

Sixth Edition

INTRODUCTION TO

Animal Science

Global, Biological, Social, and Industry Perspectives



 Pearson

W. Stephen Damron

INTRODUCTION TO ANIMAL SCIENCE

GLOBAL, BIOLOGICAL, SOCIAL,
AND INDUSTRY PERSPECTIVES

SIXTH EDITION

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*For my wife, Rebecca, and our children, Joshua and Aubryana.
I am truly blessed.*

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Preface

This book provides a text for introductory courses in Animal Science. The individual disciplines that combine to become the whole of Animal Science and how the science of each contributes to the whole are included. There is information on how to feed, manage, breed, and care for animals. Because the scope of Animal Science is so broad, this book examines how animals fit into all of society and how they contribute to the well-being of humans from a worldwide perspective. The text takes a brief tour of agriculture across the globe, exploring the many uses of domesticated animals. Dedicated chapters individually consider the species of primary importance to humans. This text also discusses the industries that have arisen around those species and their effects on our society and our economy.

In the last 70 years or so, profound changes have taken place in the animal industries. Traditional animal husbandry has been joined by business interests and profound scientific and technological advances to produce new approaches to animal production and care. Changes in the tastes, preferences and habits of consumers, economic considerations, and the relative costs of animal products have all contributed to restructuring of the animal industries. The animal industries are assuming the role of dynamic, integrated parts of a greater food-providing system that is increasingly international in scope. Those changes and their implications are explored in this book.

This text also acknowledges changing viewpoints toward the animals in our care. Concerns over animal welfare, animal rights, food safety, biotechnology, ethical resource allocation, sustainability of agriculture, and other issues now increasingly affect animal use in a very real way. These issues and others are explored in this text.

A more affluent population has reached for new animals and new uses for animals, and consequently has turned to animal scientists to demand information. This text provides information concerning llamas, companion animals, and other species not traditional to the animal sciences. These species are now a part of Animal Science as surely as are the cow, horse and pig.

Written with sufficient flexibility, this text accommodates the three major approaches to Animal Science—the biological approach, the industry approach, and the species approach. The worldview information from Part One and the societal issues from Part Four round out all approaches.

Beginning with its first edition, this book has had a distinct educational philosophy and a novel approach to the learning. The cornerstone of that approach is relevant and timely information written in a style that is student-friendly. This 6th edition is updated and improved but retains that same student-centered philosophy. Those who used the earlier editions will quickly find all the aspects previously contained, including the “flavor.”

NEW TO THIS EDITION:

- There are many new figures and redesigned and updated graphics.
- Margin terms and glossary terms are enhanced facilitating reading and understanding of the material.
- All chapters are updated with current statistical information as appropriate.
- Notable in this edition are improvements to the lactation chapter, the animal health chapter and to the animal health sections in each of the species chapters.



- The biotechnology chapter is substantially updated as were the nutrition chapters, especially sections on challenging concepts.
- Material on food safety is enhanced for this edition.
- To make room for all the new images and graphics, and because of the increasingly easy access to information via the Internet, this edition sees continued simplification of tables with greater emphasis on example information rather than on information per se.

To access supplementary materials online, instructors need to request an instructor access code. Go to www.pearsonhighered.com/irc, where you can register for an instructor access code. Within 48 hours after registering, you will receive a confirming e-mail, including an instructor access code. Once you have received your code, go to the site and log on for full instructions on downloading the materials you wish to use.



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part one

The Place of Animals and Animal Science in the Lives of Humans

CHAPTER 1 Introduction to the Animal Sciences

CHAPTER 2 The Value of Animals to Humanity

CHAPTER 3 Factors Affecting World Agricultural Structure

CHAPTER 4 Worldwide Systems of Agricultural Production



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Introduction to the Animal Sciences

Key Terms

Agriculture	Farmer
Animal behavior	Genetic code
Animal breeding	Genetics
Animal health	Green revolution
Animal science	Heredity
Biofuel	Hunter-gatherer
Biometry	Livestock revolution
Biotechnology	Meat
Civilization	Meat science
Culture	Nutrient density
Dairy product science	Nutrition
Diet	Omnivore
Domestic animals	Physiology
Draft animal	Renewable resources
Essential amino acids	

INTRODUCTION

Animals. We live with them, worship them, consume them, admire them, fear them, love them, care for them, and depend on them. They are part of our sustenance, our sociology, and our day-to-day lives. Because they are so important to us, we also study them and apply what we learn to improve their lives and enhance their roles in our lives. The branch of science that deals with domestic animals is **animal science**, which is the topic of this book.

