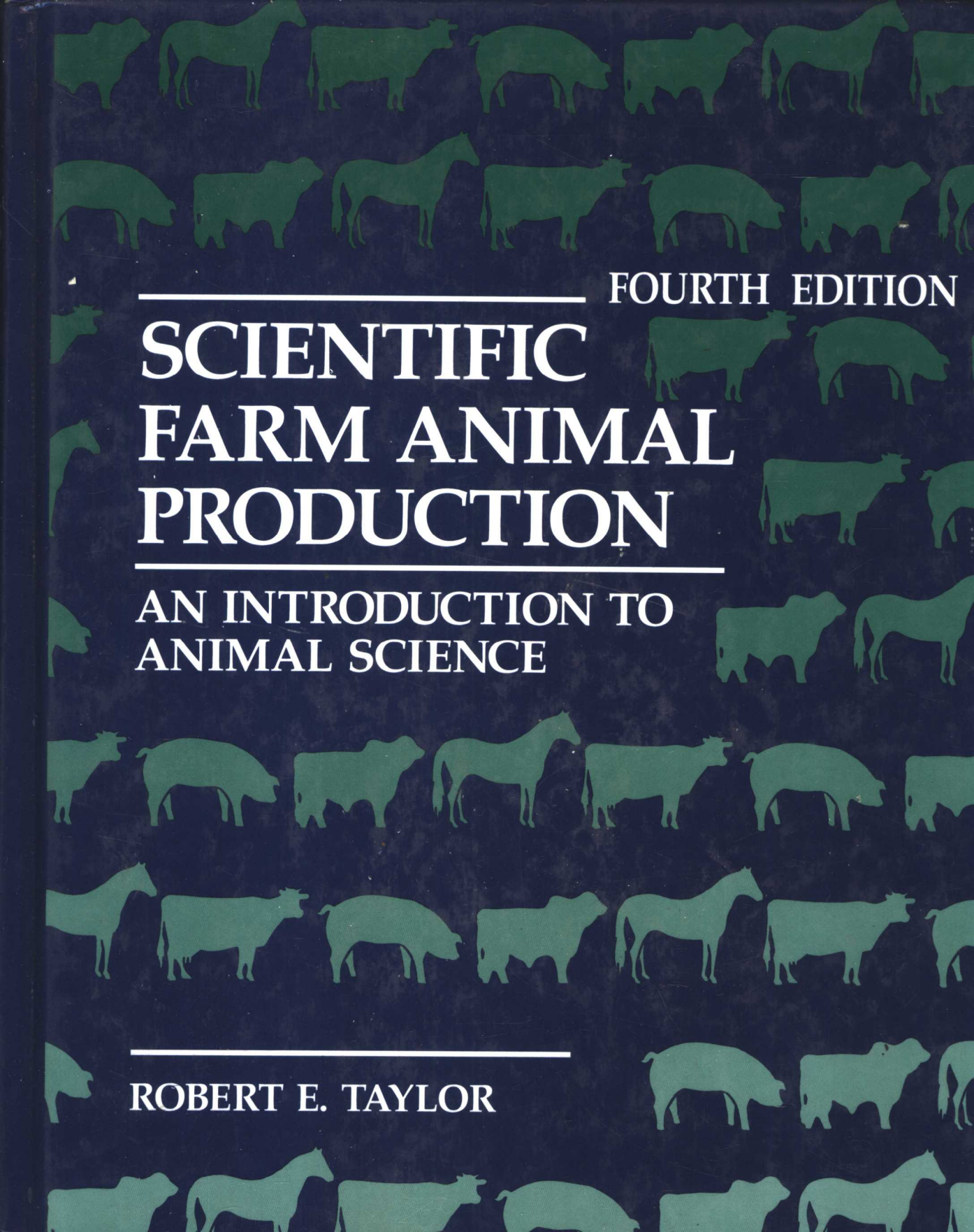

FOURTH EDITION

SCIENTIFIC FARM ANIMAL PRODUCTION

AN INTRODUCTION TO ANIMAL SCIENCE

ROBERT E. TAYLOR

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DEDICATION

This book is dedicated to the hundreds of students the author has taught. The positive and rewarding interactions with these students have provided the stimulus to write this book. Hopefully, the reading and studying of *Scientific Farm Animal Production* will be a motivational influence to current and future students as they seek to enhance their education.

