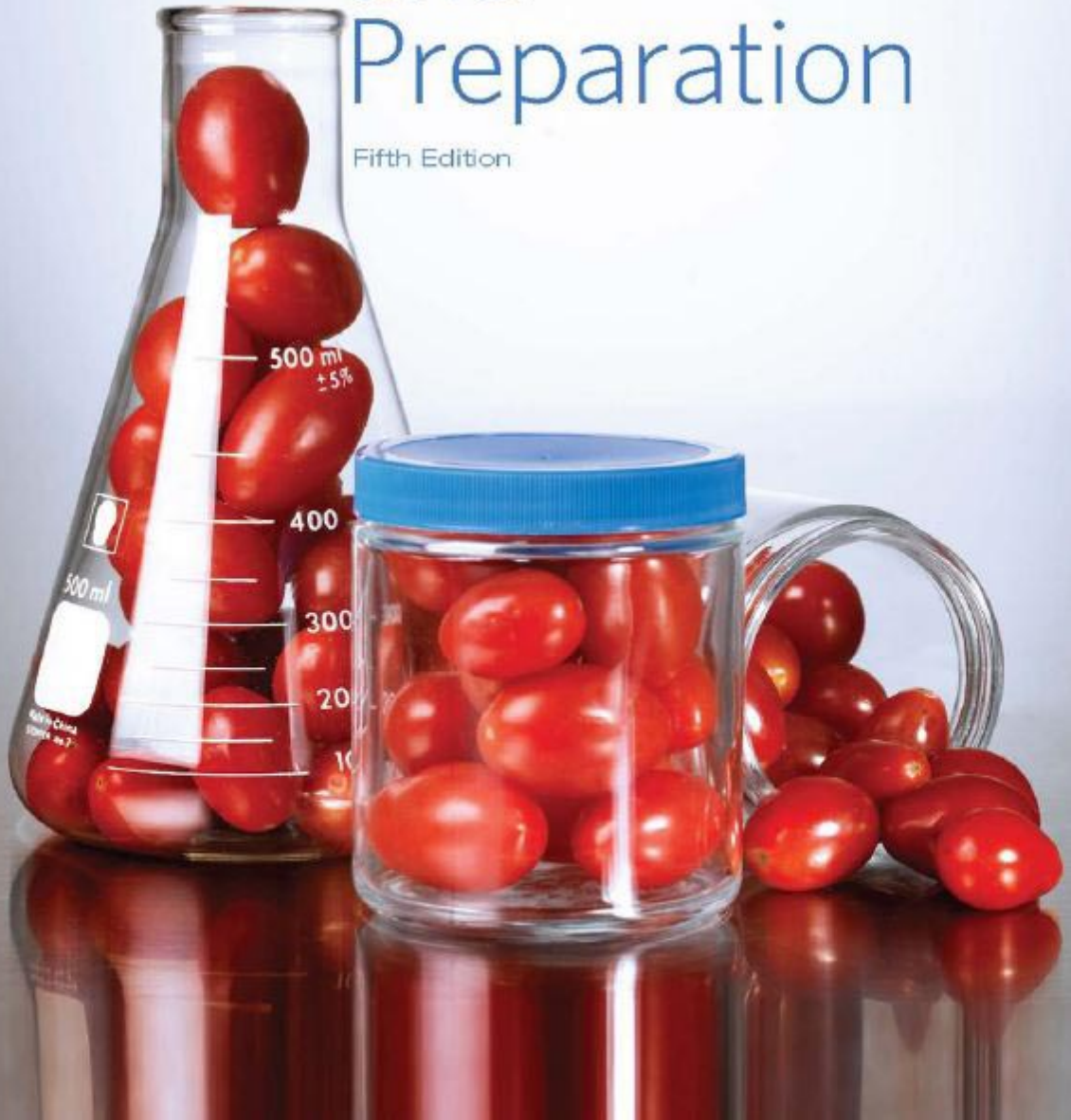
AMY BROWN

Understanding Food Principles and Preparation

Fifth Edition



Understanding Food Principles and Preparation

Understanding Food Principles and Preparation

Fifth Edition

AMY BROWN
University of Hawaii at Manoa

CENGAGE Learning®

Australia • Brazil • Japan • Korea • Mexico • Singapore • Spain • United Kingdom • United States

CENGAGE Learning®

***Understanding Food: Principles and Preparation*, Fifth Edition**
Amy Brown

Product Director: Yolanda Cossio
Product Manager: Peggy Williams
Content Developer: Elesha Feldman
Product Assistant: Kellie N. Petruzzelli
Media Developer: Miriam Myers
Brand Manager: Jenny Levandusky
Market Development Manager: Tom Ziolkowski
Production Management and Composition: Naman Mahisauria, MPS Limited
Manufacturing Planner: Karen Hunt
Rights Acquisitions Specialist: Roberta Broyer
Photo Researcher: PreMedia Global
Text Researcher: PreMedia Global
Art and Cover Direction: Carolyn Deacy, MPS Limited
Cover Image: ©Frank Bean/GettyImages

WCN 02-200-203

Library of Congress Control Number: 2013942536

ISBN-13: 978-1-133-60715-1

ISBN-10: 1-133-60715-2

Cengage Learning
200 First Stamford Place, 4th Floor
Stamford, CT 06902
USA

Cengage Learning is a leading provider of customized learning solutions with office locations around the globe, including Singapore, the United Kingdom, Australia, Mexico, Brazil, and Japan. Locate your local office at **www.cengage.com/global**

Cengage Learning products are represented in Canada by Nelson Education, Ltd.

To learn more about Cengage Learning Solutions, visit **www.cengage.com**
Purchase any of our products at your local college store or at our preferred online store **www.cengagebrain.com**

Printed in the United States of America
1 2 3 4 5 6 7 17 16 15 14 13

Brief Contents

Contents

Preface

***Comprehensive* is the word that describes *Understanding Food, the* best-selling textbook in its field. It brings together the most current information in food science, nutrition, and food service. Founded on research from more than thirty-five journals covering these disciplines, the text incorporates the very latest information on food—its science and its application. *Understanding Food: Principles and Preparation*, 5th edition, provides students with a broad foundation to launch a career in any of these food-related fields.**

ORGANIZATION OF CONTENT

Understanding Food is organized according to the various food disciplines. Part I represents information related to food science and nutrition, such as food selection, sensory and physical evaluation, and food chemistry. Part II covers aspects of food service from food safety to food preparation basics to meal management. Part III covers all of the standard food items arranged into proteins (meat, poultry, fish, dairy, and eggs); phytochemicals (vegetables, fruits, soups, salads, and gelatins); complex carbohydrates (cereals, flour, and breads); refined carbohydrates and fat (sweeteners, fats and oils, cakes and cookies, pies and pastries, candy, and frozen desserts); and water (beverages) groupings. Part IV relates to the food industry in terms of food preservation, government food regulations, and food careers. The last chapter, on food careers, is an invaluable advisement session introducing students to the many careers in food and nutrition. In addition, the Professional Profile feature found in many chapters spotlights individuals working in various areas of the food industry, so students really get a hands-on understanding of various career opportunities. Extensive appendixes provide additional key information, including approximate food measurements, weights and measures, storage temperatures, ingredient substitutions, flavorings and seasonings, and more.

FEATURES

The unique features of this text allow flexibility in teaching and create a dynamic learning environment for students.

