An Introduction to Nutrition

v. 1.0

This is the book An Introduction to Nutrition (v. 1.0).

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About the Authors

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Dr. Maureen Zimmerman earned her undergraduate degree in Nutrition and Dietetics at Arizona State University, a Master's Degree in Public Health from the University of Hawaii, and a Doctorate in Educational Leadership, with a specialization in educational research, from Northern Arizona University. She is a Registered Dietitian and has been a residential faculty member at Mesa Community College in Mesa, Arizona since 1991. She has been involved in many aspects of college life, most of them related to improving teaching and learning. She works indefatigably to assure that students enjoy their learning journey, regularly applying learning science to the online and ground classrooms. She is active every day of the week either practicing yoga, biking, hiking, tap dancing, or running. She enjoys reading a variety of genres, and likes to drink good coffee in the company of friends and family. She watches international films regularly, and tries to eat many fruits and vegetables every day. Her food first philosophy is summed up in this statement: "Enjoy real food, enjoy it with others, enjoy it in just the right amounts."

Beth Snow

Dr. Beth Snow earned a BS (Hons) in Biochemistry (with a minor in Drama) from McMaster University in 1999, an MS in Human Biology & Nutritional Sciences from the University of Guelph in 2000, and a PhD in Human Nutrition from the University of British Columbia in 2006. She also holds a Credentialed Evaluator designation from the Canadian Evaluation Society. Her PhD research focused on the effects of prenatal alcohol exposure on the developing fetal skeleton and she has published in the journals Bone, Alcohol, and Alcoholism: Clinical & Experimental Research. Following her PhD training, she spent two years working at the British Columbia Centre of Excellence for Women's Health, where she ran an interdisciplinary research training

program. She currently works as an Evaluation Specialist in Public Health in Vancouver, BC, Canada, where she also teaches at the University of British Columbia and the Justice Institute of British Columbia. Her teaching philosophy involves empowering students to take ownership of their own learning; she uses active learning techniques and encourages students to apply what they learn to real life. Being a lifelong learner herself, Beth is currently working on a Masters of Business Administration at the University of British Columbia, with the goal of combining knowledge about organizations with her health research expertise in order to help get research evidence into Public Health practice. In addition to her busy career, Beth is a true foodie who always makes time to cook and share good food and she enjoys hiking, running, yoga, and, being a Canadian, playing ice hockey.

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Dedications

Maureen Zimmerman

Many people have shaped my professional and personal life. I would be remiss not to acknowledge those who saw potential and hired me in 1991 to develop a nutrition program at Mesa Community College. To those who initiated and maintained the stellar teaching and learning movement in the Maricopa Community College District, I am grateful. To my colleagues and the doctoral faculty who helped form my teaching practice, thank you. Succor comes from my family. My five children, in particular, experienced my nutritional philosophies even before the cradle. They brought hummus to school before it ever hit the grocery store shelves. Studying and teaching nutrition has been a fulfilling part of my life; I am grateful to all who have influenced me, most especially the thousands of students I have learned with through the years.

Beth Snow

I dedicate this book to my mother, Ann Snow, who taught me the fun of cooking, and my father, the late Jack Snow, who showed me the amazing world of biology. Marrying these two interests led to my pursuit of an education in nutritional sciences and, ultimately, to authoring this textbook.

Preface

Welcome to *Essentials of Nutrition: A Functional Approach*! This book is written for students who are not majoring in nutrition, but want to learn about the fundamental aspects of nutrition and how it applies to their own lives. We have written this book with the assumption that you have little or no prior knowledge of college level chemistry, biology, or physiology. But that does not mean it's not scientific! Nutrition is a science-based discipline, so all the material included is backed up by rigorous scientific research, but it is presented in a clear, easy-to-understand fashion without requiring a background in science.

Focus on Sustainability

People are increasingly interested in sustainable food issues. They are looking for favorable ways to impact not only their health, but also the environment and their local economy. However, misinformation about how one can make a positive impact abounds. By highlighting effective sustainable food behaviors, supported by science, this book will provide you with a significant resource for increasing the sustainable practices in your day-to-day life.

Organization

This book is organized using a functional approach, which means that the material is organized around physiological functions, such as fluid and electrolyte balance, antioxidant function, bone health, energy and metabolism, and blood health, instead of organizing it strictly by nutrient. This makes the information easier to understand, retain, and apply to your own life. As this text explores the relationship between nutrition and physiology, you will receive a "behind the scenes" examination of health and disease in the body.

