EIGHTH EDITION

FOODS

EXPERIMENTAL PERSPECTIVES

Margaret McWilliams

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Ph.D., R.D., Professor Emerita
California State University, Los Angeles

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To my food science and dietetic students who made my teaching career such a pleasure and intellectual challenge!

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Brief Contents

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Contents

Preface

The world has never focused more on the food scene than is true today. Fascination, pleasures, and concerns include unusual and exotic foods, genetic modifications, and healthy eating. Farmers and fishermen are challenged to produce enough food to feed the world despite an ever-increasing population and severe detrimental weather. Voices are raised loudly on both sides of arguments about such topics as labeling, food safety, GMOs, organic, and animal rights. Careers in food and food science are right in the middle of the scene. It is a great time to be studying to gain knowledge of the underlying science as well as the philosophical and practical aspects of food.

Careers in this realm require a depth of understanding far beyond what can be seen on television. This book is designed to help readers broaden and strengthen their scientific knowledge of food and its safe preparation. Chapter 1 introduces some food topics of particular concern to consumers, surveys government involvement, and explores opportunities in food-related careers. Part I explains the role of water in food and the physical aspects of food preparation. Parts II, III, and IV discuss carbohydrates (sugars, starch, vegetables, and fruits), lipids, and proteins (meat, eggs, milk, and baked products). Part V includes food safety, preservation, and additives. Part VI examines research basics, including sensory and objective evaluation. Laboratory experiments to augment your study are presented in my *Experimental Foods Laboratory Manual*, which also is published by Pearson.

"Food for Thought" and other boxes highlighting unique ingredients are features of this new edition that broaden this look at the world of food. Numerous color pictures, objectives, margin notes and definitions, summary charts, and study questions are designed to enhance learning.

This revision has been updated to include new information pertinent to each chapter, ranging from the food scene and marketplace to the spectrum of foods and the science that forms the basis for their handling and preparation. Particularly extensive revisions occur in Chapters 1, 12, and 16. The sequence of chapters has been altered significantly, with the research chapters being placed following the parts discussing the science of food.

Space limitations make it impossible to include background information that usually is included in an introductory class. You will find this material in my book *Food Fundamentals*, 10th edition, also published by Pearson.

You have chosen an important field. I hope that you will enjoy your study of food and that it will serve you well as you proceed in your career.

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Margaret McWilliams

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Other Prentice Hall Books by Margaret McWilliams

Experimental Foods Laboratory Manual (9th edition), 2016.
Food Fundamentals (10th edition), 2013.
Illustrated Guide to Food Preparation (11th edition), 2013.
Fundamentals of Meal Management (6th edition), 2008.
Food around the World (4th edition), 2014.

Farms are the key source of much of the nation's food supply.

1 Today's Food Scene

CHAPTER OUTLINE

OBJECTIVES

After studying this chapter, you will be able to:

1. Discuss genetically modified organisms from the perspectives of both food producers and consumers.
2. Describe some of the problems farmers have to deal with in their profession.
3. Outline the issues fishermen and people running fish farms face. Discuss the significance of functional foods for consumers.
4. Discuss the roles of some federal agencies involved in the nation's food supply.
5. Describe various professional career opportunities that are centered on diverse aspects of the food industry.

INTRODUCTION

Today's professionals working in the many aspects of food, ranging from farm to table, are confronted with unique challenges as consumers increasingly focus their attention on what they are eating. Never before has there been so much media attention and public engagement in cooking and eating. The joys of fine dining have drawn many to savor their food, but negative aspects such as the obesity epidemic, the rise in diabetes, and other food-related health issues have brought sharply critical attention. **Genetically modified organisms (GMOs)**, "natural" foods, and animal rights are among leading topics that have fostered public concern and heated discussions. The publicity has caused people to be more aware of what they are eating; it has not only increased dining pleasure for many but also caused considerable anxiety about food safety and nutritional deficiencies.

Genetically modified organism (GMO) Plant or animal food developed by genetic manipulation to alter nutrient levels or other characteristics; also designated as GM.

The public has heeded the information and misinformation that is being fed to them via the Internet, television, radio, and print media. Unfortunately, the accuracy of the information and the qualifications of the source are often ignored, creating enthusiastic messengers clamoring for changes that may not be necessary and can actually be costly and harmful.