PREFACE

Scientific Farm Animal Production is distinguished by an appropriate combination of both breadth and depth of livestock and poultry production and their respective industries. The book gives an overview of the biological principles applicable to the Animal Sciences with chapters on reproduction, genetics, nutrition, lactation, end products, and others. The book also covers the breeding, feeding and management of beef cattle, dairy cattle, horses, sheep, swine, poultry, and goats. Although books have been written on each of these separate chapters, the author has highlighted the significant biological principles, scientific relationships, and management practices in a condensed but informative manner.

TARGET AUDIENCE

This book is designed as a text for the introductory Animal Science course typically taught at universities and junior or community colleges. It is also a valuable reference book for livestock producers, vocational agriculture instructors, and others desiring an overview of livestock production principles and management. The book is basic and sufficiently simple for the urban student with limited livestock experience, yet challenging for the student who has a livestock production background.

The book is designed to accommodate several instructional approaches to teaching the introductory course: (1) the life-cycle biological principles approach, including such areas as end products, reproduction, breeding, nutrition, and animal health; (2) the species approach (teaching the course primarily by the various species); or (3) a combination of the previous two. The latter appears to be the most popular teaching approach by covering principles in lecture and combining principles and species into laboratory exercises.

KEY FEATURES

Chapters 1–9 cover animal products, Chapters 10–21 discuss the biological principles while livestock and poultry management practices are presented in Chapters 22–33.

The glossary of the terms, used throughout the book, has been expanded so students can readily become familiar with animal science terminology. The bold lettered words in the text are included in the glossary.

Many illustrations in the form of photographs and line drawings are used throughout the book to communicate key points and major relationships. If "a picture is worth a thousand words", the numerous photographs and drawings expand the usefulness of the book beyond its 590 pages.

Selected references are provided for each chapter to direct students into greater depth and breadth as they become intrigued with certain topics. Instructors can also use the references to expand their knowledge in current background material. Also included in the selected references section are references to visuals that relate to the specific chapter. Instructors are encouraged to review these visuals and use those which will enrich their course.

CHANGES IN THIS EDITION

This book has been updated with current technical and applied information. A new chapter (Overview of the Livestock and Poultry Industries) has been included which gives both a global and U. S. perspective. A section on biotechnology has been added to the genetics chapter. Several sections of the genetics chapter have been simplified. The chapter on Animal Welfare and Animal Rights has been expanded.

A "costs and returns" section has been added to the management section in most species chapters. Enterprise budgets and analyses have been included and emphasized as a critical ingredient in the management decision process. The management emphasis follows current industry trends where bioeconomics focuses on combining biology with economics.

ACKNOWLEDGMENTS

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ABOUT THE AUTHOR

Dr. Taylor was raised on an Idaho livestock operation where several livestock species were produced. He received a B. S. degree in animal husbandry and a Master's degree in animal production from Utah State University. This background, combined with his Ph.D. work in animal breeding and physiology from Oklahoma State University, has provided much depth to his knowledge of livestock production. He has had practical production experience with beef cattle, dairy cattle, horses, poultry, sheep, and swine.

Dr. Taylor received teaching awards at Iowa State University (where he also managed a swine herd) and at Colorado State University. He also received the Distinguished Teaching Award from the American Society of Animal Science in recognition of his ability to organize and present materials to students. Many of his concepts for effective teaching are used in this book.

CONTENTS

CHAPTER 1

Animal Contributions to Human Needs

Our basic human needs are food, shelter, clothing, fuel, and emotional well-being. Animals and animal products supply many of these basic needs and contribute to a high standard of living associated with a high consumption of animal products.