Much of our use for animals revolves around their contributions to our food supply. To coax a more stable food supply from the land, humans developed a complicated resource management system called **agriculture**. In agriculture, **domestic** plants and animals are kept to produce for humankind's needs. Humans have practiced agriculture for thousands of years and, either directly or indirectly, every person on the planet depends on agriculture for his or her daily food (Figure 1-1). Because this is true, it is also ultimately true that all of humankind's other occupations are tied to agriculture. This is especially the case in the world's developed countries. In fact, the entire urban industrial complex of the developed world is sustained only because of food surpluses generated by agriculturists.

Learning Objectives

After you have studied this chapter, you should be able to:

- Define *animal science* and all of its component parts.
- Describe how, why, and when domestication occurred.
- Give an overview of the distribution of agricultural animals worldwide.
- Explain to a nonagriculturist the contributions of domestic animals to humankind and the value of studying animal science.
- Describe the worldwide livestock revolution and its implications.

Animal science The combination of disciplines that together comprise the study of domestic animals.

Agriculture The combination of science and art used to cultivate and grow crops and livestock and process the products.

Domestic Those species that have been brought under human control and that have adapted to life with humans.

**Figure 1-1**

Bolivian farmers cultivating potatoes on old Incan terraces. They use the same tools as those used by their ancestors. (Roberto Faidutti/ Food and Agriculture Organization of the United Nations.)



Culture In this context, culture refers to the set of occupational activities, economic structures, beliefs/values, social forms, and material traits that define our actions and activities.

Hunter-gatherer Hunter-gatherer people support their needs by hunting game, fishing, and gathering edible and medicinal plants.

Farmer Anyone who practices agriculture by managing and cultivating livestock and/or crops.

Civilization In modern context, this refers to what we consider a fairly high level of cultural and technological development.

Humans have found many other uses for domestic animals in such areas as sports, recreation, manufacturing, religion, scientific research, and as companions. Add these uses to food production and we discover that animals are at the core of virtually all of our lives, whether or not we are aware of it. Because agriculture and its animals are integral to our existence, they have become a dominating part of our **culture**, our influence on the landscape, and, either directly or indirectly, our day-to-day activities.

Exactly when individual animal species were domesticated is unknown. DNA sequencing technology suggests that the dog was domesticated from a now extinct wolf as long as 30,000 years ago, but archaeological evidence suggests that the dog was domesticated about 14,000 years ago (12000 B.C.). The earliest domestic food animal species (as most Westerners currently define it) was the sheep (somewhere around 8000 B.C.), followed by goats, pigs, and cattle (6500 B.C.); llamas (5500 B.C.); horses (3500 B.C.); donkeys (4000 B.C.); reindeer (3000 B.C.); and chickens (6000 B.C.). *Note:* This is a very active area of research with other dates being proposed for all species.

Humans did not plan their dependence on the animals they tamed and then domesticated. **Hunter-gatherers** (who first domesticated animals) used the meat, bones, and skins just as they had done before domestication. The only difference after domestication was convenience. The additional uses (milk, clothing, power, war, sport, and prestige) came later. This happened after people had lived in the company of animals for a long time in a more sedentary lifestyle.

Humans had hunted and consumed animals for 2 million years before domesticating them. The behavioral change required for hunters and gatherers to become **farmers** was a major cultural revolution and a major step toward what we call **civilization**.

With our acquisition of domestic animals came the need to ultimately manage them, care for them, and learn to use them to our best advantage. Meeting those needs led to the development of the discipline of study that we call animal science.



