part one

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

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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	

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.

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.

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/ United Nations Food & Agricultural Organization.)

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 Rodents[3]							
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.
[1]Includes yaks.
[2]Includes both llamas and alpacas.
[3]Producing animals slaughtered.
[4]Primarily 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, 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.)
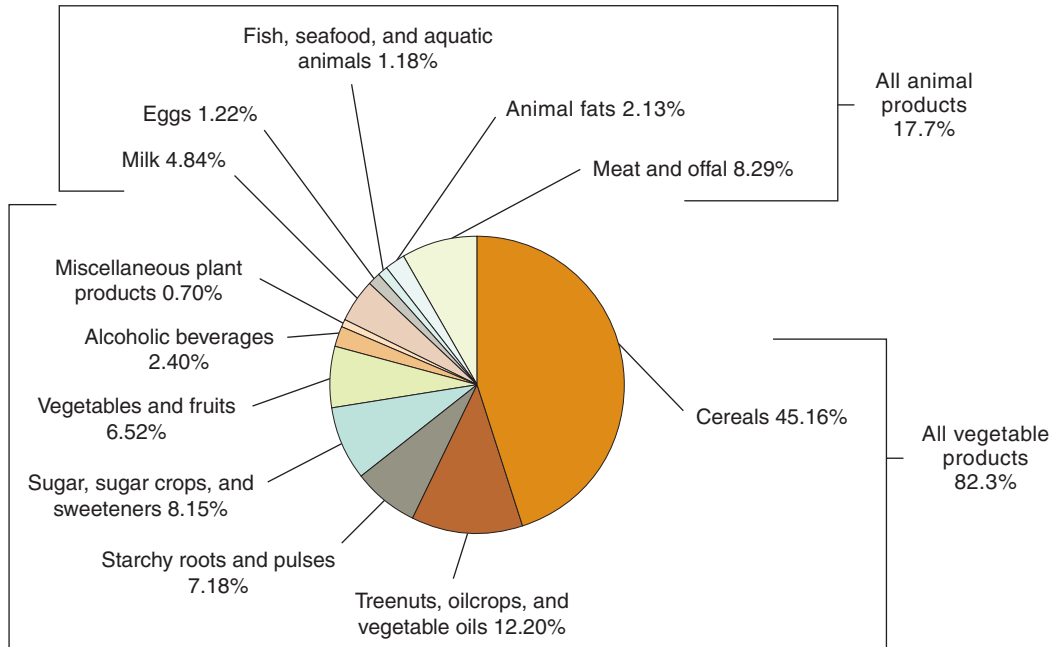

supply a greater total quantity of food. Plants supply approximately 82.3% of the total food energy consumed by the world's people, primarily because such a high percentage of the human diet in the developing countries is of plant origin. Animal products supply approximately 17.7%. In developed countries, 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.)
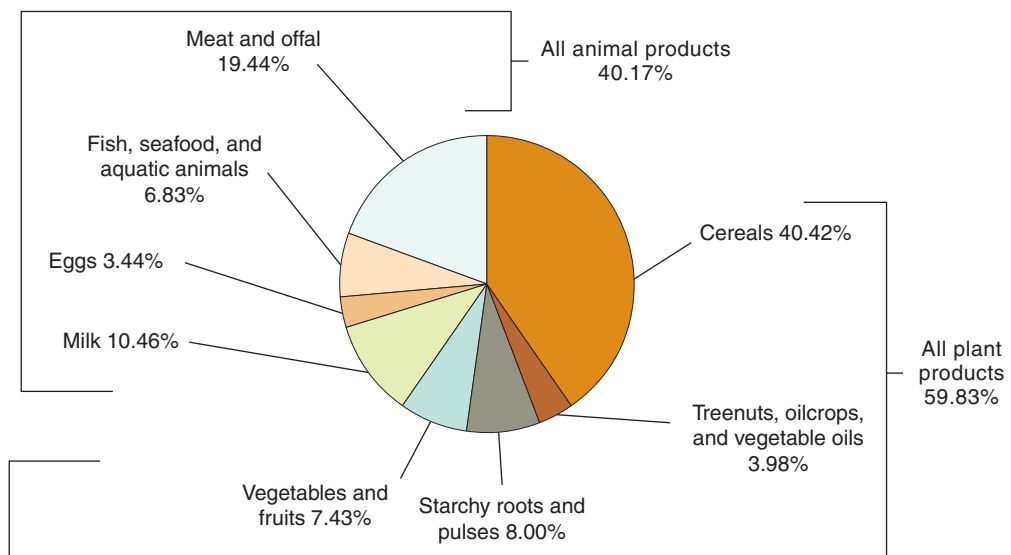
Table 1-3
PERCENTAGE CONTRIBUTION OF FOOD GROUPING TO VARIOUS NUTRIENTS IN THE U.S. FOOD SUPPLY

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	2	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 Stated Department of Agriculture.
[1]Coffee, tea, chocolate-liquor equivalent of coca beans, spices, and fortification of foods not assigned to a specific group.
[2]SFAs = saturated fatty acids; MUFAs = monounsaturated fatty acids; PUFAs = polyunsaturated fatty acids.