- **Career Corner** features provide interviews with people working in the food and nutrition arena to help students on their career path.
- **How and Why** inserts answer the questions most frequently asked by students, sparking natural curiosity and exercising the mind's ability to answer.
- **Chemist's Corner** features provide more advanced information on food chemistry for students and instructors who wish to further explore this topic, allowing flexibility in the level of food chemistry presented within the individual course.
- **Calorie Control** teaches students how to identify food sources of kcalories, how many daily kcalories are recommended, and how to practice portion control.
- **Nutrient Content** boxes provide an overview of the nutritional composition of the foods.
- **Pictorial Summarie**s are a proven favorite with readers. These pictorial chapter summaries use a combination of art and narrative text to encapsulate the key concepts in each chapter for student review.
- **Key terms,** boldfaced in the text, are defined on the same page to allow for quick review of the essential vocabulary in each chapter. A glossary at the end of the book assembles all of the key terms in one place.
- **Functions of ingredients** are highlighted in the introduction to each chapter to aid students in successful food product development and food preparation. They introduce a focus of the food industry that is often missing in other books.
- **Food additive information** has been incorporated throughout the book.
- **Problems and causes tables** summarize the problems that may occur when preparing specific food products and describe the possible causes, providing students with a handy reference tool for deciphering "what went wrong."
- **A 16-page full-color insert** displays exotic varieties of fruits and vegetables, salad greens, flowers used in salads, traditional cuts of meats (including the lowest-fat meat cuts), and much more, all with detailed captions describing use and preparation tips.
- **Chapter review questions** help students prepare for both their class exams and the Academy of Nutrition and Dietetics registration examination.

The dynamic world of food changes rapidly as new research constantly adds to its ever-expanding knowledge base. *Understanding Food: Principles and Preparation,* 5th edition, is designed to meet the needs of this evolving and expanding discipline and to provide students with a strong foundation in any food-related discipline that they select.

NEW TO THIS EDITION

Each chapter of *Understanding Food* has been revised to reflect the evolution of research, consumer preferences, and food-service practices since the publication of the prior edition. Specific additions and other enhancements for the fifth edition are detailed here.

- **Chapter 1:** Updated information on the *Dietary Guidelines for Americans,* including MyPlate, and added a figure comparing the typical U.S. diet to the *Dietary Guidelines;* updated statistics on diversity in the

U.S. population; added information on classifications of natural and processed foods.

- **Chapter 2:** Added a description of electronic noses.
- **Chapter 3:** Enhanced the discussion of water's structure and properties, adding a "Chemist's Corner" feature on calculating the effects of solute concentration on water's boiling and freezing points; reorganized and expanded the discussion of dispersions, adding a figure showing forms of dispersion destabilization, a more in-depth explanation of formation of saturated and supersaturated solutions, and a table describing various types of dispersions; added information on fructooligosaccharides; updated the discussion of food fiber measurement; enhanced the explanation of the Maillard reaction.
- **Chapter 4:** Modified the "food risk road" and thermometers figures to improve clarity; added information on the FDA Food Safety Modernization Act, *Clostridium perfringens,* and *Toxoplasma gondii;* updated statistics on foodborne illness incidence; added a "Chemist's Corner" feature on measurement of protein in foods; expanded the discussion of food safety surveillance.
- **Chapter 5:** Clarified the discussion of induction; updated the information on dietary sodium intakes and reduction; added "How & Why?" features on preparation of substitute cake flour and the differences among hot peppers and powders made from them.
- **Chapter 6:** Added figures of a healthy meal plan and cycle menu; thoroughly updated the discussion of USDA meal plans; added information on the impact of the Healthy, Hunger-Free Kids Act of 2010 and the Patient Protection and Affordable Care Act of 2010.
- **Chapter 7:** Clarified the discussion of protein contraction/relaxation; updated the information on antibiotic use in livestock; clarified the explanation of meat quality problems and their causes; expanded the explanation of the process of rigor mortis; added information on lean finely textured beef (a.k.a. "pink slime"); updated and expanded the section on meat packaging for storage.
- **Chapter 8:** Improved the figure showing how to truss poultry.
- **Chapter 9:** Enhanced the figures showing shrimp deveining and "count per pound" sizes; added information on DNA bar coding of fish.
- **Chapter 10:** Expanded the discussion of casein and whey proteins; updated the "How & Why?" feature contrasting milk intolerance and allergy; clarified the discussion and table on pasteurization techniques; thoroughly updated the discussion of probiotics and prebiotics.
- **Chapter 11:** Enhanced the explanation of enzymes used in cheese coagulation, including bacteria-produced and plant-derived enzymes.
- **Chapter 12:** Updated the information on nutrient contents of eggs.
- **Chapter 13:** Updated the vegetable intake recommendations; clarified the explanation of soy sauce; expanded the "How & Why?" feature on the distinctions among potatoes, sweet potatoes, and yams.
- **Chapter 14:** Updated and reorganized the nutrient content information; updated the discussion of "superfruits" and phytochemicals in fruits.
- **Chapter 15:** Clarified the discussion of bouillons, adding a "How & Why?" feature explaining the distinctions between broths and stocks; expanded discussions of gel preparation and dishes prepared with whipped gels.
- **Chapter 16:** Updated the data and figure on world grain production; added information on black and red rice varieties; reorganized the section of types of grains to categorize them by gluten content, and the grain preparation section to improve flow and clarity.
- **Chapter 17:** Clarified the figures classifying flour proteins and demonstrating the proposed function of lipids in gluten development; reorganized the section on types of flour to categorize them by gluten content.
- **Chapter 18:** Better illustrated starch gelatinization, gel formation, retrogradation, and dextrinization using the example of a pie filling; added a figure categorizing the methods of modifying starches and a table of resistant starch types.
- **Chapter 19:** Updated the references.
- **Chapter 20:** Clarified the proofing discussion; reorganized the figures to follow the bread preparation process sequentially.
- **Chapter 21:** Clarified the use of terminology (e.g., "sucrose" is used consistently to refer to that sugar, and the two meanings of "fruit sugar" are clearly differentiated); enhanced the discussions of high-fructose corn syrup and invert sugar production; added details about luo han guo and stevia extracts to the nonnutritive sweeteners section and table; added a "How & Why?" feature explaining the different ways to express solubility measurements.
- **Chapter 22:** Added a "How & Why?" feature explaining how emulsifiers are distinct from other surfactants; added a "Chemist's Corner" feature on the factors affecting fatty acid melting points; added "How & Why?" features on derivation of the terms *margarine* and *shortening*.
- **Chapter 23:** Added a figure showing several traditional types of unshortened cakes.
- **Chapter 24:** Clarified the distinctions between laminated and nonlaminated pastries and among long flake, short flake, and mealy pastry textures; added photos of types of pies to Table 24-1 and a figure featuring photos of different types of nonlaminated and laminated pastries.
- **Chapter 25:** Added a figure comparing saturation and supersaturation of solutions, a "Chemist's Corner" feature on factors promoting small crystal formation in candies, and a "How & Why?" feature explaining how interfering agents work.
- **Chapter 26:** Clarified various minor points and updated the statistics.
- **Chapter 27:** Streamlined the content and organization to focus on the important characteristics of each type of beverage and its preparation.

- **Chapter 28:** Added figures showing edible biosensors, freeze-drying, irradiation equipment, and irradiation effects on bacteria; expanded the discussion of fermentation; added a "How & Why?" feature on nano foods; added a discussion of sous-vide as a heat preservation method.
- **Chapter 29:** Added information on the FDA Food Safety Modernization Act; clarified the discussion of health claims, updating the list of approved qualified health claims.
- **Chapter 30:** Added a table of salaries for nutrition- and food-related jobs; updated the information on relevant professional organizations, websites, and publications. Added the new registered dietitian nutritionist (RDN) option for registered dietitians (RDs).