ANIMAL SCIENCE SPECIALTIES

Animal science is simply the collective study of domestic animals. This includes every aspect, from conception to death, behavior to management, physiology to nutrition, and reproduction to product distribution. Animal science represents an accumulation of knowledge that began with observations of those hunter-gatherers who began the process of domestication long ago. As animal scientists have learned more and more about animals, the accumulated wealth of information has become too large for any one person to comprehend completely. Out of necessity, its study is divided into disciplines, or specialties, as a means of creating manageable pieces. These specialties may be broken down several ways, but the following categories illustrate the point:

- **Genetics** is the science of **heredity** and the variation of inherited characteristics. **Animal breeding** is the use of **biometry** and genetics to improve farm animal production. Genetics is an expanding field due largely to steady progress in deciphering the **genetic code**.
- **Nutrition** is the study of how organisms take in and use food/feed for body needs. Whether or not animals develop their genetic potential depends on their environment. The most important environmental factor is feed. Nutrition is the science that combines feeds with feeding management to bring about the economical production of livestock and/or health and long life to animal companions.
- **Physiology** is the study of the mechanisms of life from the single biochemical reactions in cells to the coordinated total of specialized cells that constitute a living animal. Because physiology is complex, we usually break down the study to the workings of physiological systems. Examples include reproductive physiology, renal physiology, and exercise physiology.
- **Animal health** is the study of how diseases, parasites, and environmental factors affect productivity and animal welfare. Disease is defined as any state other than a state of health.
- **Animal behavior** and welfare developed along with the livestock industry's increased dependence on confinement rearing systems, which provide greater control over animals, reduce labor and feed costs, and help maximize genetic potential. Animals in these systems often present problems in their behavior. It includes animal welfare assessment, optimizing production, behavioral control, behavioral disorders, and behavioral genetics.
- **Meat science** deals with the handling, distribution, and marketing of finished meat products. **Meat** is defined as the edible flesh of animals that is used for food. Meat by-products are all of the products other than the carcass meat, some of which are edible and some of which are not.
- **Dairy product science** deals with the collection, handling, and marketing of milk in its many forms to the consuming public.
- **Biotechnology** involves technological applications of biology. This discipline has received new attention in animal science because of recombinant DNA. Each of the other disciplines of animal science has benefited from biotechnology and will continue to do so at an ever-increasing rate.

Certainly, tremendous overlap occurs in these areas, and separations are made for our convenience. However, this convenience can also be a hindrance. By breaking the discipline of animal science down into smaller units, we have made it easier to learn but harder to grasp—we know the pieces of the puzzle better, but it is harder to put the pieces together. Always remember that it is the combination of the specialties that constitutes the whole discipline of animal science.

Genetics The science of heredity and the variation of inherited characteristics.

Heredity The transmission of genetic characteristics from parent to offspring.

Animal breeding The use of biometry and genetics to improve farm animal production.

Biometry The application of statistics to topics in biology.

Genetic code The set of rules by which information encoded in genetic material (DNA or RNA sequences) is translated into proteins (amino acid sequences) by living cells.

Nutrition The study of nutrients and how the body uses them.

Physiology The study of the physical and chemical processes of an animal or any of the body systems or cells of the animal.

Animal health The study and practice of maintaining animals as near to a constant state of health as is possible and feasible.

Animal behavior The study of animal welfare assessment, optimizing production, behavioral control, behavioral disorders, and behavioral genetics.

Meat science The science of handling, distributing, and marketing meat and meat products.

Meat The flesh of animals used for food.

Dairy product science The science of providing milk and milk products as food.

Biotechnology A collective set of tools and applications of living organisms, or parts of organisms, to make or modify products, improve plants or animals, or develop microorganisms for specific uses.