- In Chapter 1 "Nutrition and You", we provide an overview of nutrition as an evidence-based science and explore the concepts of health, wellness, and disease. We also provide an introduction to the different types of nutrients, health factors, personal health assessment, and the concept of sustainable food systems.
- In Chapter 2 "Achieving a Healthy Diet", we explore the tools you can use to achieve a healthy diet, as well as important nutrition concepts like balance and moderation.

- In Chapter 3 "Nutrition and the Human Body", because we know that you may not have a background in biology, we start with a tour through the human body, from the single cell to the full organism, we set up for a discussion about the processes of digestion and absorption, followed by explorations of the other organ systems. After that, we discuss the concept of energy and calories. We also discuss some disorders and diseases related to nutritional health.
- In Chapter 4 "Carbohydrates", we explore the many types of carbohydrates, including their functions. We also take a look at diabetes and at sugar substitutes.
- In Chapter 5 "Lipids", we look at the types, structure, and roles of lipids, and we explain the different types of cholesterol in the blood. We also explore topics of interest such as omega-3 and omega-6 fatty acids and trans fats.
- In Chapter 6 "Proteins", we cover the structure and roles of protein, and explore the consequences of getting too little or too much protein in your diet. Tips for getting the right amount and quality of protein, as well as a look at special populations, such as the elderly and athletes, are also covered.
- In Chapter 7 "Nutrients Important to Fluid and Electrolyte Balance", we look at the nutrients important to fluid and electrolyte balance, including water, sodium, chloride, and potassium. We also look at sports drinks, caffeinated beverages, and alcohol.
- In Chapter 8 "Nutrients Important As Antioxidants", nutrients important as antioxidants are explored, starting with an explanation of what oxidation and antioxidants are, then looking at vitamins E, C, and A, selenium, and phytochemicals.
- In Chapter 9 "Nutrients Important for Bone Health", we delve into nutrients important for bone health. First, we explore the structure and function of bones, and then calcium, vitamin D, phosphorus, magnesium, fluoride, and vitamin K. A look at osteoporosis and at supplements rounds out this chapter.
- In Chapter 10 "Nutrients Important for Metabolism and Blood Function", we look at the nutrients important in energy metabolism and blood health, by first looking at blood and at metabolism, and then discussing the B vitamins, vitamin K, magnesium, iron, zinc, and other micronutrients. We also explore iron-deficient anemia and iron toxicity.
- In Chapter 11 "Energy Balance and Body Weight", we take a look at the obesity epidemic and eating disorders—the extremes of energy imbalance—and we look at evidence-based recommendations for maintaining a healthy weight.
- Chapter 12 "Nutrition through the Life Cycle: From Pregnancy to the Toddler Years" is the first of two chapters exploring nutrition through

the life cycle and it looks at pregnancy through the toddler years. Topics include pregnancy, breastfeeding, introducing solid foods, and nutrition during the toddler years.
- In Chapter 13 "Nutrition through the Life Cycle: From Childhood to the Elderly Years" we continue to explore nutrition through the life cycle, this time looking at childhood to the elderly years.
- In Chapter 14 "Nutrition and Society: Food Politics and Perspectives", we explore food politics, sustainability, the food industry, food security, and diets from around the world.
- In Chapter 15 "Achieving Optimal Health: Wellness and Nutrition", we look at a number of topics of interest to students: diet trends, food supplements and food replacements, fitness, chronic diseases, and food safety. Also included in this chapter are tips for living a sustainable lifestyle, and information about careers in nutrition.

Features

Each chapter starts with a "**Big Idea**," which provides a preview of the main theme of the chapter.

You Decide challenges you to apply what you are learning about nutrition topics—sometimes controversial ones—to your own life.

Key Takeaways and **Key Terms** provide the key take-home messages and definitions from each section, helping you to focus on the main points you should be learning.

Discussion Starters are questions that can prompt discussions with fellow students and your instructor to examine and extend what you've learned in the chapter.

There are many **Videos** available online and it is not always clear which ones have reliable information. We have done the legwork for you by providing interesting videos from reputable sources to accompany and highlight the content. Similarly, we provide links to useful online learning tools through the **Interactive** feature.

