to catch the female during ovulation. This ensures the female and male are on the same farm for mating at the right time. With this method, the main issue stems from some animals struggling to adapt to mating around people or in artificial conditions.

The third method is the use of **Artificial Insemination (AI)** for mating animals. With this method, semen is collected from the male animal by a human. The semen can be used immediately or refrigerated until needed. When it's used, the semen is inserted into the female's reproductive tract by a human using special tools. AI is most often used with horses, cattle, swine, and sheep. Offspring variation decreases with AI since certain males are favored by breeders. The same male animals may father many offspring. This is especially true when the semen is transported across the nation or across countries. So, the same traits are seen repeatedly among many offspring. While this method has advantages in reducing risk to the mating animals, a few problems must be managed. Problems include injury to either male or female animals during the collection or implantation process. Human handlers can also be injured during the collection or implantation processes. Also, semen loses potency during storage or transportation. A major consideration with this method is ensuring proper temperature for the storage of semen from horses, swine, and poultry. Cattle semen doesn't seem to have as many issues with storage. The second major issue is the transmission of disease across hundreds of females if the semen is contaminated with disease.

Managing the mating of large herds of animals, especially cattle, can be difficult when the cows ovulate at different times in the month. Even using the AI method, scheduling the veterinarian with semen available for cows on the right date of ovulation can be difficult. So, some people are using the concept of in-sync breeding or estrus synchronization. In this method, farmers give the cows a series of hormones to bring their ovulation cycles into the same pattern. This allows more efficient use of time and resources when moving bulls between different farms or when using AI. This also means the cows will have their calves at about the same time. The calves can be weaned at the same time and housed together with the same feed. The calves are ready for the next phase of production together. These practices increase the efficiency of time and resources. More than 60 percent of dairy cows are bred this way, while only about 5 percent of beef cows have AI used for reproduction. **Figure 6.38** shows the technology tools sometimes used in the field for AI.

Figure 6.38 AI of a Cow A veterinarian prepares the tools used for AI for a cow. *How might this AI practice increase the efficiency for cattle breeders and veterinarians?*

Factors to Consider When Planning Breeding Programs

When planning to breed animals, several factors need to be considered. First, what is the objective of breeding these particular animals? What trait do you want to preserve or increase? For instance, are you interested in increasing the weight your cows gain before going to market? If so, then you will want to look for male animals who are known to produce calves that gain weight quickly. Another example would be producing goats of a particular color. You would look for male goats whose young are consistently born with the colors you want.

One method to consider when choosing mates for animals is **selection intensity**. This means considering both the negative traits that you don't want to see in the offspring, as well as the positive traits you desire. Choosing males with dominant positive traits to counter negative traits in the female means you are using selection intensity. For example, if you are raising dairy cattle, you want cows who produce greater amounts of milk. So, you will want to breed cows who are heavier milk producers to bulls whose daughters are good milk producers. Then, that trait should be passed along to their offspring. We also must consider the **accuracy of selection**. So, if a male animal is not known for reproducing specific traits very often, this animal would not be a likely candidate for your female animals. If the example is about the dairy cow, you would not want to choose a bull for your cow if the bull produces more male calves. The bull does not have the accuracy of selection.

We must also consider **additive genetic variation**. For example, if you are raising goats, you want to have a variety of males that are mated to your female herd in different years. Using this practice means the offspring have more diversity in their genes, which decreases the chances of offspring mating who are too closely related in their genes. We can use **standard deviation** to examine the number of offspring from a specific parent animal that show the desired trait. This helps us determine how likely the trait will be exhibited in our potential young animals. Standard deviation is a measure of the amount of variation in a set of numbers. The numbers represent the offspring with the desired trait. Mating young male animals who show excellence in their traits may increase the number of young they produce with those traits, especially when using AI.