Since the domestication of dogs, horses, cattle, and sheep, some 6,000 to 10,000 years ago, wide differences have developed among people in various regions of the world in using agricultural technology to improve their standard of living. But in all societies, domestic animals are a source of food, other commercial products, and companionship for people.

Of particular importance among the multitude of benefits that domestic animals provide for humans are food; clothing; slaughter by-products used for various chemical purposes and animal feeds; power; manure for fuel (Fig. 1.1), buildings, and fertilizer; information on human disease through studies of experimental animals; and pleasure for those who keep animals. Table 1.1 shows the major domesticated animal species, their approximate numbers, and how they are used by people throughout the world. Chickens (10.5 billion) are most numerous, followed by cattle (1.3 billion), sheep (1.2 billion), and swine (846 million).

CONTRIBUTIONS TO FOOD NEEDS

When opportunity exists, most humans consume both plant and animal products (Fig. 1.2). Meat is nearly always consumed in quantity when it is available. Its availability in most countries is closely related to the economic status of the people and their agricultural technology. Vegetarianism in countries such as India may be the long-term result of intense population pressures and scarcity of feed for animals because of competition between humans and animals for food. Rising population pressures, particularly in developing regions (Southeast Asia, Africa, and Latin America), force people to consume foods primarily of plant origin. Some major groups in human society practice vegetarianism for ethical reasons. In the Buddhist philosophy and some religions of India, for example, all animal life is considered sacred.

The development of vegetarianism in England and in the United States was closely linked to temperance movements and to conservative attitudes toward sexuality. Vegetarianism was

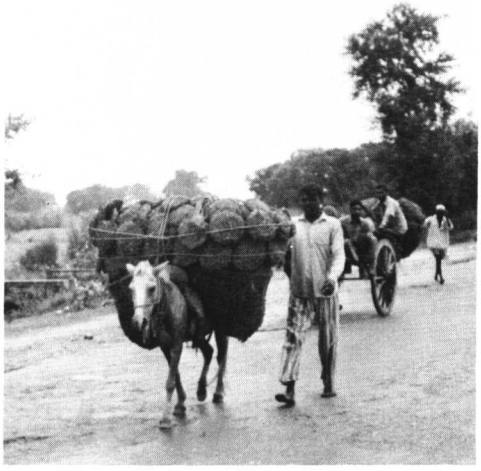

FIGURE 1.1.
A load of cow-dung cakes en route to a market in India. Courtesy of R. E. McDowell, Cornell University.

thought to cool "animal passions." It has never been practiced to a large extent in the United States. The vegetarian movement in this country developed in the nineteenth century and was based on the view that eating only plant products was healthier than including meat in the diet. However, some medical surveys of vegetarians have shown evidence of anemia and poor health.

The contribution of animal products to the per-capita calorie and protein supply in food is shown in Table 1.2. Animal products comprise approximately 16% of the calories and 34% of the protein in the total world food supply. Large differences exist between developed countries and developing countries in both total daily supply of calories (3,398 vs. 2,434) and protein (103

FIGURE 1.2.
Animal food products, such as meat, milk, and eggs, are the preferred foods in countries with high standards of living. Courtesy of the American Egg Board.

TABLE 1.1. Major Domesticated Animal Species — Their Numbers and Uses in the World