Nutrient density A measurement of the nutrients provided in a food compared to the calories it contains.

Diet The total of the foods and water being consumed by an individual or group.

Essential amino acids Those amino acids required by the body that must be consumed in the diet.

Undernourished Receiving inadequate nourishment for proper health and growth.

Meat, eggs, and dairy products are important food sources because they are **nutrient dense.** This means they have many nutrients compared to their calories, and the nutrients are digestible and readily available. High-quality protein and biologically available levels of vitamins and minerals, as well as a significant amount of energy, are supplied to the **diet** by animal foods.

Animal foods are generally preferred over plant foods by human populations, and the vast majority of the world's population routinely chooses food produced from animals in its diet. A country's living standards can be gauged by the proportion of its food supply that consists of animal foods. Time and again, people have demonstrated that increasing animal-derived foods in their diet is one of the first things they will do when their income increases. Not only are animal foods palatable and delicious, they are also the most nutritionally complete foods. They are an important source of vitamins and minerals, and the protein in animal foods is more likely than are plant proteins to include the **essential amino acids** in the correct proportions.

Absolute food quantity and amount of animal products are more available to some of the world's people than to others. Approximately 27.8% of the calories in the average diet in North America are from animal products compared to 8.4% for the average African. There is also a tremendous difference in food distribution to the world's people. The average African eats only 72% of the daily calories eaten by the average North American. Globally, 795 million people are **undernourished.**

Most people include meat and dairy products in their diets whenever they can. Exceptions are almost always because of religious prohibitions, principally beef and pork, or because of prohibitive costs. The world's meat (excluding fish) is predominantly supplied by pigs, cattle, and poultry with lesser amounts from sheep, goats, buffalo, and horses. Several other species provide a significant amount of meat to the people of various geographic regions. Most milk comes from cows, but buffalo, goats, and sheep provide significant amounts of milk, and most domestic hooved animals are milked somewhere in the world.

Other Uses

In addition to food, other animal products are also of great importance to humans, who have used wool, hair, and other fibers for clothing, and feathers and hides for leather footwear and apparel, even baseball gloves. Manure from animals is a valuable by-product used for fertilizer and other applications (Figure 1-4).

Figure 1-4
Liquid manure from a hog-feeding operation in Iowa is being pumped onto cropland with a "honey wagon."
(Tim McCabe/U.S. Department of Agriculture.)

Figure 1-5
Draft animals are still the most important nonhuman power source in developing countries. (©FAO/G.De Sabatino.)

Slaughter by-products are the source of a large number of industrial and consumer products. Some examples include pharmaceuticals, insecticides, crayons, cosmetics, plastics, cellophane, glass, water filters, plywood adhesive, soap, gelatin, air filters, and animal feed.

Draft animals are vitally important to many Asian, African, and Latin American countries. Oxen plow fields; water buffalo work in rice paddies; yaks, donkeys, and camels still trudge over ancient trade routes; and dogs still pull sleds (Figure 1-5). Much of the world's food production in less developed regions is dependent on draft animals, as is transportation of goods to and from markets. Tasks such as carrying water and fuel are significant contributions of draft animals. As much as 80% of the nonhuman power of subsistence agriculture is provided by draft animals.

Animals are used as models for humans in biomedical research, helping to extend human life span. Thirty years have been added to the average American life span since 1900. In addition, the quality of life for people afflicted with chronic diseases has been improved dramatically. Medical research depends on the use of animals as models. It will continue to do so in the foreseeable future (Figure 1-6). In addition, animals are

Draft animal An animal whose major purpose is to perform work that involves hauling or pulling. An ox or a horse pulling a plow or wagon is a draft animal.

Figure 1-6
Biomedical research depends on the use of animals as research models. This two-year-old Spanish goat underwent a successful cleft palate repair in utero. Goats were first developed as an animal model for the study of lupine-induced crooked calf syndrome. The model is now playing a role in developing procedures for prenatal repair of cleft palate in children.
(Peggy Greb/USDA-Agricultural Research Service.)

Figure 1-7

Service dogs help people with disabilities. Here, a Seeing Eye® dog in action, with student and instructor, on the streets of Morristown, New Jersey. The dog has stopped the person from proceeding across the driveway as the van turns. (Photo Courtesy of The Seeing Eye, Inc.)

Figure 1-8

Many entertainment industries are based on animal use. Horse racing is among the most popular. (Clarence Alford/Fotolia.)

used in research to benefit animal health, resulting in healthier, longer-lived pets and healthier, more productive livestock.