Most of the databases for **diet analysis** programs primarily feature industrial food. As we promote sustainable food activities in our text, we cannot use these common diet analysis programs because they do not cater to students who eat real food prepared at home. As a result, we provide links to http://www.choosemyplate.gov/ throughout the text. You will be encouraged to create your own meals, shop

smarter, choose wisely, and, at the same time, foster an active attitude toward food sustainability.

Every chapter ends with **Exercises**, which are activities that can be used to test what has been learned in the chapter and may be used by your instructor as homework or assignment questions. There are exercises at three different levels (It's Your Turn, Apply It, and Expand Your Knowledge) to meet the varied needs of different students.

Please do not use this book to substitute for professional medical care or advice. If you have medical concerns or questions, always seek guidance from a health-care professional. The authors and publisher are not responsible for the accuracy of any content added by faculty.

Chapter 1

Nutrition and You

Big Idea

Nutrition is an evidence-based science. Nutritional scientists continuously advance our knowledge of nutrition by building on prior research.

Video Link 1.1

Nutrition Quiz

Listen to questions and answers to common concerns about food and eating habits.

http://videos.howstuffworks.com/discovery-health/36937-bob-greene-man-on-the-streets-nutrition-quiz-video.htm

As we get started on our journey into the world of health and nutrition, our first focus will be to demonstrate that nutritional science is an evolving field of study, continually being updated and supported by research, studies, and trials. Once we establish this, your confidence will be strengthened in nutritional science to help guide your eating habits. Let's begin with the story of hurry, curry, and worry: the story of H. pylori.

Peptic ulcers are painful sores in the gastrointestinal tract and can cause symptoms of abdominal pain, nausea, loss of appetite, and weight loss. The cure for this ailment took some time for scientists to figure out. If your grandfather complained to his doctor of symptoms of peptic ulcer, he was probably told to avoid spicy foods, alcohol, and coffee, and to manage his stress. In the early twentieth century, the medical community thought peptic ulcers were caused by what you ate and drank,

and by stress. In 1915, Dr. Bertram W. Sippy devised the "Sippy diet" for treating peptic ulcers. Dr. Sippy advised patients to drink small amounts of cream and milk every hour in order to neutralize stomach acid. And then, increasingly, introduce soft bland foods with frequent meal times. For a while this diet sometimes worked, fooling both doctors and patients. However, the disappearance of peptic ulcer symptoms was likely the result of having a full stomach all the time, as the symptoms more often occur when the stomach is empty. Ultimately, the Sippy diet did not cure peptic ulcers and in the latter 1960s scientists discovered the diet was associated with a significant increase in heart disease due to its high saturated fat content.

In the 1980s, Australian physicians Barry Marshall and Robin WarrenCurrey, R. "Ulcers—The Culprit Is H. Pylori!" National Institutes of Health, Office of Science Education. Accessed November 10, 2011. http://science.education.nih.gov/home2.nsf/Educational+ResourcesResource+FormatsOnline+Resources+High+School/928BAB9A176A71B585256CCD00634489 proposed a radical hypothesis—that the cause of ulcers was bacteria that could survive in the acidic environment of the stomach and small intestine. They met with significant opposition to their hypothesis but they persisted with their research. Their research led to an understanding that the spiral shape of the bacterium H. pylori allows it to penetrate the stomach's mucous lining, where it secretes an enzyme that generates substances to neutralize the stomach's acidity. This weakens the stomach's protective mucous, making the tissue more susceptible to the damaging effects of acid, leading to the development of sores and ulcers. H. pylori also prompt the stomach to produce even more acid, further damaging the stomach lining. Marshall actually drank a dish of H. pylori hoping to give himself an ulcer to prove his point. A few days later he was vomiting and had inflamed tissue in his stomach. The presence of H. pylori was confirmed. He then took an antibiotic and the symptoms of H. pylori infection dissipated. Experimental success? It still took years for the medical community to be entirely convinced of the link between peptic ulcers and H. pylori.