Animal Species	World Numbers (mil)	Leading Countries or Areas with Numbers[a] (mil)	Primary Uses
Ruminants			
Cattle	1,282	India (195), Brazil (137), USSR (120), United States (99), China (77)	Meat, milk, hides
Sheep	1,176	Australia (152), USSR (140), China (102), New Zealand (61), United States (11)	Wool, meat, milk, hides
Goats	526	India (107), China (79), Pakistan (34), Nigeria (26), United States (1.8)	Milk, meat, hair, hides
Buffalo	140	India (74), China (22), Pakistan (14), Thailand (5)	Draft, milk, meat, hides, bones
Camel	19	Somalia (6.7), Sudan (2.9), India (1.4), Ethiopia (1.1)	Packing, riding, draft, meat, milk, hides
Yak	13	USSR,[b] Tibet[b]	Packing, riding, draft, meat, milk, hides
Llama	13	South America[b]	
Nonruminants			
Chickens	10,584	China (1,981), USSR (1,160), United States (1,550), Brazil (600)	Meat, eggs, feathers
Swine	846	China (349), USSR (78), United States (55), Germany (36)	Meat
Turkeys	234	United States (75), USSR (47), Italy (23)	Meat, eggs, feathers
Ducks	527	China (333), Bangladesh (33), Indonesia (29), Vietnam (24), United States (7)	Meat, eggs, feathers
Horses	60	China (11), Mexico (6), USSR (6), Brazil (6), United States (5)	Draft, packing, riding, meat, companion animals
Asses	43	China (11), Ethiopa (5), Mexico (3) United States (0.028)	
Mules	15	China (5.4), Mexico (3.2), Brazil (2), United States (0.024)	

[a] U.S. numbers are given for comparison; may not always be among the leading countries.
[b] Data not available.
Source: Adapted from several sources, including the 1989 *FAO Production Yearbook.*

vs. 59 g). The comparison of developed and developing countries for the contribution of animal products in calories is 30% versus 9%, respectively, and the comparison for protein is 57% versus 22%.

Table 1.2 also shows calorie and protein data for selected countries in both developed and developing market economies. It is interesting to compare countries that have larger and smaller contributions of calories and protein from animal products to total calories (Iceland and Denmark vs. Nigeria and Bangladesh) and to total protein (Iceland vs. India and China). The United

TABLE 1.2. Animal Product Contribution to Per-capita Calorie and Protein Supply (selected countries (1986–88)

Country	Per-capita Calorie Supply (calories per day)			Per-capita Protein Supply		
	Total Calories	From Animal Products		Total Protein (g)	From Animal Products	
		Calories	Percent		Grams	Percent
Developed Market Economies						
United States	3,644	1,234	34%	109	72	66%
United Kingdom	3,259	1,109	34	89	54	61
Germany	3,855	1,405	36	105	70	67
Canada	3,451	1,125	33	99	61	62
Australia	3,347	1,169	35	100	65	65
Denmark	3,605	1,625	45	100	65	65
Israel	3,133	646	21	98	52	53
Japan	2,822	575	20	90	48	53
Iceland	3,361	1,445	43	136	101	74
USSR	3,382	918	27	106	55	52
Poland	3,434	1,184	34	102	57	56
Developing Market Economies						
Mexico	3,123	514	16	81	30	37
Brazil	2,703	405	15	62	24	39
Egypt	3,196	201	6	79	11	14
Turkey	3,084	279	9	84	18	21
Nigeria	2,083	39	2	46	4	9
China	2,637	258	10	64	12	19
India	2,104	140	7	51	7	14
Kenya	2,016	226	11	56	14	25
Bangladesh	1,925	59	3	41	5	12
All Developed Countries	3,398	1,028	30	103	59	57
All Developing Countries	2,434	220	9	59	13	22
World Total	2,671	419	16	70	24	34

Source: 1989 *FAO Production Yearbook.*

States ranks high compared to other countries in the contribution of animal products to the available calories and protein.

Selected recommended daily intakes (recommended daily allowance) of calories and protein are given in Table 1.3. Although the data in Table 1.3 do not represent an average of the U.S.

TABLE 1.3. Recommended Daily Caloric and Protein Intake for Selected Males and Females in the United States

Sex	Age (years)	Weight (lb)	Height	Average Daily Calories	Protein (g day)
Female	23–50	120	5 ft 4 in.	2,000	44
Male	23–50	155	5 ft 10 in.	2,700	56

population, a comparison of these data with those in Table 1.2 is interesting. Some countries have a larger supply of calories and protein than needed, whereas other countries have an inadequate calorie and protein supply. This assumes an equal distribution of the available supply, which in reality does not occur.