Animal companionship is important to people around the world, enhancing human physical, emotional, and spiritual well-being. Specially trained animals assist people with visual disabilities (guide animal), hearing disabilities (hearing or signal animal), and other disabilities (service or assistance animal), helping people live more independently (Figure 1-7). Therapy animals are commonplace.

In addition, many entertainment industries such as racing, rodeos, and bull-fighting are based on animal use (Figure 1-8).

Agricultural animals convert inedible feeds to valuable products. About two-thirds of the feed used in the U.S. livestock industry is not suitable for human consumption. Hay, pasture, coarse forages, by-products, garbage, and damaged food are examples. Animal use diversifies agriculture, the food supply, and the economy. Diversified agriculture is more stable and more sustainable.

THE FUTURE OF LIVESTOCK PRODUCTION

Global livestock production is undergoing huge increases in animals and products with further increases predicted. To keep pace with demand, many are predicting the need to double animal product output by 2050. This increasing animal production is being referred to as the **livestock revolution,** and it is being likened to the cereal grains boom of the **green revolution,** which began in the 1960s and is credited with saving millions of lives and building many national economies.

The forces driving increased global demand for animal products are simple: human population growth and increasing income. Unprecedented economic development

Livestock revolution
Large increases in supply and demand of livestock and animal products worldwide at the end of the 20th century and into the 21st century.

Green revolution
Dramatic improvements in grain production in developing countries during the 1960s to the 1980s because of technological innovation and application.

around the world is increasing **per capita** income. The world's human population is increasing and is projected to reach approximately 9.6 billion by 2050. These factors are causing increased per capita consumption of animal products and large increases in total demand. Most of the new demand for animal products is in developing countries, which are expected to soon produce the majority of the world's meat and milk. Along with the increased demand for animal products is an increased demand for other agricultural commodities to feed people and livestock. In addition, the world's developing demand for **biofuel** production will increasingly play a role in food availability and prices.

The challenges associated with these profound changes in agriculture are significant. The prime agricultural lands are already in use, and, worldwide, the potential new agricultural lands are covered by forests, under human settlements and infrastructure, or likely to be marginally productive. With increased human population, agricultural land per person will continue to decrease. Therefore, agricultural land will need to be more productive. To make this happen, there is a pressing need for research and subsequent technology development to increase productivity per unit of land. Agriculture of all kinds has the potential to affect the environment both negatively and positively. For the sake of future generations, we must achieve these massive increases in yield while protecting air, soil, and water quality. Combined, the opportunities and the challenges suggest an unprecedented dynamic period in the world agricultural order.

Per capita Per unit of population: by or for each person.

Biofuel Gas or liquid fuel made from biological materials, such as crops and animal waste.

SUMMARY AND CONCLUSION

Animal science has its roots in the challenges that the first domesticators of animals encountered many millennia ago when they permanently brought in animals from the wild. Today, animal science is a vital field with specialties in genetics and animal breeding, nutrition, physiology, animal health, animal behavior, meat and dairy product science, and biotechnology. Animals are used for a myriad of purposes, including food, fiber, work, research, companionship, and entertainment.

Although agricultural animals have come under attack in recent years by those who feel they are a luxury, the numbers of agricultural animals are steadily increasing, and they are becoming more important in helping to feed the human population. For this reason, we should learn something about the factors that determine the kinds of agricultural animals found throughout the world. Chapter 2 explores in depth the contributions animals make to humankind.

STUDY QUESTIONS

1. Define animal science. Why did animal science begin?
2. Explain why all of the world's occupations are tied to agriculture.
3. When did animal domestication occur? When were each of the major animal species domesticated?
4. Define the specialties of animal science.
5. Why is the specialization in animal science disciplines both a help and a hindrance?
6. Study Table 1-1, which gives livestock numbers in the world. Notice the relative numbers of each species. Offer some reasons why animals are distributed as they are. Based on the numbers in this table, what are the world's major farm species?
7. Table 1-2 gives an overview of the goods and services derived from domestic animals by humans. (These

are explored in detail later in the text.) Develop a list of uses from this table that are ranked from "most useful" to "least useful" from your current perspective. (At the end of the book, come back to your list and see if your perspective has changed.)

8. What proportion of human food energy and protein comes from animal products?
9. What proportion of the U.S. calorie and protein supply comes from animal products? How do other countries compare?
10. If a person does not eat meat, what are the most common reasons?
11. Which animals supply most of the world's meat?
12. Meat is important as a food for the human population because it is nutrient dense. What does "nutrient density" mean?

13. List some of the important products made from by-products of the slaughter industry.

14. How important are draft animals to subsistence agriculture? Name six important draft animals.

15. What is the role of animals in medical research?

16. Briefly discuss some of the ways that animals provide companionship, recreation, and entertainment to humans.

17. What types of humanly unusable feeds do animals convert to valued products?

18. Why is a diversified agriculture important, and what role do animals have in diversification?

19. What is the livestock revolution, and what are some of its challenges?

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