ANIMAL DISTRIBUTION

There are approximately 4.9 billion large farm animals and 22.9 billion poultry distributed throughout the world (Table 1-1). The number of large farm animals has been increasing at an average rate of about 1% annually for several decades. During that time, there have been shifts in the size of individual species populations and their worldwide

Table 1-1
AGRICULTURAL ANIMAL NUMBERS IN THE WORLD

	World Total	South America and the Caribbean	North and Central America	Oceania	Africa	Europe	Asia
Large Farm Animals							
Cattle (head) ¹	1,443,524,363	360,916,613	148,659,089	39,925,338	277,049,952	122,169,914	494,803,457
Sheep (head)	1,149,162,250	71,106,969	15,349,172	104,927,966	295,881,039	129,195,959	532,701,144
Pigs (head)	978,658,479	67,039,665	100,146,080	5,272,389	33,778,271	183,900,028	588,522,048
Goats (head)	962,157,224	24,029,643	11,551,707	3,974,641	330,073,129	16,835,657	575,692,446
Buffalo (head)	193,566,739	1,311,421		177	4,013,083	397,909	187,844,149
Horses (head)	58,257,819	14,533,149	17,943,100	405,617	5,455,855	5,720,269	14,209,829
Asses (head)	43,430,035	3,404,666	3,385,793	9,000	19,412,278	512,367	16,705,931
Camels (head)	24,136,822				20,032,028	7,475	4,097,319
Mules (head)	10,246,096	2,445,779	3,459,308		989,763	231,659	3,119,587
Other camelids (head) ²	8,829,374	8,829,374					
Total	4,871,979,202	553,617,279	300,494,249	154,515,127	986,685,399	458,971,238	2,417,695,910
Rabbits and Rodents³							
Rabbits (1,000 head)	742,033	4,334	1,370		18,619	107,104	610,607
Other rodents ⁴ (1,000 head)	18,925	18,925					
Poultry							
Chickens (1,000 head)	20,900,629	2,563,005	2,805,118	127,004	1,770,811	2,084,806	11,549,844
Ducks (1,000 head)	1,156,821	9,663	17,344	1,428	27,744	87,627	1,013,014
Geese and guinea fowl (1,000 head)	336,872	430	343	81	25,283	19,907	290,828
Turkeys (1,000 head)	467,236	64,799	253,272	1,374	22,967	111,784	13,039
Total (1,000 head)	22,861,558	2,637,898	3,076,078	129,888	1,846,806	2,304,124	12,866,570
Insects							
Beehives (number)	79,948,916	5,518,533	5,497,377	700,409	16,329,648	16,607,379	35,295,570
Silkworm cocoons (MT)	563,034	2,886			160	930	559,058

Source: Food and Agriculture Organization of the United Nations, 2016, <http://faostat3.fao.org/download/Q/QA/E>. Reproduced with permission.

¹Includes yaks.

²Includes both llamas and alpacas.

³Producing animals slaughtered.

⁴Primarily guinea pigs.



Table 1-2
CONTRIBUTIONS OF ANIMALS TO HUMAN SOCIETIES

Food

Eggs	Blood
Meat	Fat
Milk	Edible slaughter by-products

Body Coverings

Wool
Leather, pelts, hides
Hair, fur, feathers

Work

Draft and other labor
Transportation

Body Wastes

Fuel	Construction material
Fertilizer	Animal feed

Other Uses

Income	Religion and other cultural needs
Storage of capital	Slaughter by-products
Storage of food	Recreation and sport
Biomedical research models	Pest and weed control
Contributions to the economy	Companionship and service
Buffer for fluctuating grain supplies	Pet foods and treats
Soil fertility enhancement	Conservation
Prestige	

Sources: Compiled from *A partnership for humans and animals* by R. E. McDowell and *Agricultural animals of the world* by E. J. Turman.

distribution. Poultry numbers have increased more rapidly at an average rate of over 5% annually. Until very recently, greater than two-thirds of the large farm animals were found in developing countries, but they produced only about a third each of the meat, milk, and wool produced in the world due to environmental stresses, disease challenges, lack of access to technology, and different objectives of livestock production. However, the world agricultural order is undergoing profound changes, which are causing a greater percentage of the world's livestock to be found in the developing world. In addition, the productivity of the livestock in the developing world is improving dramatically.

Agricultural animals have made a major contribution to the welfare of human societies for millennia by providing a variety of products and services, as shown in Table 1-2. They are a **renewable resource**, and they use another renewable resource—plants—to produce these products and services.