ANCILLARY MATERIALS

An assortment of student and instructor support materials, thoroughly updated for the fifth edition, are available:

- The print **Lab Manual,** revised by Janelle M. Walter (Baylor University), presents food experiments and recipes to demonstrate the principles discussed in the text. Pretest questions and materials/time needed information for instructors enhance the lab units, which parallel the organization and content of the text.
- **Cengage Learning Testing powered by Cognero.** A flexible, online system that allows you to author, edit, and manage test bank content from multiple Cengage Learning solutions. Create multiple test versions in an instant. Deliver tests from your LMS, your classroom, or wherever you want. Test questions for this edition were written by Joan Aronson (New York University).
- An **Instructor's Manual** written by Joan Aronson and Cheryl Houston (Fontbonne University), available electronically, features engaging classroom activities, objectives, recommendations, and lecture outlines.
- **Instructor Companion Website.** Everything you need for your course in one place! This collection of book-specific lecture and class tools is available online "http://www.cengage.com/login" www.cengage.com/login. Access and download PowerPoint presentations, images, instructor's manual, videos, and more.
- The text's **CourseMate Website** offers various test preparation exercises for students, including quizzes, and instructor downloads.

ACKNOWLEDGMENTS

Many individuals assisted me in the development of this textbook. First and foremost I thank Peter Marshall, Publisher, without whose knowledge and experience this book would never have come to be. I also thank Peggy Williams, who masterfully brought this book to the completion of yet another edition.

I also extend my thanks to the outstanding members of the Cengage nutrition team: Elesha Feldman, Developmental Editor, for helping me revise and enhance the fourth and fifth editions with incredible finesse, eagle editor eye, and an over and above the call of duty work ethic; Elizabeth Howe, second edition Developmental Editor, for her excellent skills in working with me to create a well-organized manuscript; and Tom Ziolkowski, Marketing Manager, who understands the process of book publishing and marketing to such a high degree that his presence alone is invaluable. My thanks to Yolanda Cossio, Publisher; Kellie Petruzzelli, Editorial Assistant; and Bob Kauser and Roberta Broyer, Permissions Editors. I also thank Michelle Clark at Cengage and the tremendous production staff at MPS Limited who worked miracles on this book, especially Carolyn Deacy, Lynn Lustberg, and Naman Mahisauria.

A special thanks goes to the person who kindled my writing career, Nackey Loeb, Publisher of *The Union Leader.* Your early support and encouragement did far more than you will ever know.

Many colleagues have contributed to the development of this text. Their thoughtful comments provided me with valuable guidance at all stages of the writing process. I offer them my heartfelt thanks for generously sharing their time and expertise. They are:

Renee Hirschman Alster, MS, RD
Brooklyn College CUNY

Elizabeth Christian
Texas Woman's University

Kristi Crowe, PhD, RD, LD
University of Alabama

Alyce D. Fly, PhD
Indiana University

Keely Hawkins, MS
Texas Tech University

Georgia Jones, PhD
University of Nebraska–Lincoln

Lalitha Samuel, PhD
Lehman College CUNY

Finally, I wish to express my appreciation to the students. Were it not for them, I would not have taken pen to paper. I am grateful to be part of your academic journey.

Amy Christine Brown, PhD, RD
University of Hawaii at Manoa
amybrown@hawaii.edu

About the Author

Carl Shameff

Amy Christine Brown received her PhD from Virginia Polytechnic Institute and State University in 1986 in the field of Human Nutrition and Foods. She has been a college professor and a registered dietitian with the Academy of Nutrition and Dietetics since 1986. Dr. Brown currently teaches at the University of Hawaii's John A. Burns School of Medicine in the Department of Complementary and Alternative Medicine. Her research interests are in the area of bioactive plant substances beneficial to health and medical nutrition therapy. Some of the studies she has conducted include "Diet and Crohn's disease," "Potentially harmful herbal supplements," "Kava beverage consumption and the effect on liver function tests," and "The effectiveness of kukui nut oil in treating psoriasis." Selected research journal publications include: "Position of the American Dietetic Association: functional foods" (*Journal of the American Dietetic Association*); "The Hawaii Diet: Ad libitum high carbohydrate, low fat multi-cultural diet for the reduction of chronic disease risk factors" (*Hawaii Medical Journal*); "Lupus erythematosus and nutrition: A review" (*Journal of Renal Nutrition*); "Dietary survey of Hopi elementary school students" (*Journal of the American Dietetic Association*); "Serum cholesterol levels of nondiabetic and streptozotocin-diabetic rats" (*Artery*); "Infant feeding practices of migrant farm laborers in northern Colorado" (*Journal of the American Dietetic Association*); "Body mass index and perceived weight status in young adults" (*Journal of Community Health*); "Dietary intake and body composition of Mike Pigg—1988 Triathlete of the Year" (*Clinical Sports Medicine*); and numerous newspaper nutrition columns.

Feedback welcome, contact: amybrown@hawaii.edu

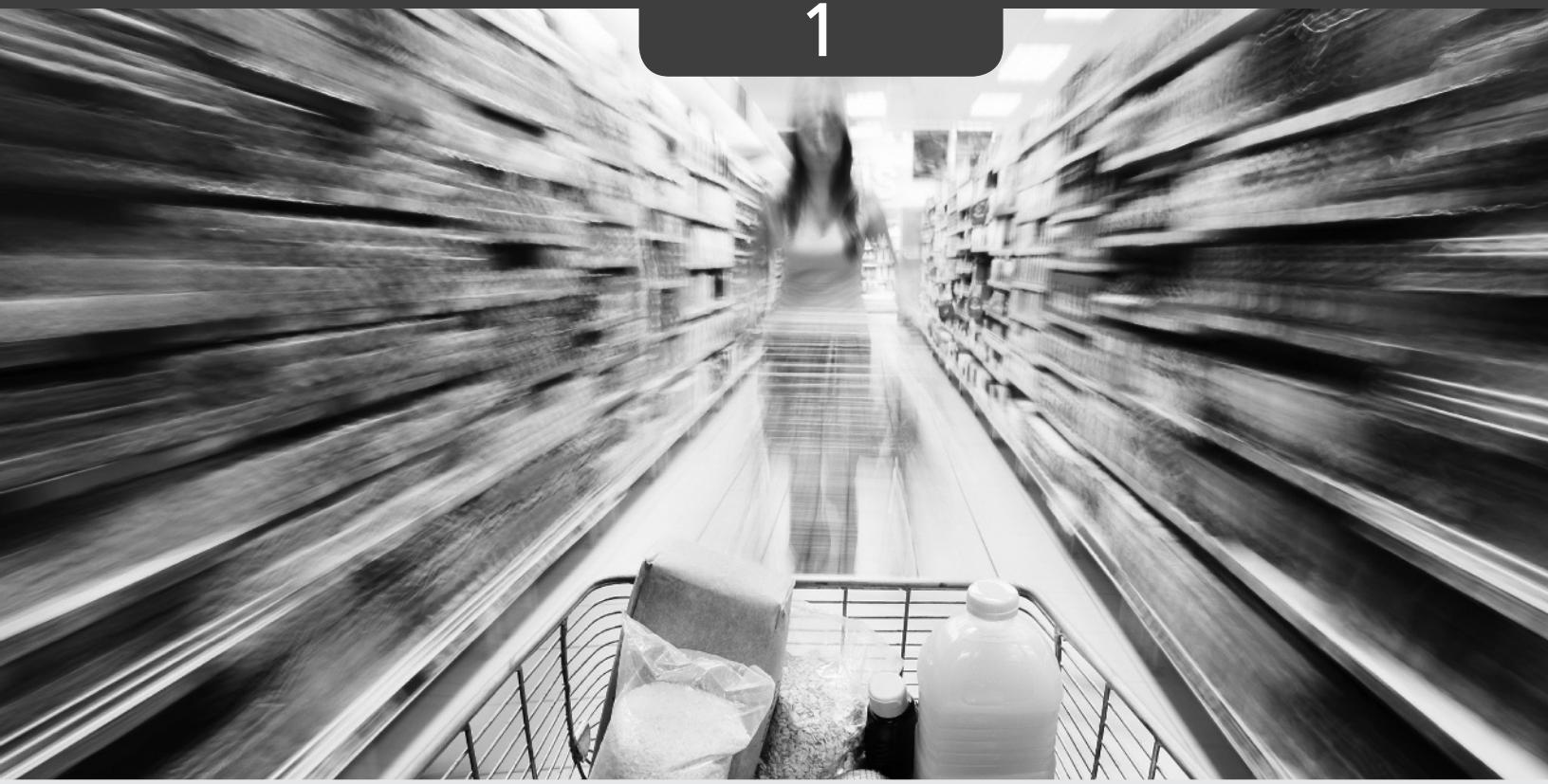
To Jeffery Blanton

The person who saw me through four years of writing the first edition. Four years, four thousand laughs, and only one you.