In contrast, the U.S. Department of Agriculture (USDA) has provided accurate information on food groups and recommendations for healthy eating to the public for many

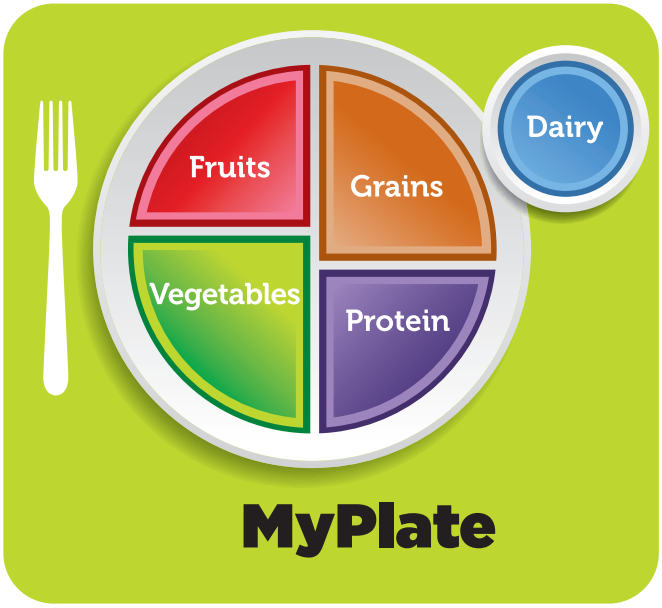

Figure 1.1 MyPlate is the logo for the USDA's current dietary guidelines. (Courtesy of USDA.)

years. The USDA's Food Guide Pyramid was the icon in 1992 and was replaced with MyPyramid in 2005. The most recent format for guiding eating is "MyPlate," which was introduced in 2011. MyPlate features five food groups: fruit, vegetable, grains, protein foods, and dairy (Figure 1.1). Detailed guidance for using MyPlate is available at http://www.choosemyplate.gov/.

What people choose to eat is defined jointly by consumers and the food industry. Changes have come to the marketplace as the public's voice has increasingly been heard. A trip through a supermarket today immediately reveals that the food world is flat; that is, it has become international. Ingredients are imported from around the world, and cultural food specialties are stocked. Labels shout claims about health benefits, and fresh produce often is identified as locally grown and/or organic. Although gourmet cooking at home is a hobby pursued by some, delicatessen sections are gaining more space in supermarkets as people cope with the challenges of lack of time and healthy eating.

ISSUES IN THE FOOD SUPPLY

Production Perspectives

The food for sale in markets is available via a chain of workers, beginning with farmers or fishermen. Some farmers are operating on a family farm, and they make decisions on such critical matters as when and what to plant, how to cultivate, and when to harvest and market their crops. The trend for decades has been consolidation as family farms have been sold and merged into megafarms. These large-scale operations are operated often under distant management and with less involvement in local communities.

Big farming operations face the same issues as small farmers, but the operating decisions that are made can have a significant impact on the immediate environment. For example, the problem of safe waste removal from a single milk cow for a family is of very limited consequence, whereas waste from a herd of 1,000 cattle has to be managed carefully to avoid carrying microbiological contamination into soil when heavy rains flood and run off into neighboring fields. Operators of large-scale livestock and poultry farms need to constantly monitor sanitation to maintain healthy animals and to minimize the environmental impact of their farm on the air quality (an aroma that can quickly draw complaints) in the neighborhood.

Animal rights have garnered news stories as some activists have recorded documentaries (usually surreptitiously obtained) showing how some farmers are housing and treating their livestock and poultry. Reports of crowded conditions led to calls for allowing poultry to roam outdoors, and "free range" chicken entered the marketplace. The American Humane Association and other organizations are dedicating their efforts to improving the quality of life for livestock and even providing their own certification when producers meet the guidelines established by the certifying organization. Federal agencies are not involved in these unofficial certification programs.

Small, family-owned farms are disappearing gradually as a consequence of economic challenges. Large-scale farming requires relatively less human labor because big operators are tilling enough land to justify the high cost of giant farm equipment. However, some small-farm operators help each other and may share special equipment during threshing and harvesting. Gradually, many small towns scattered across the farm belt have shrunk or even disappeared as family farms have been acquired by corporations.

Regardless of the size of the farm, weather introduces a major factor into the size of the crop and the income it brings in. Seed or livestock must be purchased at the beginning of the season, and additional expenditures for plant fertilizers and pesticides or for animal feed and antibiotics and other healthcare have to be paid during the growing season regardless of flood or drought conditions. A storm at the wrong time can suddenly cause huge losses for farmers. The severe droughts of the past few years have caused many small farmers in the affected regions to lose their farms.