When choosing animals to make, study all the genes that may affect a particular trait in the offspring and the **generational interval**. This is the space between related generations. It affects the speed of genetic changes. Animals like rabbits, which mature and reproduce by six months, have a shorter general interval. So, genetic changes in related animals can occur quickly. More genetic variation in traits can be seen in shorter time spans. However, horses have a longer generational interval. They may not reproduce until they are about three to four years old. That makes the generational interval longer. The female parent horse needs time to mature, nearly a year to carry a foal, and another three to four years for the young to mature for reproduction. So, the equine generational interval takes about six to eight years. Their genetic change is slower, and the variation in traits is slower to occur.

Breeding Systems

When planning to mate a female animal, the farmer needs to consider which breeding program will provide the desired results. Five specific programs each offer benefits under different circumstances. Whether we have one animal or

hundreds for breeding, we want to choose the program that builds upon the traits we desire but also reduces undesirable traits in the breed and species.

- **Pedigree breeding** uses a document showing a particular animal's parents and other ancestors. The document shows the family tree of the parents. Knowing the pedigree allows a farmer to see how closely related potential mates may be. Mating closely related individuals can also increase the risk of inherited diseases or negative traits being passed along to the offspring. Purebred animals registered with a specific breed association can trace their pedigree back for many generations. Pedigree breeding means that animals are chosen to pass on desirable traits consistently. Llamas are a species in which pedigree breeding is used. Breeders can track parent animals who pass along desirable traits, as well as avoid parent animals who produce offspring with undesirable traits, such as animals who are excessively nervous.
- **Selective breeding** is the process of planning matings between animals that have the desired traits in the breed. AI increases the efficiency of mating for desired traits. Hundreds or thousands of females can be mated using stored semen from one male animal. However, this process tends to focus on traits wanted by humans rather than the traits that are most helpful for animal species. For instance, Quarter horses were expected to have very large muscles, although this resulted in using only a few select male horses. These male horses also passed along a genetic disease that causes severe muscle spasms at certain times. In many species, breeders have become more conscientious about selective breeding than they were in the past. People have recognized the unfavorable outcomes of focusing on just one or two traits in a species.
- **Crossbreeding** means mating animals of two different breeds to produce offspring with the most desirable traits of each breed. Sometimes this creates a whole new breed, such as the Goldendoodle dog. Their ancestors were Golden Retrievers and Poodles. Hybrid vigor is the concept of mating two animals of different breeds to gain the best traits of the two breeds. This is more common in cattle and may result in improved feed efficiency, adaptability to different climates, longer lifespans, etc. Breeds resulting from this method created the beefalo (beef cattle and buffalo) and the Brangus (Angus and Brahma breeds).
- **Inbreeding** results from mating animals who are very closely related, such as brother and sister. This can result in problems with health and behavior. The offspring have too many similar genes. Inbreeding is the opposite of genetic variation. However, this method of inbreeding can also intensify preferred traits, such as the extra-large wings and breasts in many modern chickens. The extra-large wings and chicken breasts are desired since they have more meat.
- **Preservation breeding** means trying to maintain the pureness of breeds. This method benefits breeds with few living individuals. The focus is to keep the form and function of the original breed rather than breeding to meet the latest fad in the show ring or demand by the public for a certain look in the animal. The Collie dog breed is an example of that issue. The fad was for Collies to have very narrow heads, which reduced the size of the brain. Now, Collie dog breeders are trying to increase the head and brain size of Collies to preserve the unique abilities of the breed. This method may also apply when trying to maintain a breed that is in danger of extinction, such as the Navaho-Churro sheep breed.

Since male animals can produce many offspring in one year, attention is given to marketing the most desired males to people who own female animals of that species. People who have male animals that will be used for mating must consider the most appropriate information when advertising their males. The most desired traits of the male animal should be emphasized, as well as the pedigree of the male during marketing. If the male animal has a show or racing record, the information will be highlighted in promoting the desirability of the male. Likewise, if the male animal is a known producer of quality offspring, the offspring can be highlighted in advertising materials. Marketing the male animals to owners of female animals begins several months before the typical mating season of the species and continues throughout the entire breeding season. For instance, horse owners will begin advertising the male horses during the winter. This allows owners of female horses to compare traits and fees for mating before the female horses are ready to mate in the spring. Advertising continues into the summer. People with male animals may advertise online at breed or activity websites in addition to local and state newspapers and magazines, and at breed shows and sales.