Always Grateful,

Amy Christine Brown

1



Food Selection

Don Bayley/RapidEye/istockphoto.com

Not too long ago, meats, milk, grains, nuts, vegetables, and fruits were the only foods available for consumption. Today, food companies offer thousands of prepared and packaged foods, which are primarily mixtures of these basic ingredients but often include natural and/or artificial additives. This wide assortment of processed foods makes planning a nutritious diet more difficult, rather than easier. Food companies compete fiercely to develop ever newer and more attractive products. The food scientists they employ focus on why people eat, what they eat, and which food characteristics entice consumers to choose one brand over another.

People choose foods and beverages for at least five basic reasons: how foods look and taste, health, cultural and religious values, psychological and social needs, and budgetary concerns (17). This chapter addresses the factors influencing consumer food selection.

SENSORY CRITERIA

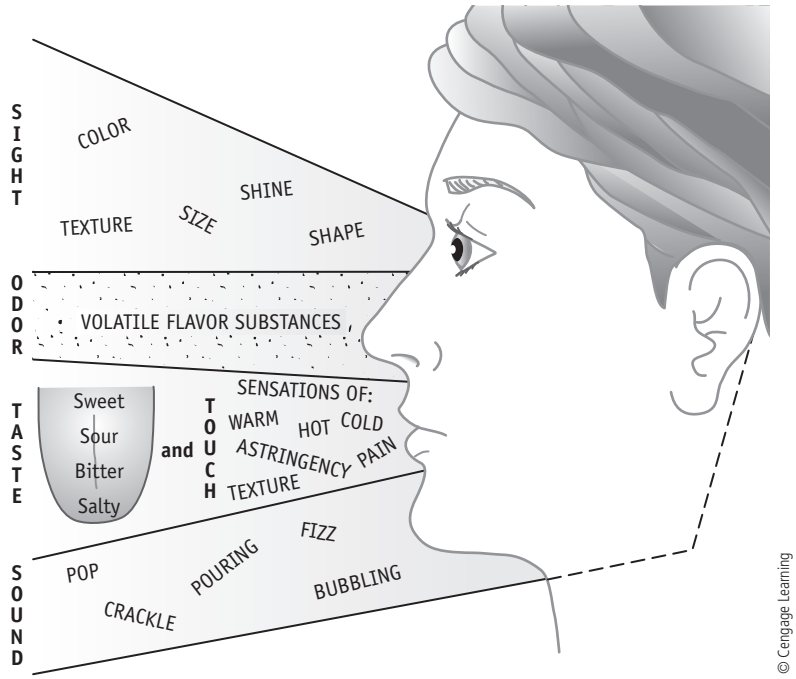
When people choose a particular food, they evaluate it consciously or unconsciously, primarily by how it looks, smells, tastes, feels, and even sounds (Figure 1-1). These sensory criteria are discussed first because of their strong influence on food selection. How a food or beverage affects the senses is more important to most consumers than other criteria for food selection. The sensory criteria of sight, odor, and taste are evaluated below.

Sight

The eyes receive the first impression of foods: the shapes, colors, consistency, serving size, and presence of any outward defects. Color can denote the ripeness, strength of dilution, and even degree to which the food was heated. Black bananas, barely yellow lemonade, and scorched macaroni send visual signals that may alter a person's choices. Color can be deceiving; if the colors of two identical fruit-flavored beverages are different, people often perceive them as tasting different even though they are exactly the same (88). People may judge milk's fat content by its color. For instance, if the color of reduced-fat (2%) milk is improved, it is often judged to be higher in fat content, smoother in texture, and better in flavor than the reduced-fat milk with its original color (71).

The color palette of foods on a plate also contributes to or detracts from

FIGURE 1-1 Sensory impressions of food provided by the five senses.



their appeal. Imagine a plate containing baked flounder, mashed potatoes, boiled cabbage, and vanilla ice cream, and then compare it to one that contains a nicely browned chicken breast, orange sweet potatoes, green peas, and blueberry cobbler. Based on eye appeal alone, most people would prefer the latter.

Odor

Smell is almost as important as appearance when people evaluate a food item for quality and desirability. Although the sense of smell is not as acute in human beings as it is in many other mammals, most people can differentiate between 2,000 and 4,000 odors, whereas some highly trained individuals can distinguish as many as 10,000 (5).

Classification of Odors

Naming each of these thousands of odors separately would tax even the most fertile imagination; researchers have categorized them into major groups. One classification system recognizes six groups of odors: spicy, flowery, fruity, resinous (eucalyptus), burnt, and foul. The other widely used grouping scheme consists of four categories: fragrant (sweet), acid (sour), burnt, and caprylic (goaty) (5). A newer proposed classification divides odors into categories based on whether they are perceived as edible (e.g., fruit, candy, bakery, or spice) or inedible (e.g., clean, flower, and cosmetic) and overlaps with previous classification systems (98).

Detecting Odors

Regardless of the classifications, most odors are detected at very low concentrations. Vanillin can be smelled at 2×10^{-10} (0.0000000002) mg per liter of air (18). The ability to distinguish between various odors diminishes over the time of exposure to the smells; this perception of a continuously present smell gradually decreasing over time is called *adaptation*. People living near a noxious-smelling paint factory will, over time, come not to notice it, whereas visitors to the area may be taken aback by the odor.

We are able to detect odors when **volatile molecules** travel through the air and some of them reach the yellowish-colored **olfactory** epithelium, an area the size of a quarter located inside the upper part of the nasal cavity. This region is supplied with olfactory cells that number from 10 million to 20 million in a human and about 100 million in a rabbit (13), reflecting the difference in importance of the sense of smell between people and rabbits. The exact function of these specialized cells in the sense of smell is not well understood.

Interestingly, molecules can sometimes reach the olfactory epithelium by first going through the mouth and then back up to the nose. Who has not experienced the feeling of bubbles tingling in the nose brought on by drinking a carbonated beverage while simultaneously being made to laugh unexpectedly?

Volatile molecules Molecules capable of evaporating like a gas into the air.

Olfactory Relating to the sense of smell.

How & Why?

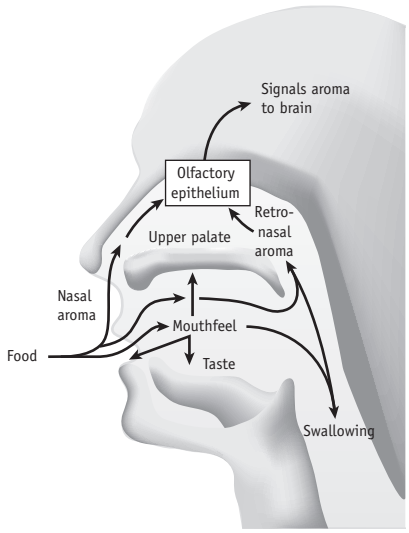
Imagine the scent of chocolate chip cookies wafting through the house as they bake. How does this smell get carried to people? Why is the odor of something baking more intense than the odor of cold items like ice cream or frozen peaches?