In 1994, the National Institutes of Health held a conference on the cause of peptic ulcers. There was scientific consensus that H. pylori cause most peptic ulcers and that patients should be treated with antibiotics. In 1996, the Food and Drug Administration (FDA) approved the first antibiotic that could be used to treat patients with peptic ulcers. Nevertheless, the link between H. pylori and peptic ulcers was not sufficiently communicated to health-care providers. In fact, 75 percent of patients with peptic ulcers in the late 1990s were still being prescribed antacid medications and advised to change their diet and reduce their stress. In 1997, the Centers for Disease Control and Prevention (CDC), alongside other public health organizations, began an intensive educational campaign to convince the public and health-care providers that peptic ulcers are a curable condition

requiring treatment with antibiotics. Today, if you go to your primary physician you will be given the option of taking an antibiotic to eradicate H. pylori from your gut. Scientists have progressed even further and mapped the entire genome of H. pylori, which will hopefully aid in the discovery of even better drugs to treat peptic ulcers.

The H. pylori discovery was made recently, overturning a theory applied in our own time. The demystification of disease requires the continuous forward march of science, overturning old, traditional theories and discovering new, more effective ways to treat disease and promote health. In 2005, Marshall and Warren were awarded the prestigious Nobel Prize in medicine for their discovery that many stomach ulcers are caused by H. pylori—not by hurry, curry, and worry.

You Decide

Make a commitment to empower yourself with scientific evidence as a strategy for achieving a healthier diet.

A primary goal of this text is to provide you with information backed by nutritional science, and with a variety of resources that use scientific evidence to optimize health and prevent disease. In this chapter you will see that there are many conditions and deadly diseases that can be prevented by good nutrition. You will also discover the many other determinants of health and disease, how the powerful tool of scientific investigation is used to design dietary guidelines, and recommendations that will promote health and prevent disease.

“The most exciting phrase to hear in science, the one that heralds new discoveries, is not ‘Eureka!’ but ‘That’s funny…’”

- Isaac Asimov (January 2, 1920–April 6, 1992)

1.1 Defining Nutrition, Health, and Disease

LEARNING OBJECTIVE

1. Explain the terms nutrition, health, health promotion, and disease prevention.

Your View of Food

Americans are bombarded with television programs that show where to find the best dinners, pizzas, and cakes, and the restaurants that serve the biggest and juiciest burgers. Other programs feature chefs battling to prepare meals, and the top places to burst your belly from consuming atomic chicken wings and deli sandwiches longer than a foot. There are also shows that feature bizarre foods from cultures around the world. How do you use the information from popular network food shows to build a nutritious meal? You don't—these shows are for entertainment. The construction of a nutritious meal requires learning about which foods are healthy and which foods are not, how foods and nutrients function in your body, and how to use scientific resources. This text is designed to provide you with the information necessary to make sound nutritional choices that will optimize health and help prevent disease.

How do you fill your plate?

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The word nutrition first appeared in 1551 and comes from the Latin word *nutrire*, meaning "to nourish." Today, we define **nutrition**[1] as the sum of all processes involved in how organisms obtain nutrients, metabolize them, and use them to support all of life's processes. **Nutritional science**[2] is the investigation of how an organism is nourished, and incorporates the study of how nourishment affects personal health, population health, and planetary health. Nutritional science covers a wide spectrum of disciplines. As a result, nutritional scientists can specialize in particular aspects of nutrition such as biology, physiology, immunology, biochemistry, education, psychology, sustainability, and sociology.

Without adequate nutrition the human body does not function optimally, and severe nutritional inadequacy can lead to disease and even death. The typical American diet is lacking in many ways, from not containing the proper amounts of essential nutrients, to being too speedily consumed, to being only meagerly satisfying. Dietitians are nutrition professionals who integrate their knowledge of nutritional science into helping people achieve a healthy diet and develop good dietary habits. The Academy of Nutrition and Dietetics (AND) is the largest organization of nutrition professionals worldwide and dietitians registered with the AND are committed to helping Americans eat well and live healthier lives. To learn more from the AND's nutritional advice, visit http://www.eatright.org/default.aspx.

Your ability to wake up, to think clearly, to communicate, to hope, to dream, to go to school, to gain knowledge, to go to work, to earn a living, and to do all of the things that you like to do are dependent upon one factor—your health. Good health means you are able to function normally and work hard to achieve your goals in life. For the next few minutes, take some time to view snapshots of the insides of the refrigerators of American mechanics, doctors, school teachers, hunters, short-order cooks, college students, vegans, and more. Visit Mark Menjivar's portrait exhibition, "You Are What You Eat" (Note 1.7 "Interactive 1.1"). Menjivar hopes these images will invoke new thoughts about, "How we care for our bodies. How we care for others. And how we care for the land." As you look at these images think about your personal health, the health of your family and friends, and the health of this planet. These hopes encompass the inspirations for this book.

