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
Introduction to the Animal Sciences

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.

Key Terms

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

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.
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 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.
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 distribution.

<table>
<thead>
<tr>
<th>Table 1-1</th>
<th><strong>AGRICULTURAL ANIMAL NUMBERS IN THE WORLD</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>World Total</strong></td>
</tr>
<tr>
<td>Large Farm Animals</td>
<td></td>
</tr>
<tr>
<td>Cattle (head)</td>
<td>1,443,524,363</td>
</tr>
<tr>
<td>Sheep (head)</td>
<td>1,149,162,250</td>
</tr>
<tr>
<td>Pigs (head)</td>
<td>978,658,479</td>
</tr>
<tr>
<td>Goats (head)</td>
<td>962,157,224</td>
</tr>
<tr>
<td>Buffalo (head)</td>
<td>193,566,739</td>
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<tr>
<td>Horses (head)</td>
<td>58,257,819</td>
</tr>
<tr>
<td>Asses (head)</td>
<td>24,136,822</td>
</tr>
<tr>
<td>Mules (head)</td>
<td>10,246,096</td>
</tr>
<tr>
<td>Total (head)</td>
<td>8,829,374</td>
</tr>
<tr>
<td>Total</td>
<td>4,871,979,202</td>
</tr>
</tbody>
</table>

Rabbits and Rodents

| Rabbits (1,000 head) | 742,033 | 4,334 | 1,370 | 18,619 | 107,104 | 610,607 |
| Other rodents (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 | 142,8 | 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 |


1Includes yaks.
2Includes both llamas and alpacas.
3Producing animals slaughtered.
4Primarily guinea pigs.
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
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.
Table 1-3

PERCENTAGE CONTRIBUTION OF FOOD GROUPING TO VARIOUS NUTRIENTS IN THE U.S. FOOD SUPPLY

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<thead>
<tr>
<th></th>
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<td>10.0</td>
<td>1.0</td>
<td>27.0</td>
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<td>23.0</td>
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<td>19.0</td>
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<td>66.0</td>
<td>4.0</td>
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<td>Total fat</td>
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<td>12.0</td>
<td>2.0</td>
<td>38.0</td>
<td>0.0</td>
<td>4.0</td>
<td>2.0</td>
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<td>54.0</td>
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<td>2.0</td>
<td>2.0</td>
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<td>MUFAs²</td>
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<td>8.0</td>
<td>2.0</td>
<td>38.0</td>
<td>0.0</td>
<td>5.0</td>
<td>1.0</td>
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<td>55.0</td>
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<td>PUFA§</td>
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<td>2.0</td>
<td>1.0</td>
<td>14.0</td>
<td>1.0</td>
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<td>Vitamin A</td>
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<td>22.0</td>
<td>5.0</td>
<td>48.0</td>
<td>33.0</td>
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<td>7.0</td>
<td>3.0</td>
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<td>2.0</td>
<td>8.0</td>
<td>6.0</td>
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<td>3.0</td>
<td>47.0</td>
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<td>42.0</td>
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<td>1.0</td>
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<td>60.0</td>
<td>3.0</td>
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<td>5.0</td>
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<td>38.2</td>
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<td>49.0</td>
<td>19.0</td>
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<td>6.0</td>
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<td>Folate</td>
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<td>3.0</td>
<td>2.0</td>
<td>8.0</td>
<td>8.0</td>
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<td>71.0</td>
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<td>62.0</td>
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<td>19.0</td>
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<td>3.0</td>
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<td>20.0</td>
<td>22.0</td>
<td>5.0</td>
<td>0.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

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

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 Grab/USDA-Agricultural Research Service.)
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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 bullfighting 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.

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.

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
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.

**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?
14. List some of the important products made from by-products of the slaughter industry.

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?

BIBLIOGRAPHY