Heat converts many substances into their volatile form. Because only volatile molecules in the form of gas carry odor, it is easier to smell hot foods than cold ones. Hot coffee is much easier to detect than cold coffee. Relatively large molecules such as proteins, starches, fats, and sugars are too heavy to be airborne, so their odors are not easily noticed. Lighter molecules capable of becoming volatile are physically detected by the olfactory epithelium by one of two pathways: (1) directly through the nose and/or (2) during eating when they enter the mouth and flow retronasally, or toward the back of the throat and up into the nasal cavity (Figure 1–2) (70).

Taste

Taste is usually the most influential factor in people's selection of foods (20). Taste buds—so named because the arrangement of their cells is similar to the shape of a flower bud—are located primarily on the tongue, but are also found on the mouth palates and in the pharynx. These taste detectors are not

FIGURE 1-2 Detecting aroma, mouthfeel, and taste.



© Cengage Learning

Stockbyte/Jupiter Images

found on the flat, central surface of the tongue, but rather on the tongue's underside, sides, and tip.

Mechanism of Taste

What is actually being tasted? Many tasted substances are a combination of nonvolatile and volatile compounds. In order for a substance to be tasted, it must be dissolved in liquid or saliva, which is 99.5% water. In the middle of each taste bud is a pore, similar to a little pool, where saliva collects.

When food comes into the mouth, bits of it are dissolved in the saliva pools and they come into contact with the cilia, small hair-like projections from the **gustatory** cells. The gustatory cells relay a message to the brain via one of the cranial nerves (facial, vagus, and glossopharyngeal). The brain, in turn, translates the nervous electrical impulses into a sensation that people recognize as "taste." As people age, the original 9,000 to 10,000 taste buds begin to diminish in number, so people over 45 often find themselves using more salt, spices, and sugar in their food. Genetics also plays an important role in taste; for example, some people can detect monosodium glutamate (MSG) in foods because it contains glutamate. Another important factor influencing the ability of a person to taste is the degree to which a compound can dissolve (59). The more moisture or liquid, the more the molecules triggering flavor can dissolve and spread over the tongue to contact the taste buds (34).

The Five Taste Stimuli

The common concept of a "tongue map," in which different areas on the tongue are associated with the basic types of tastes—sweet, sour, bitter, and salty—has been largely discredited (14). Nonetheless, these four basic tastes, along with a fifth known as savory (*umami*, a Japanese word meaning "delicious"), are perceived in response to certain chemical stimuli. The time it takes to detect taste stimuli varies from a split second for salt to a full second for bitter substances (13). Bitter tastes, therefore, have a tendency to linger. The chemical basis of these five categories of taste is as follows:

- The sweetness of sugar comes from the chemical configuration of its molecule. A long list of substances yield the sweet taste, including sugars, glycols, alcohols, and aldehydes. Little is known, however, about the sweet taste receptor and how "sweetness" actually occurs (34).
- Sour taste comes from the acids found in food. It is related to the concentration of hydrogen ions (H^+), which are found in the natural acids of fruits, vinegar, and certain vegetables. The perceived unpleasantness of too much sour food may protect against disrupting the body's acid–base balance (14).
- Bitterness is imparted by compounds such as caffeine (tea, coffee), theobromine (chocolate), and phenolic compounds (grapefruit). Many other substances yield bitter tastes, including the alkaloids often found in poisonous plants (7). Thus, the ability to taste bitterness can warn us against ingesting some toxins.
- Salty taste comes from ionized salts—for example, from the sodium ions (Na^+) in sodium chloride (NaCl) or other salts found naturally in some foods.
- Savory (*umami*) taste was first identified in 1908 by researchers at Tokyo Imperial University. *Umami* is attributed to glutamate, an amino acid that imparts the taste of beef broth, but without the salt (62).

Taste Interactions

Each item used in food preparation contains several compounds, and bringing these items together creates new tastes when all their compounds interact.

Gustatory Relating to the sense of taste.

Factors Affecting Taste

Not everyone perceives the taste of apple pie the same way. There is considerable genetic variation among individuals in sensitivity to basic tastes (70). Tasting abilities may also vary within the individual, depending on a number of outside influences (67). One such factor affecting taste is the temperature of a food or beverage. Taste buds operate best at temperatures of around 86°F(30°C). As the temperature of foods or beverages goes below 68°F(20°C) or above 86°F(30°C), it becomes harder to distinguish their tastes accurately. For example, very hot coffee tastes less bitter, whereas slightly melted ice cream tastes sweeter. Other factors influencing taste include the color of the food; the time of day it is eaten; and the age, sex, and degree of hunger of the taster (35). Psychological factors, such as preconceived ideas based on appearance or on previous experiences with a similar food, also affect a person's perception of taste. For instance, cherry-flavored foods are expected to be red, but if they are colored yellow, they become difficult to identify as cherry. Also, unpleasant experiences associated with a food may influence the perceived taste of that food in the future.

Variety in available food choices also affects taste. This can be seen when the "taste," or appetite, for a food eaten day after day starts to diminish. Even favorite foods can eventually lose their appeal when consumed daily. Some weight-reducing fad diets that severely restrict choices are based on the idea that people will get tired of eating just one type of food and therefore eat less. A routine of grapefruit for breakfast, grapefruit for lunch, and grapefruit for dinner quickly becomes boring and unappetizing.

Definition of Flavor

In examining the factors affecting taste, it is important to distinguish between taste and **flavor.** Taste relies on the taste buds' connection to the brain via nerve cells, which signal the sensations of sour, salt, sweet, bitter, and savory. Flavor is a broader concept than either taste or aroma; in fact, it includes both. The perception of aroma is triggered by volatile compounds reaching the nose and provides about 75% of the impression of flavor (18, 79). Thus, a food without aroma has very little flavor. To get some idea of how the ability to smell affects flavor perception, think of having a cold with a badly stuffed-up nose. Everything tastes different. The nasal congestion interferes with the function of the olfactory sense, impairing the ability to detect the aromas contributing to the perception of flavor. Some people apply this principle to their advantage by pinching their nostrils shut to lessen the bad flavor of a disagreeable medicine they must swallow.

Whether in a package or on a plate, a commercial food's flavor is the single most important factor determining its success in the marketplace (21).

How & Why?

Why does a dash of salt make some foods sweeter?

Taste sensitivity depends on a number of factors, including: (1) the amount of time allowed to taste a substance, (2) the concentration of the substance generating the taste, and (3) the individual's ability to detect various tastes. The threshold concentration is the minimum concentration required to detect a substance. This is not easy to determine, because people more sensitive to a particular taste than others can detect it at a lower concentration. Below the threshold concentration are subthreshold concentrations that are not detected but may influence the person's ability to perceive other tastes. For example, subthreshold salt levels increase perceived sweetness while decreasing perceived acidity, even though the actual amount of sugar or acid in the food is unchanged. Conversely, subthreshold sugar or acid concentrations make a food taste less or more salty, respectively. This principle can be applied to foods when too much salt is added to soups or stews. Even though the salt cannot be removed, adding a small amount of sugar will make the dish taste less salty (66). Trace additions of sugar also make acids taste less sour and coffee or tea less bitter. Small amounts of salt sprinkled on grapefruit or added to fruit pies tend to decrease tartness and enhance sweetness. Some compounds, like monosodium glutamate, often used in Chinese cooking, actually improve the taste of meat and other foods by making them sweeter (53, 69).

How & Why?

How are food flavors preserved during storage?

Flavors, regardless of the medium in which they are dissolved, do not stay at the same intensity day after day, but diminish over time. Sensory chemists and flavor technologists know that one way to keep the food products sold by manufacturers from losing their appeal is to prevent the volatile compounds responsible for flavor from deteriorating, escaping, or reacting with other substances. In devising flavor preservation strategies, they look at processing, storage, and cooking methods, all of which affect the volatile flavor compounds. One of the major functions of protective packaging is to retain a food's flavor. Packaging guards flavor in several ways. It protects against vaporization of the volatile compounds and against physical damage that could expose food to the air and result in off odors. It keeps unpleasant odors from the outside from attaching to the food. It also prevents "flavor scalping"—the migration of flavor compounds from the packaging (sealers, solvents, etc.) to the food or vice versa (54).