1. The sum of all processes involved in how organisms obtain nutrients, metabolize them, and use them to support all of life's processes.
2. The investigation of how an organism is nourished, and how nourishment affects personal health, population health, and planetary health.

Interactive 1.1

Mark Menjivar has traveled around the United States taking photographs of the contents of refrigerators of numerous types of people. The portraits are available for viewing on his website under "You Are What You Eat."

http://markmenjivar.com/you-are-what-you-eat/statement/

Nutrition and Health and Disease

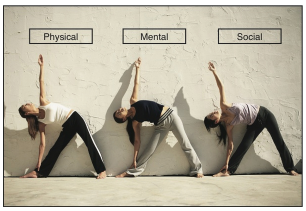
In 1946, the World Health Organization (WHO) defined **health**[3] as "a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity."World Health Organization. Preamble to the *Constitution of the World Health Organization* as adopted by the International Health Conference, New York, June 19–July 22, 1946. http://www.who.int/suggestions/faq/en/ This definition was adopted into the WHO consititution in 1948 and has not been ammended since. A triangle is often used to depict the equal influences of physical, mental, and social well-being on health (Figure 1.1 "The Health Triangle"). **Disease**[4] is defined as any abnormal condition affecting the health of an organism, and is characterized by specific signs and symptoms. Signs refer to identifying characteristics of a disease such as swelling, weight loss, or fever. Symptoms are the features of a disease recognized by a patient and/or their doctor. Symptoms can include nausea, fatigue, irritability, and pain. Diseases are broadly categorized as resulting from pathogens (i.e., bacteria, viruses, fungi, and parasites), deficiencies, genetics, and physiological dysfunction. Diseases that primarily affect physical health are those that impair body structure (as is the case with osteoporosis), or functioning (as is the case with cardiovascular disease). Mental illnesses primarily affect mental and social well-being.

3. A state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity.

4. Any abnormal condition that affects the health of an organism and is characterized by specific signs and symptoms.

The foods we eat affect all three aspects of our health. For example, a teen with Type 2 diabetes (a disease brought on by poor diet) is first diagnosed by physical signs and symptoms such as increased urination, thirstiness, and unexplained weight loss. But research has also found that teens with Type 2 diabetes have impaired thinking and do not interact well with others in school, thereby affecting mental and social well-being. Type 2 diabetes is just one example of a physiological disease that affects all aspects of health—physical, mental, and social.

Figure 1.1 *The Health Triangle*



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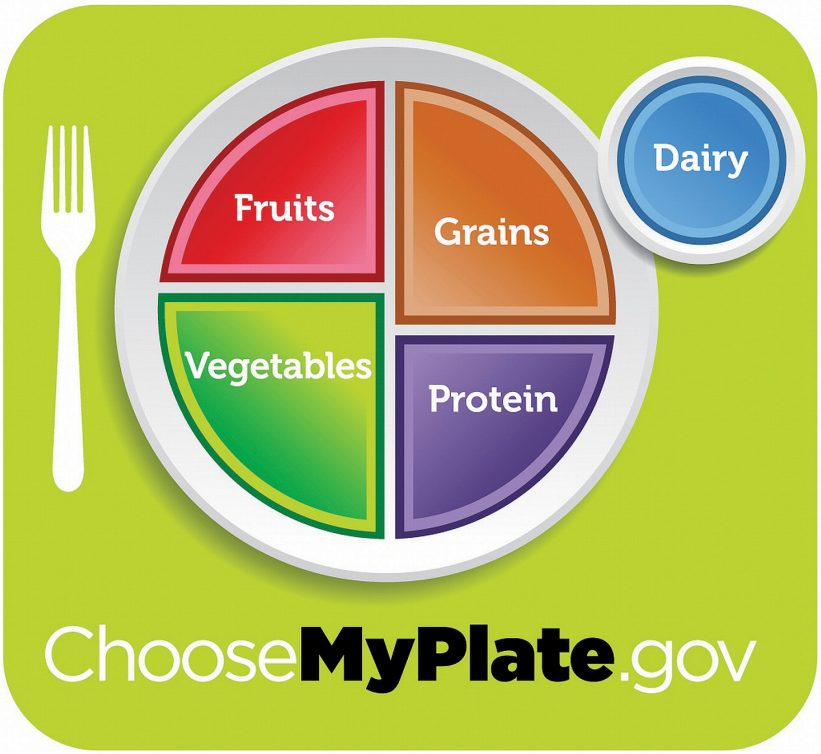
Public Health and Disease Prevention