Reading Check

Briefly define the five main animal breeding techniques.

Animal Breeding Technologies

What techniques are currently being used in farm animal breeding?

Animal breeding uses modern technology to increase the breeding efficiency of animals. Modern technology can also help overcome reproductive problems in male and female animals. Modern technology includes the use of the electron microscope, sequencing of species' DNA gene maps, as well as direct manipulation of the egg and sperm cells in the laboratory. Assisted reproduction is the term given to techniques using modern technology. Several techniques are used to improve issues with livestock.

The first technique, embryo transfer/implantation, allows a female animal with excellent traits to reproduce more than normal. The eggs are harvested from her body, fertilized, and placed into surrogate female animals for gestation. So, females who are used in the show ring or in training programs can continue with their work. They don't need time off for repeated visits with the male animal, nor lose fitness during pregnancy. This technique is especially important in the equine world with rigid training, showing, and racing schedules to follow. **Figure 6.39** shows a medical researcher using tools in assisted reproduction processes.

Figure 6.39 Medical Research Laboratory tools used in new techniques of animal breeding. *Which of these laboratory tools can you identify?*

In the technique known as multiple ovulation, female animals are given hormone injections to stimulate more egg production than normal. More young animals can be produced each year with the desired parent genes. The technique is used more often with dairy cattle. Cows that are large milk producers can increase the number of calves they produce each year. However, multiple ovulation injections are not used very often with horses, as mares have more difficulty carrying twin foals to term. Additionally, sheep and goats may naturally produce twins or triplets, so multiple ovulation injections are not used frequently.

Some female horses may not ovulate regularly. Giving hormone injections helps to regulate ovulation in female horses. The injections streamline the breeding process and reduce time and effort. With regular hormone injections, planning matings and veterinary attention is easier for equine breeders. Additionally, the hormone regulating injections can also be used with mares (female horses) who become very unruly during their ovulation cycle. The hormones help stabilize their cycles and calm their temperament. In that situation, hormone injections can be used even if the mare won't be bred.

Another use of modern technology is to manage reproductive disorders of animals. Aging animals past reproductive age can benefit from technology-based techniques to stimulate egg cell production. The technique can support superior animals who were infertile or unable to reproduce with egg cell production. With the aid of technology, parent animals can provide their genes to their young animals.

Modern technology is also useful when specific genes of the parent animal need to be fixed. The technique used in this case is **gene targeting**. With gene targeting, the egg or sperm cells are removed from the animal. In a laboratory, the gene is modified inside the cell. The scientists modify these genes with problems to create offspring that don't have that genetic problem. Then, the sex cells are placed into a female animal for gestation. A technology used in gene targeting is known as CRISPR. Using precise technological tools, scientists can edit or cut specific genes in the egg or sperm cells. They may use this method when certain changes need to be made in the animal's DNA in order to prevent a health issue or to increase muscle mass or hair growth.

The cattle industry is also using sexed semen to produce wanted offspring. For example, the dairy industry prefers female calves who can become dairy cows, producing calves and milk. However, the beef industry prefers bull calves since they gain weight faster.

Most people have heard about **cloning** animals. The first animal cloned was Dolly, a sheep, in 1996. Since then, dogs, rabbits, horses, cows, and deer have been cloned. Cloning an animal means that an exact genetic copy of an animal is created. However, the cloned animal may be slightly different in behavior due to its life experiences. Two techniques can be used for cloning. The first involves splitting a fertilized embryo in half and placing both halves back into the mother animal. The resulting babies look like twins, but they have the same genes.

Figure 6.40 shows the body of Dolly, the first cloned animal, on display in Scotland.

The other technique for creating a cloned animal involves using **somatic cell nuclear transfer (SCNT).** In SCNT, the nucleus of one sex cell is removed and replaced by the nucleus of another animal's cell. This creates a clone cell with genetic information in the new nucleus. This can be used to clone animals, for research into the survival of cloned animals, or to fix damaged genes. The cloned animal that is born is known as a **transgenic** animal. Transgenic animals have been created in cattle, sheep, goats, horses, and swine. The technique has also been used to try to create new animals from endangered species, such as Przewalski's horse breed and the Enderby Island cattle breed.