Touch

The sense of touch, whether it operates inside the mouth or through the fingers, conveys to us a food's texture, consistency, astringency, and temperature.

Texture is a combination of perceptions, with the eyes giving the first clue. The second comes at the touch of fingers and eating utensils, and the third is mouthfeel, as detected by the teeth and the tactile nerve cells in the mouth.

Flavor The combined sense of taste, odor, and mouthfeel.

CAREER CORNER

Ben Cohen and Jerry Greenfield—Cofounders of Ben & Jerry's

Steve Liss/Time Life Pictures/ Getty Images

Ben Cohen and Jerry Greenfield

It's hard to believe, but some people taste food for a living. "Taste testers" have such sensitive taste buds or olfactory detection that they are hired by food companies to taste new products being developed. Food companies need to be sure that the absolute best product is being produced for consumers. The first taste tester at Ben & Jerry's Ice Cream was the company's cofounder, Ben Cohen. He had such weak taste buds that he kept asking the flavor developers for more sugar, salt, chocolate cookies, or caramel. His challenged taste buds made Ben & Jerry's ice creams famous for their intense flavors.

Ben & Jerry's started small. Ben Cohen and Jerry Greenfield were high school friends, and Ben drove an ice cream truck selling ice cream pops to kids. He went to college, dropped out, and returned to his ice cream job. Ben also taught crafts in a residential school for emotionally disturbed children, where he began experimenting with ice cream–making as a craft activity for the students. This led to him selling ice cream with Jerry, whose application to medical school had been rejected twice. Their first store was "Ben & Jerry's Homemade Ice Cream Parlor" in a renovated gas station in Vermont. The rest is ice cream history (www.benjerry.com).

Textural or structural qualities are especially obvious in foods such as apples, popcorn, liver, crackers, potato chips, tapioca pudding, cereals, and celery, to name just a few. Textures can be described as coarse (grainy, sandy, mealy), crisp, fine, dry, moist, greasy, smooth (creamy, velvety), lumpy, rough, sticky, solid, porous, bubbly, or flat. Tenderness, which is somewhat dependent on texture, is judged by how easily the food gives way to the pressure of the teeth.

Consistency is only slightly different from tenderness; it is expressed in terms of brittleness, chewiness, viscosity, thickness, thinness, and elasticity (rubbery, gummy).

Astringency, which causes puckering of the mouth, is possibly due to the drawing out of proteins naturally found in the mouth's saliva and mucous membranes (13). Foods such as cranberries, lemon juice, and vinegar have astringent qualities.

Another term used in the sensory perception of foods is **chemesthesis.** Chemesthesis defines how certain foods that are not physically hot or cold appear to give the impression of being "hot" (hot salsa) or "cooling" (cucumbers) when placed on the tongue (37). Although extremely hot temperatures can literally burn the taste buds (they later regenerate), the other kind of "heat" experienced with food results from eating "hot" peppers (Chemist's Corner 1-1). Capsaicin (cap-SAY-iss-in) is the chemical responsible for the "heat" that many people enjoy in moderation, as well as the real pain experienced when an excess irritates nerves in the nose and mouth. In fact, this compound is so caustic when concentrated that it is used by many law enforcement agencies in place of mace-like sprays.

How & Why?

Why do flavors differ in how quickly they are detected or how long they last?

The amount of fat in a food or beverage determines how intense the flavor is over time. Flavor compounds dissolved in fat (fat-soluble compounds) take longer to be detected and last longer than flavor compounds dissolved in water (water-soluble compounds), which are quickly detected but also disappear much more quickly (18). This explains why a reduced-fat product is unlikely to duplicate the flavor of the original food: the original fat's flavor compounds are missing, causing an imbalance of the other flavors present. Reduced-fat cookies, for example, taste sweeter unless they are modified to compensate for this difference (50). It is even more difficult to replace certain fats that have their own distinctive flavor, such as butter, olive oil, and bacon fat (54).

CHEMIST'S CORNER 1-1

Hot Peppers and Body Chemistry

The warming sensation experienced by some people eating hot peppers (or foods made with them) is due to the body's secreting catecholamines, a group of amines composed of epinephrine (adrenaline), norepinephrine (noradrenaline), and dopamine. These catecholamines activate the "fight-or-flight" response, which normally triggers an increased respiration rate, a faster heart beat, slowed digestion, widened pupils, and enhanced energy metabolism (39, 72).

Consistency A food's firmness or thickness.

Astringency A sensory phenomenon characterized by a dry, puckery feeling in the mouth.

Chemesthesis The ability to feel a food's chemical properties (e.g., cool mints or hot chili peppers).

Hearing

The sounds associated with foods can play a role in evaluating their quality. How often have you seen someone tapping a melon to determine whether it is ripe? Sounds like sizzling, crunching, popping, bubbling, swirling, pouring, squeaking, dripping, exploding (think of an egg yolk in a microwave), and crackling can communicate a great deal about a food while it is being prepared, poured, or chewed. Most of these sounds are affected by water content, and their characteristics thus give clues to a food's freshness and/or doneness.

NUTRITIONAL CRITERIA

Over the past several decades, emerging scientific evidence about health and nutrition has resulted in changing food consumption patterns in the United States (8). Past surveys reveal that at least half of all consumers were reportedly making a major change in their diets, with nutrition being second only to taste in importance to shoppers (96). Currently, about 71 percent of Americans say they are trying to limit the intake of some type of fats, and 66 percent of Americans say they are trying to limit their consumption of saturated fats and/or trans fatty acids. More than half of Americans are trying to limit their consumption of sugars (47). Attempts to improve food habits are related to the increased awareness that a poor diet can be related to some of the leading causes of death—heart disease, cancer, and diabetes—as well as to other common health conditions such as osteoporosis, diverticulosis, and obesity (38).

Calorie The amount of energy required to raise 1 gram of water 1°C (measured between 14.5°C and 15.5°C at normal atmospheric pressure). A *kilocalorie* (kcalorie, kcal), the unit commonly used to measure food energy, is equal to 1,000 calories.

Weight Management

Obesity has reached epidemic proportions in the United States (19). As a risk factor for heart disease, cancer, diabetes, and other health conditions, obesity is one of the biggest and costliest health problems in the nation. Health care costs are higher for people who are obese as compared to people of normal weight (55). Also, billions are spent annually by millions of North Americans seeking "quick fix" weight loss solutions, most of which achieve no permanent results. According to an International Food Information Council survey, most Americans (69%) are trying to reduce or maintain their weight (47). They consider this a strong factor influencing their decision to make dietary changes and remain physically active.

Generally, individuals must restrict their intake of food energy and increase their expenditure of energy (e.g., through bodily movement) in order to lose weight. Energy can be correlated to heat and is measured in units called **calories** (or joules or Btu; see Chemist's Corner 1-2). Food energy is measured in kilocalories (abbreviated kcalories or kcal). The "Measuring Heat Energy" section in Chapter 3 provides further details.

CHEMIST'S CORNER 1-2

Other Units of Measurement for Energy

The metric equivalent of the calorie is the joule (J) or kilojoule (kJ). One joule is defined as the work or energy required to move 1 kilogram of mass 1 meter. One calorie is equivalent to 4.184 joules, whereas 1 kilocalorie equals 4.2 kilojoules. Another measure of heat is the British thermal unit (Btu), which is the amount of energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit. The Btu is more commonly used to measure the heating capacity of fuels used in various industries (heating, power, steam, and air conditioning).

Because a calorie is a unit of measure, not a component of foods (or of the body), it is more accurate to speak of energy rather than calories, unless a specific amount is being discussed. The "Calorie Control" features found in many chapters of this book explain the basics of weight management and provide practical guidelines for making lower-kcalorie food choices to reduce energy intake.