In 1894, the first congressional funds were appropriated to the US Department of Agriculture (USDA) for the study of the relationship between nutrition and human health. Dr. Wilbur Olin Atwater was appointed as the Chief of Nutrition Investigations and is accoladed as the "Father of Nutrition Science" in America.Combs, G.F. "Celebration of the Past: Nutrition at USDA." *J Nutr* 124, no. 9 supplement (1994): 1728S–32S. http://jn.nutrition.org/content/124/9_Suppl/1728S.long Under his guidance the USDA released the first bulletin to the American public that contained information on the amounts of fat, carbohydrates, proteins, and food energy in various foods. Nutritional science advanced considerably in these early years, but it took until 1980 for the USDA and the US Department of Health and Human Services (HHS) to jointly release the first edition of *Nutrition and Your Health: Dietary Guidelines for Americans*.

Although wide distribution of dietary guidelines did not come about until the 1980s, many historical events that demonstrated the importance of diet to health preceded their release. Assessments of the American diet in the 1930s led President Franklin D. Roosevelt to declare in his inaugural address on January 20, 1937, "I see one-third of our nation is ill-housed, ill-clad, and ill-nourished." From the time of Atwater until the onset of the Great Depression nutritional scientists had discovered many of the vitamins and minerals essential for the functioning of the human body. Their work and the acknowledgement by President FDR of the nutritional inadequacy of the American diet evoked a united response between scientists and government leading to the enrichment of flour, the development of school lunch programs, and advancements of nutritional education in this country.

Figure 1.2 *The Federal Government's New and Improved Tool of Nutritional Communication*



In the latter part of the twentieth century nutritional scientists, public health organizations, and the American public increasingly recognized that eating too much of certain foods is linked to chronic diseases. We now know that diet-related conditions and diseases include hypertension (high blood pressure), obesity, Type 2 diabetes, cardiovascular disease, some cancers, and osteoporosis. These diet-related conditions and diseases are some of the biggest killers of Americans. The HHS reports that unhealthy diets and inactivity cause between 310,000 and 580,000 deaths every single year.Center for Science in the Public Interest. "Nutrition Policy." Accessed March 1, 2012. http://www.cspinet.org/nutritionpolicy/nutrition_policy.html#disease According to the USDA, eating healthier could save Americans over $70 billion per year and this does not include the cost of obesity, which is estimated to cost a further $117 billion per year.Combs, G.F. "Celebration of the Past: Nutrition at USDA." *J Nutr* 124, no. 9 supplement (1994): 1728S–32S. http://jn.nutrition.org/content/124/9_Suppl/1728S.long Unfortunately, despite the fact that the prevalence of these diseases can be decreased by healthier diets and increased physical activity, the CDC reports that the federal government spends one thousand times more to treat disease than to prevent it ($1,390 versus $1.21 per person each year).Combs, G.F. "Celebration of the Past: Nutrition at USDA." *J Nutr* 124, no. 9 supplement (1994): 1728S–32S. http://jn.nutrition.org/content/124/9_Suppl/1728S.long In 2010, the new edition of the dietary guidelines identified

obesity as the number one nutritional-related health problem in the United States and established strategies to combat its incidence and health consequences in the American population. A 2008 study in the journal *Obesity* reported that if current trends are not changed, 100 percent of Americans will be overweight or obese in 2048!Wang Y, et al. "Will All Americans Become Overweight or Obese? Estimating the Progression and Cost of the US Obesity Epidemic." *Obesity* 10, no. 16 (October 2008): 2323–30. http://www.nature.com/oby/journal/v16/n10/full/oby2008351a.html In 2011, the US federal government released a new multimedia tool that aims to help Americans choose healthier foods from the five food groups (grains, vegetables, fruits, dairy, and proteins). The tool, called "Choose MyPlate," is available at choosemyplate.gov.