CONTRIBUTIONS OF ANIMALS TO HUMANITY

A detailed look at animal use comes later in this book. This section briefly surveys some of the many contributions of livestock and other animals to humans.

Food Source

Humans are **omnivores**, consuming both plant- and animal-based foods. Figure 1-2 shows the contributions of different food sources to the world food supply. Although food is the most important contribution of agricultural animals to humans, plants

Renewable resources

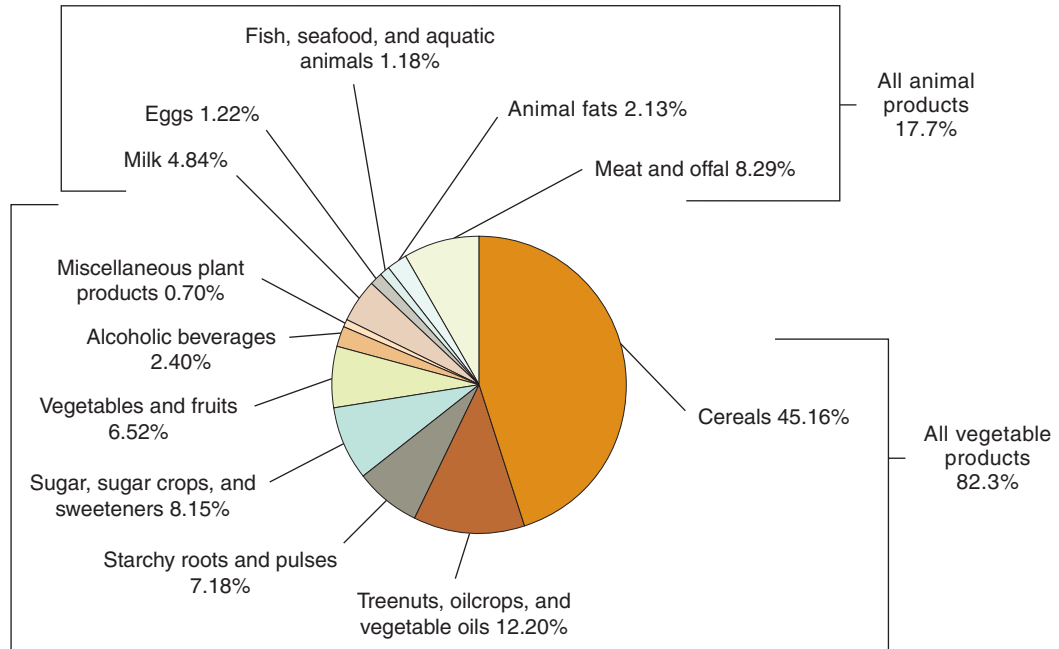
Those resources that can be replaced or produced by natural ecological cycles or management systems.

Omnivore An animal that eats both animal- and plant-based feeds.

**Figure 1-2**

Contributions of food sources to human energy (calorie) consumption.

(Source: Food and Agriculture Organization of the United Nations, 2016, <http://faostat3.fao.org/download/Q/QA/E>. Reproduced with permission.)



supply a greater total quantity of food. Plants supply approximately 82.3% of the total food energy consumed by the world's people, primarily because such a high percentage of the human diet in the developing countries is of plant origin. Animal products supply approximately 17.7%. In developed countries, animals contribute a greater percentage of the total food energy. In the United States, for instance, they provide 27%. Animals are a more important source of protein than they are of calories (Figure 1-3), supplying 40% of the protein consumed in the world. Of the animal protein sources, meat provides approximately 48.4%, milk provides approximately 26%, fish supplies approximately 17%, and eggs supply 8.6%. Developed countries obtain a greater percentage of their total protein from animal products. The United States, for example, gets approximately 66% of its protein from animal products. Table 1-3 shows a more complete picture of the contribution of various foods to the U.S. food supply.

Figure 1-3

Contributions of food sources to human protein consumption.

(Source: Food and Agriculture Organization of the United Nations, 2016, <http://faostat3.fao.org/download/Q/QA/E>. Reproduced with permission.)