Dietary Guidelines for Americans

In an effort to reduce dietary risk factors for some of the major health conditions affecting Americans, the U.S. Department of Agriculture (USDA) and the U.S. Department of Health and Human Services (DHHS) have published the *Dietary Guidelines for Americans* every 5 years since 1980 (93, 94). The 2010 *Dietary Guidelines* for healthy adults published in January 2011 represent the federal government's evidence-based nutritional guidance to promote health, reduce the risk of chronic diseases, and reduce the prevalence of overweight and obesity through improved nutrition and physical activity (83). They also serve to guide federal food programs and nutrition education programs (85). They encourage people to follow the recommendations available at www.choosemyplate.gov (select Dietary Guidelines). In general, a healthy diet emphasizes:

- Staying within daily energy needs for recommended body weights.
- Consuming a variety of vegetables, fruits, whole grains, and fat-free and low-fat milk products.
- Eating lean meats, poultry, seafood, legumes, eggs, seeds, and nuts.
- Keeping intakes of saturated and trans fats, cholesterol, salt (sodium), and added sugars low.

ChooseMyPlate

MyPlate is a pictorial illustration of the concepts of the 2010 *Dietary Guidelines*. It shows people what to put on their plate by dividing it into four sections—vegetables, fruits, grains,

CALORIE CONTROL
Calorie Balance

One out of every three people in the United States was classified as "obese" in 2010 according to the Centers for Disease Control and Prevention (CDC) (10). A website link at the end of this chapter allows each person to calculate his/her body mass index (BMI). This number is a ratio based on a person's weight to height that classifies him or her as underweight, normal weight, overweight, or obese.

The CDC is concerned about obesity because of health consequences, high health care costs, increased absenteeism, and work-related injuries (49). Although many other factors such as environment, genetics, disease, and drugs may contribute to obesity, this book focuses on the primary cause of obesity—too many kcalories (Figure 1-3).

The purpose of the "Calorie Control" sections in this book is to address the obesity epidemic by providing readers with kcalories found in foods and healthful ways to modify their diets. Specific topics to be included are: (1) average daily caloric intakes by Americans (see below), (2) kcalorie sources (see Chapter 3, "Chemistry of Food Composition"), (3) the average number of kcalories found in foods (see individual chapters), (4) suggestions for practicing portion control (see Chapter 5, "Food Preparation Basics" and various individual chapters), and (5) healthful preparation methods (various chapters).

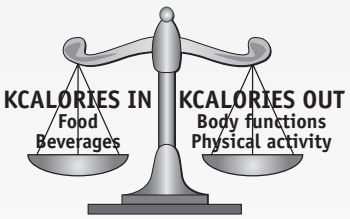
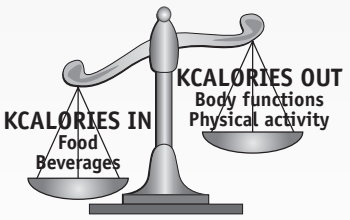
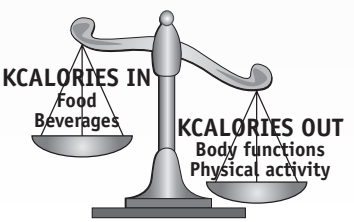
How Many Kilocalories Do People Consume Each DAY?

The Dietary Reference Intakes (DRI) for kcalories (2,403 per day for women and 3,067 for men) exceed those reported by the National Health and Nutrition Examination Survey (2009–2010), which measures the actual kcaloric intakes (1,778 for women and 2,512 for men over 20 years of age) of a population in which one fourth are obese (11). Although it's best for people to determine their specific caloric and nutrient needs by seeing a registered dietitian (RD) or using the USDA's SuperTracker (https://www.choosemyplate.gov/SuperTracker/CreateProfile.aspx), the intakes below serve as general guidelines for healthy adults who wish to "reach" and "maintain" a healthy goal weight:

Women	Approximately 1,600 kcalories for each day
Men	Approximately 2,400–2,600 kcalories for each day

This estimate includes exercising three times a week for at least 20 minutes each session. A person will need more kcalories if they exercise more than three times a week—approximately 300 to 600 kcalories for each hour of aerobic exercise. The exceptions are active (athletes) and larger people, who need more calories; sedate and shorter people, who need fewer calories; and older people, who need fewer kcalories (after 40, people need 100 fewer kcalories for each 10 years of age) (93).

FIGURE 1-3 Caloric balance is like a scale. To remain in balance and maintain your body weight, the kcalories consumed (from foods) must be balanced by the kcalories used (in normal body functions, daily activities, and exercise).

If you are:		Your caloric balance is:
Maintaining Weight		• "IN BALANCE" • You are eating roughly the same number of kcalories that your body is using. • Your weight will remain stable.
Gaining Weight		• "IN KCALORIC EXCESS" • You are eating more kcalories than your body is using. • You will store these extra kcalories as fat and you'll gain weight.
Losing Weight		• "IN KCALORIE DEFICIT" • You are eating fewer kcalories than you are using. • Your body is pulling from its fat storage cells for energy, so your weight is decreasing.

(Continued)

How Many Kilocalories for Each MEAL?

Because it's challenging to count total daily kcalories, the easier method is to break it down for each "meal." For example, a woman requiring 1,600 kcalories (kcal) a day could divide this into three 400-kcalorie meals plus one 400-kcalorie snack (or two 200-kcalorie snacks). The snacks are best eaten midmorning and midafternoon, but can be taken in any combination of kcalories during any part of the day and even as part of a meal. A man requiring 2,400 kcalories a day could divide this into three 600-kcalorie meals plus one 600-kcalorie snack (or two 300-kcalorie snacks).

Starving Is a Bad Idea

About two thirds of a person's kcalories are used to sustain life: heart beating, lungs breathing, body temperature at 97.6°F (36.4°C), and other bodily functions. Most of the remaining 30% of kcalories are burned by activity.

The bottom line is that based on sex, a person should not consume less than the following amount of daily kcalories:

Women	1,200 kcalories (about 70% of 1,600)
Men	1,600 kcalories (about 70% of 2,400)

How to Gain or Lose Weight

The recommended method of gaining or losing weight is to either increase or decrease caloric intake, respectively, by at least 500 kcalories a day. This should result in a weekly 1-pound weight gain or loss, respectively.

How Many Kilocalories Equal a Pound?

3,500 kcalories = 1 pound

To lose 1 pound = Consume 3,500 kcalories less and/or burn it off with exercise

To gain 1 pound = Consume 3,500 kcalories over what your body burns

Combination of Diet and Exercise

If a person can achieve a deficit of 500 kcalories per day through diet and/or exercise, they will lose approximately 1 pound a week.

Successful Weight Loss is Usually Slow

Consistency is the goal. The slower you lose the weight, the more likely it will stay off.

1 pound a week for 1 month = 4 weeks = 4 pounds

1 pound a week for 1 Year = 52 weeks = 52 pounds

and protein foods (Figure 1-4). The www.choosemyplate.gov website provides interactive tools to assist people in creating a personalized **food group plan** based on the *Dietary Guidelines* and taking small steps toward making better daily food and lifestyle choices.

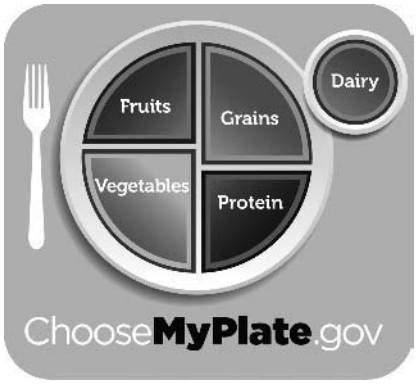
SuperTracker

The SuperTracker is an online diet and physical activity tracking tool. It is available at http://www.choosemyplate.gov/supertracker-tools/supertracker.html. Here, consumers can look up individual foods to see or compare their nutritional values, find recommendations for what and how much to eat, and compare food choices to these recommendations and their personal nutrient needs (78).