Figure 6.40 Dolly the First Cloned Animal Dolly lived for six and a half years before being euthanized with a lung infection. *What would you expect her mother to look like and why?*

Cloning animals is very costly and trained technicians and specialized equipment are needed. Additionally, time is needed for the egg cell to grow into a young animal ready for birth. Many factors affect the success rate of embryos.

Through all these techniques, people take direct control of changing the genes of animals much faster than if animals reproduced naturally. The use of this technology is controversial. Some people feel it isn't right to make nature work faster or differently. They believe animals should be allowed to reproduce naturally at their normal pace. Also, some breed registry organizations will not allow certain assisted reproduction techniques to be used. Check with your breed registry for information on disallowed assisted reproduction techniques in raising animals for show or for sale.

Reading Check

Identify why transgenic and cloning technologies are different from traditional animal breeding techniques.

6.3 Animal Breeding and Genetics Review

After You Read

1. **Explain** how genes affect animal traits.
2. **Describe** the five main animal breeding techniques and when they are typically used.
3. **Describe** animal breeding technologies, why they are used, and why they are considered controversial.

Online Explorations

Exploring Animal Cloning

Research new developments and trends in animal cloning.

Chapter 6 Review

Chapter Summary

Section 6.1

- Animal science focuses on the science and business of raising and caring for domestic farm and specialty animals.
- Domestic farm and specialty animals are produced and kept by people for food and fiber production, companionship and recreation activities, sporting endeavors, and therapy uses.
- Animal science is a key industry for the nation in terms of the money generated by livestock, their products, and their byproducts.
- The United States is a leading producer of beef, poultry, pork, dairy products, and eggs for the world.
- States produce specific animal species due to the abundance of natural resources needed by the animals or the ease of transporting animal feed and animals to food production facilities.
- The types of agricultural facilities in the nation vary from small homes with a single animal or small flocks to large corporation-owned operations responsible for producing thousands of animals for human food uses, as well as the feed for these animals.

Section 6.2

- Farm animals have ten major body systems, composed of specific organs, with the body systems differing depending on the animal's class, such as mammal, bird, or fish.
- The body systems of animals and their external structure developed over time based upon the species' needs for survival in the wild, the species' place in a particular environment, and the food that was available for them.
- All body systems are made of animal cells, with many cells having specialized functions in the body tissues.
- The skeletal and muscular systems of animals have adapted to the species' roles on land, in the water, or in the air. Bone placement and weight vary based on the natural environment of the species.
- The nervous systems of animals control their responses to their environment, as well as directing other body systems to release hormones at specific times, such as during puberty or in response to stress.
- The cardiovascular and respiratory systems have adaptations that enable certain animal species to survive using oxygen from either air or water.
- The digestive, excretory, and reproductive processes of mammals developed in response to their needs on land, the types of food they eat, and the production of live young. Mammal digestive systems are adapted for survival needs, developing from one to four stomachs to manage the digestion of varied types of roughage.

- Birds developed digestive, excretive, and reproductive processes based upon their need for swift flight. Female birds' ability to lay eggs nearly daily aids them in reproduction but is also used by humans as a food source.
- The digestive, excretory, and reproductive processes of fish evolved due to their adaptation to life in water. Fish use multiple methods to produce large numbers of eggs as a survival mechanism for the species.

Section 6.3

- Animal production uses several breeding techniques, including pasture breeding, natural cover, and AI.
- When considering the mating of animals, people must examine both the desired and undesired traits of the parent animals to determine the best males and females to mate. The goals of a breeding program may depend upon the use of crossbreeding, selective mating, pedigree examination, or preservation of a species.
- Modern technology techniques support agricultural producers in increasing the breeding effectiveness of farm animals and reducing issues with the reproduction of desired genes.
- The use of modern technology for animal reproduction offers benefits, but it is also controversial, as humans modify the genes of animals rather than allowing them to mate naturally. The creation of cloned or transgenic animals may offer solutions for endangered species.

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