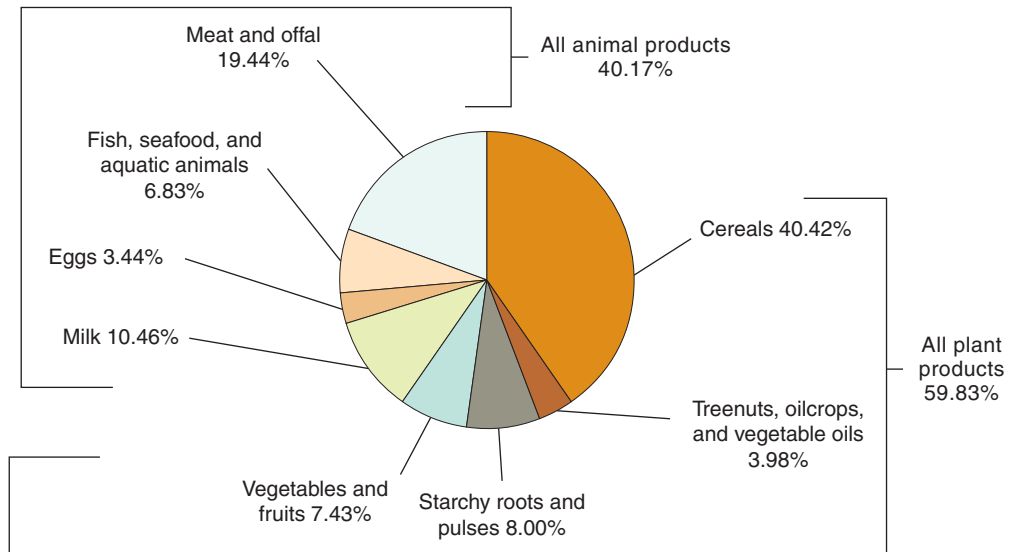


Table 1-3
PERCENTAGE CONTRIBUTION OF FOOD GROUPING TO VARIOUS NUTRIENTS IN THE U.S. FOOD SUPPLY

Nutrient	Meat, Poultry, Fish	Dairy (Excl. Butter)	Eggs	Total Animal	Vegetables	Legumes, Nuts, Soy	Grains	Fruits	Fats and Oils	Sugars and Sweeteners	Misc. ¹
Energy	16	10	1	27	4	3	23	3	23	15	1
Protein	43	19	4	66	4	6	21	1	0	0	2
Total fat	25	12	2	38	0	4	2	1	54	0	1
SFAs ²	29	23	2	54	0	2	2	0	41	0	1
MUFAs ²	28	8	2	38	0	5	1	1	55	0	1
PUFAs ²	12	2	1	14	1	5	4	0	75	0	1
Cholesterol	48	16	32	95	0	0	0	0	5	0	0
Vitamin A	21	22	5	48	33	0	7	3	8	0	2
Vitamin E	4	2	2	8	6	7	4	3	73	0	0
Vitamin C	2	1	0	3	47	0	6	42	0	0	1
Thiamin	18	5	1	24	7	5	60	3	0	0	1
Riboflavin	18	28	5	51	5	2	38	2	0	1	2
Niacin	39	1	0	40	8	4	43	2	0	0	3
Vitamin B ₆	41	6	2	49	19	4	20	6	0	0	2
Folate	3	3	2	8	8	8	71	4	0	0	1
Vitamin B ₁₂	72	23	5	100	0	0	0	0	0	0	0
Calcium	4	72	2	77	6	5	5	2	0	1	4
Phosphorus	27	32	4	62	7	7	19	2	0	0	4
Magnesium	14	14	1	29	12	15	24	6	0	1	14
Iron	17	2	3	22	8	8	51	2	0	1	9
Zinc	42	16	2	60	5	6	25	1	0	0	4
Copper	22	3	2	26	11	20	22	5	0	1	15

Source: *Agricultural statistics*, United States Department of Agriculture.

¹Coffee, tea, chocolate-liquor equivalent of coca beans, spices, and fortification of foods not assigned to a specific group.

²SFAs = saturated fatty acids; MUFAs = monounsaturated fatty acids; PUFAs = polyunsaturated fatty acids.