Food group plan A diet-planning tool that groups foods together based on nutrient and/or kcalorie content and then specifies the amount of each group a person should consume based on their recommended kcalorie intake.

Antioxidant A compound that inhibits oxidation, which can cause deterioration and rancidity.

FIGURE 1-4 MyPlate: A pictorial demonstration of the 2010 *Dietary Guidelines.*



Source: United States Dept. of Agriculture.

Previous Food Group Plans

MyPlate is a successor to several previous food plans, including MyPyramid (released in 2005) and the Food Guide Pyramid (1992), all developed to encourage Americans to improve their diets. One of the first food group plans was the basic four food groups of milk, meat, vegetable/fruit, and bread/cereal (28). Other countries have their own versions of food group plans; Canada's version is available online (see websites at the end of chapter) (73).

Vegetarianism

About 3 to 4% of the U.S. population does not consume meat, poultry, or seafood, and approximately 1% of adults are vegan (29), compared to approximately 15% of college students who define themselves as vegetarians. The Academy of Nutrition and Dietetics has suggested that properly planned vegetarian diets may reduce the risk of certain chronic, degenerative diseases and conditions, including heart disease, some cancers, diabetes mellitus, obesity, and high blood pressure (1). Other factors, however, may contribute to the decreased morbidity and mortality from these diseases among vegetarians. These include positive lifestyle differences such as lower rates of smoking and drinking. Nevertheless, the benefits of vegetarian diet probably come from lower intakes of fat, saturated fat, cholesterol, and animal protein, balanced by higher levels of phytochemicals, fiber, complex carbohydrates, **antioxidants** such as vitamins C and E, carotenoids, and folate (a B vitamin) (58). A 2007 World Cancer Research Fund (WCRF) and American Institute for Cancer Research (AICR) report stated that one's risk of cancer can

be reduced by maintaining a healthy weight throughout life, consuming a diet high in plant-based foods, limiting intakes of red meat, avoiding salty foods and processed meat, and consuming alcohol in modest amounts, if at all (90).

Consumer Dietary Changes

As a result of these dietary guidelines and other influences, consumers have shifted their dietary concerns and intakes, and more people are reading the Nutrition Facts on food labels to understand what they are consuming (Chapter 29). Throughout the 1990s, consumers reported that their biggest nutritional concern was fat (84). Today, Americans are ingesting less milk and more poultry, fish, fresh vegetables, and grains. As a result, fat consumption has dropped from 42% of kcalories in the mid-1960s to less than 33% today (12, 95). Despite some positive dietary trends, progress remains to be made by Americans in order to meet the *Dietary Guidelines for Americans,* as shown in Figure 1-5 (89).

Complementary and Alternative Medicine

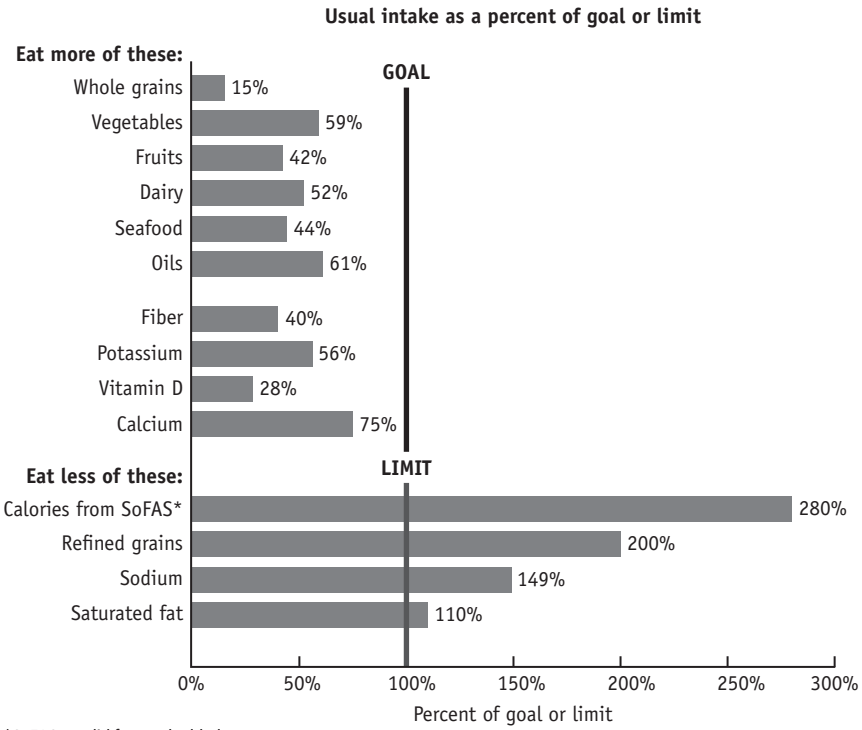
Another influence on consumer dietary changes is complementary and alternative medicine (CAM), which is making permanent inroads in the U.S. medical landscape. Terms such as **nutraceuticals** and **functional foods** (described more fully following this section) are becoming commonplace. In the United States, *nutraceuticals* is a term often used to refer to dietary supplements, while the official definition in Canada is "a product isolated or purified from foods, and generally sold in medicinal forms not usually associated with food and demonstrated to have a physiological benefit or provide protection against chronic disease" (42). About 33% of Americans have used herbs or herb products medicinally, and about 60% take a multivitamin supplement.

Europe and Japan lead the way in complementary medicine. In Germany, the E Commission was created in 1978 to ensure product standardization and safe use of herbs and phytomedicines. Composed of a body of experts from the medical and pharmacology professions, the pharmaceutical industry, and laypersons, the German E Commission studies the scientific literature for research data on herbs based on clinical trials, field studies, and case studies. It has created a collection of **monographs** representing the most accurate information available in the world on the safety and efficacy (power to produce effects or "does it work?") of herbal products. Germany defines herbal remedies in the same manner as it does drugs, because its physicians, and others in Europe, often prescribe herbal remedies that are paid for by government health insurance.

Functional Foods

Overall, more and more people are viewing foods as an integral part of maintaining their health (47). The "food is medicine" concept is common to many cultures, and the shift from treating an established disease to possibly delaying or even preventing it is slowly gaining ground globally. The functional food concept first developed in Japan in the late 1980s. In Japan, "Foods for Specified Health Use," are functional foods produced, selected, or consumed for reasons beyond basic caloric and nutrient content. Purported uses for which functional foods have been manufactured include cancer risk reduction, heart health (blood pressure and blood cholesterol levels), and maintenance of gastrointestinal health (3, 45). Both Japan and Europe appear to surpass the United States in their interest in how foods can benefit health beyond providing carbohydrates, protein, fat, and vitamins/minerals. In fact, Japan is the only country that recognizes functional foods as a distinct

FIGURE 1-5 What Americans eat versus what the 2010 *Dietary Guidelines* recommend they should eat.



*SoFAS = solid fats and added sugars.

Source: U.S. Department of Agriculture and U.S. Department of Health and Human Services. Dietary Guidelines for Americans, 2010. 7th Edition, Washington, DC: U.S. Government Printing Office, December 2010. Figure 1-5 How Do Typical American Diets Compare to Recommended Intake Levels or Limits? (p. 46).

Nutraceutical A bioactive compound (nutrient or nonnutrient) that has health benefits.

Functional food A food or beverage that imparts physiological benefits that enhance overall health, prevents or treats a disease or condition, and/or improves physical/mental performance.

Monograph A summary sheet (fact sheet) describing a substance in terms of name (common and scientific), chemical constituents, functional uses (medical and common), dosage, side effects, drug interactions, and references.