The large differences among countries in the importance of animal products in their food supply can be partially explained by available resources and development of those resources. Most countries with only a small percentage of their population involved in agriculture have higher standards of living and a higher per-capita consumption of animal products. Comparing Table 1.4 with Table 1.2, note that the countries in Table 1.4 are listed by percentage of their population involved in agriculture. The countries in Table 1.2 are listed in the same order as in Table 1.4.

TABLE 1.4. Population Involved in Agriculture in Selected Countries (countries ranked by percent of population in agriculture)

Country	1989 Population (mil)	1989 Population in Agriculture[a] (mil)	Percent of Population Economically Active in Agriculture (1989)[b]	Number of Tractors (1988) (thou)
Developed Market Economies				
United States	248	7	2%	4,670
United Kingdom	57	1	2	518
Canada	26	1	4	756
Germany	62	2	4	1,460
Israel	4	0.2	4	24
Australia	17	1	5	332
Denmark	5	0.2	5	168
Japan	123	8	7	1,985
Iceland	0.3	0.02	7	13
Ireland	4	0.5	14	164
USSR	289	39	14	2,692
Poland	38	7	22	1,101
Developing Market Economies				
Mexico	87	26	31	165
Egypt	53	22	41	46
Turkey	55	25	49	655
Nigeria	109	71	65	11
India	836	528	67	750
Bangladesh	113	78	69	5
China	1,117	761	68	876
Kenya	24	19	77	9
Nepal	19	17	92	3
All Developed Countries	1,243	106	9	21,005
All Developing Countries	3,962	2,262	60	4,806
World Total	5,205	2,368	47	25,865

[a] *Agricultural population* is defined as all persons depending for their livelihood on agriculture. This comprises all persons actively engaged in agriculture and their nonworking dependents.
[b] Includes all economically active persons engaged principally in agriculture, forestry, hunting, or fishing.
Source: 1989 *FAO Production Yearbook.*

TABLE 1.5. Persons Supplied by One Farm Worker in the United States and the Percent of Income Spent on Food

Year	No. Persons Supplied Per Farm Worker	Percent of Personal Disposable Income Spent on Food
1820	4	—
1850	4	—
1880	6	—
1910	7	—
1940	11	—
1950	16	30.0
1960	26	20.2
1970	48	17.3
1980	76	16.6
1985	78	14.7
1990	80	11.8

Source: USDA.

Developed countries have approximately 9% of their population economically active in agriculture, whereas more than 60% of the population in developing countries are involved in agriculture (Table 1.4). Agriculture mechanization (note tractor numbers in Table 1.4) has been largely responsible for increased food production and allowing many people to work in other industries. This facilitates the provision of many goods and services and thus raises the standard of living in a country.

The tremendous increase in the productivity of U.S. agriculture and the relative cost of food are vividly demonstrated in Table 1.5. From 1820 it took 100 years to double productivity. Then productivity doubled in shorter, successive time periods—30 years (1920–50), 15 years (1950–65), and 10 years (1965–75). A dramatic change occurred after World War II, when productivity increased more than fivefold in 30 years. During that time, the abundant production of feed grains provided a marked stimulus in increasing livestock production, thus providing large amounts of animal products for the human population.

TABLE 1.6. *Amount of Food Purchased by an Hour's Pay (average U.S. worker)*

Food Item	1950	1970	1980	1989
Frying chicken (lb)	2.3	7.9	9.4	10.7
Milk (half gal)	3.5	9.0	11.6	7.6
Eggs (doz)	2.2	5.3	7.9	9.7
Pork (lb)	2.5	4.2	4.8	5.3
White bread (lb)	9.3	13.3	13.1	14.4
Ground beef (lb)	2.4	5.0	4.2	6.7

NOTE: Average hourly pay: $1.34 (1950), $3.23 (1970), $6.66 (1980), and $9.66 (1989).
Source: USDA.