Consumer Voices

Among the words consumers speak frequently and with authority and enthusiasm are *natural*, *fresh*, and *locally grown*. USDA regulations allow food labels to include the word **natural** if no ingredients have been added and if little or minimal processing has been done. Alice Waters and other famous chefs and restaurateurs created the demand for produce straight from the garden or local farm to the table. Gradually these terms have become part of table talk in many settings. They also have helped to promote shopping at local farmers markets. Unlike *organic*, *fresh*, and *locally grown* have not been given legal definitions and are dropped liberally into table talk about food, but with little attention to accuracy.

Natural
USDA allows this term on labels if the product contains no artificial ingredient or added color and is only minimally processed. Minimal processing means that the product was processed in a manner that does not fundamentally alter the product. The label must include a statement explaining the meaning of the term *natural* (e.g., "no artificial ingredients, minimally processed").

A related issue is identification of products on the basis of point of origin. As the market for upscale food products has increased, careful control of products by their source has become significant for marketing. Examples of producers protecting their "point of origin" names include Champagne and Roquefort cheese in France, Parma hams, and Parmigiano-Reggiano cheese (Figure 1.2) from Parma in northern Italy, and Wensleydale and Stilton cheese from Leicestershire, Nottinghamshire, and Derbyshire, England. To avoid having competitors from other places invade their carefully cultivated customers, some authentic producers are gradually establishing legal ownership of their "point of origin," thus making it necessary for imitation products to stop using the original name; a different name must be stated on the label.

Organic Concerns Gradually during the decades since the 1960s, consumers have become more aware of what they eat and where it comes from. In some cases, this has added considerable emotion to the dialog about food. Perhaps the most obvious change such voices have generated is **organic foods**.

Organic foods
Foods raised to meet the legal requirements blocking use of fertilizers, pesticides, ionizing radiation, and bioengineering.

Some consumers say they want organic or natural foods as though they were synonymous terms, but they are not the same legally. When used in reference to foods, *natural* generally mean that original food ingredients have been used and that no artificial or chemical additives have been included. Using beet pigments rather than a red chemical dye to color a food product is one example of using a natural coloring agent.

The legal definition to label a food *organic* is that the plant or animal food has been produced without using growth hormones, antibiotics, or petroleum-based or sewage sludge-based fertilizers. Designation as organic does not mean that the food is higher in

Figure 1.2 Parmigiano-Reggiano cheese is identified clearly by its point of origin to distinguish it as the authentic Parmesan cheese from Parma in northern Italy. (Courtesy of Barbara Boyer.)

nutrients than the same type of food that has not been produced according to organic requirements. Nevertheless, many consumers often are willing to pay more for organic produce because they think they are buying more nourishing food.

The first federal legislation regarding producing and marketing organic foods was the **Organic Food Production Act of 1990**. However, the impact of this act was not evident until passage of legislation in 2002 that implemented the earlier act. The **National Organic Program**, administered by the Agricultural Marketing Service of the USDA, went into effect in late 2002 (Figure 1.3).

Organic Food Production Act of 1990
Federal legislation that regulates production and marketing of organic foods.

National Organic Program
Federal legislation passed in 2002 to implement the Organic Food Production Act of 1990.

Plant and animal foods marketed as organic may carry the USDA Organic seal if they meet the following requirements:

- To be eligible for the designation of organic or 95 percent organic, at least 95 percent of produce (by weight) must not have been treated with sewage sludge-based or petroleum-based fertilizers, conventional pesticides, ionizing radiation, or bioengineering.
- Food mixtures in packages may be labeled "made with organic ingredients" if 70 percent of the ingredients (by weight) meet the requirements for being designated organic.

Today many markets have a large display of organic foods in the produce department, and many packaged foods display organic labels. Despite the fact that organic

Figure 1.3 This USDA official seal can only be used to identify foods that meet organic standards. (Courtesy of USDA.)

foods often cost more, they frequently are the choice of shoppers who feel that their health is in jeopardy if they do not buy organic foods. While these are safe food choices, they often are no better for one's health than foods that are not identified as organic. Vegetables and fruits clearly are essential in the diet, but today's farming practices yield high-quality produce regardless of their labeling. The important thing is to eat a variety of them.

Biotechnology Plants have been modified for centuries by crossbreeding to develop strains with improved characteristics. These hybrids have been an established part of farming for many decades, and their safety as food has not been a concern. However, when scientists were experimenting with rice and some other basic crops after World War II, some research was directed toward altering plants genetically. The goal was to develop strains with improved characteristics so that crop harvests would be large enough to feed the expanding world population. The "Green Revolution" was under way and is continuing today.

The challenge of providing food security for the burgeoning population of the world (expected to reach 9 billion by 2050) is the impetus to create new strains with higher yields, more resistance to insects, and greater drought tolerance (of importance as nations deal with global warming and extreme weather conditions). Plants that have increased resistance to insects can be raised using less pesticide protection, which is a bonus for both farmers and consumers. Scientists have been striving to develop plants with these beneficial characteristics through **genetic engineering** (also referred to as biotechnology).

Genetic engineering Another term for biotechnology.

A gene is a segment of DNA that encodes enough information to synthesize a protein. By identifying specific genes that provide the codes for making proteins that impart desirable traits, researchers have then been able to transfer the desired genes to other organisms to develop plants or animals that continue to replicate the desired gene(s) in succeeding generations (Figure 1.4). These food crops are designated as GMOs, sometimes simply referred to as GM. Corn and soybeans are major crops that have been the object of efforts to create plants that can effectively resist infections from insects, viruses, and/or fungi. Roundup-Ready® is one brand of genetically modified crops (e.g., soybeans) already being grown in the United States. Biotechnology also has led to the development of sunflower, peanut, and other oilseed plants with reduced levels of *trans* fatty acids and higher smoke points (see Chapter 8).

Figure 1.4 Bottom: Parent variety of rice with normal phytic acid. Middle: The new low-phytic-acid variety. Top: The new variety given a gene for golden hull color to help identify it. (Courtesy of USDA.)

Continuing research projects to develop a range of crops with modified nutrient value and health benefits include:

- Altering oil composition of oilseed rape and soybeans
- Using soybean protein for use as meat substitutes
- Reducing discoloration of potatoes from bruising during commercial storage; lowering moisture content (to reduce oil absorption during cooking)
- Increasing vitamin A levels in rice (Golden Rice™) to aid in preventing blindness in Southeast Asia
- Increasing the antioxidant content in some vegetables

Other research in biotechnology is aimed toward improving flavor, color, and/or texture of tomatoes (e.g., FlavrSavr® tomato), corn, and squash. Additional research is being directed toward creating plants that are drought resistant, heat resistant, and/or able to survive increased salinity.

In many countries in various parts of the world, particularly in Europe, concerns were raised regarding the growing and marketing of food resulting from biotechnology. Nevertheless, farmers in many parts of Asia, South America, and the United States have been raising GMO crops for more than a decade. In 2013, 174 million hectares around the world were planted in GMO crops, and these crops were raised by 18 million farmers. Soybeans, maize, cotton, and rapeseed were the leading GMO crops planted.

Resistance to insect attack on corn and a few other crops is being incorporated by inserting a gene from *Bacillus thuringiensis* (a soil bacterium), resulting ultimately in the formation of a toxin that serves as an insecticide in the plant. Crops that incorporate this gene are designated as Bt. **Bt maize** is being grown in Europe despite the fact that France has banned it. Ongoing research and monitoring are being done to detect possible negative consequences of Bt crops. On the positive side is a significant decrease in worldwide fertilizer use (estimated to be almost 30 percent during the decade from 1996 to 2006) because of Bt maize and cotton.

Bt maize
Corn that has been modified genetically by inserting a gene from *Bacillus thuringiensis*.

Governmental regulatory agencies are involved in approving and regulating the products of biotechnology. In the United States, the FDA is responsible for food products of plant biotechnology. Agricultural products are under the purview of the USDA, primarily its Animal and Plant Health Inspection Service (APHIS). Herbicides and pesticides are under the aegis of the U.S. Environmental Protection Agency (EPA). These agencies are all involved in the regulation and oversight of some products of biotechnology.

The possibilities for improved food products as the result of biotechnology (specifically by techniques of genetic engineering) are diverse and multiplying. Examples include increased essential amino acid content in corn and soybeans, naturally decaffeinated coffee, plant oils with modified fatty acid content, potatoes and tomatoes with higher solids content (to decrease energy needed to remove water during processing), and controlled ripening of fruits and vegetables that are difficult to ship to markets in satisfactory condition.

FOOD FOR THOUGHT

Ultragrain®

The conflict that some people face when choosing bread that is good for them (whole grains) and the one they prefer (soft, white) has been addressed by ConAgra. This food company spent more than eight years developing a new strain of wheat and a modified milling process to produce a flour for people who want whole grain nutrition benefits and soft white bread. The new strain of wheat is grown in the Midwest, the part of the country where the hard wheat traditionally used for bread making is grown. New milling

(Continued)