KEY TAKEAWAYS

- Health is defined as "a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity."World Health Organization. "WHO definition of health." http://www.who.int/about/definition/en/print.html.
- Disease is defined as any abnormal condition that affects the health of an organism, and is characterized by specific signs and symptoms.
- Disease affects all three aspects of the health triangle.
- Good nutrition provides a mechanism to promote health and prevent disease.
- Diet-related conditions and diseases include obesity, Type 2 diabetes, cardiovascular disease, some cancers, and osteoporosis.
- It took until the 1980s for the US federal government to develop a diet-related public policy designed to equip Americans with the tools to change to a healthier diet.

DISCUSSION STARTERS

1. How might the way we nourish our bodies affect planetary health?
2. Debate your classmates: Should the federal government be concerned with what Americans eat?

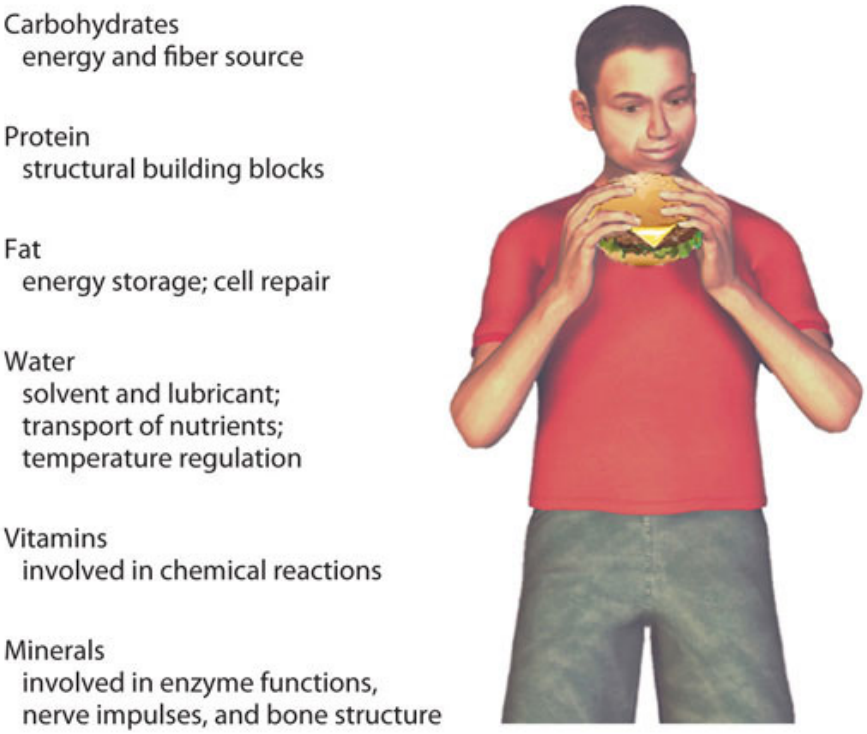
1.2 What Are Nutrients?

LEARNING OBJECTIVES

1. Define the word "nutrient" and identify the six classes of nutrients essential for health.
2. List the three energy-yielding nutrients and their energy contribution.

What's in Food?

Figure 1.3 *The Six Classes of Nutrients*



Source: *http://www.chemistry.wustl.edu/~edudev/LabTutorials/Vitamins/vitamins.html*.

The foods we eat contain **nutrients**[5]. Nutrients are substances required by the body to perform its basic functions. Nutrients must be obtained from diet, since the human body does not synthesize them. Nutrients are used to produce energy, detect and respond to environmental surroundings, move, excrete wastes, respire

5. Substances required by the body that must be obtained from the diet.

(breathe), grow, and reproduce. There are six classes of nutrients required for the body to function and maintain overall health. These are carbohydrates, lipids, proteins, water, vitamins, and minerals. Foods also contain nonnutrients that may be harmful (such as cholesterol, dyes, and preservatives) or beneficial (such as antioxidants). Nonnutrient substances in food will be further explored in Chapter 8 "Nutrients Important As Antioxidants".

Macronutrients

Nutrients that are needed in large amounts are called **macronutrients**[6]. There are three classes of macronutrients: carbohydrates, lipids, and proteins. These can be metabolically processed into cellular energy. The energy from macronutrients comes from their chemical bonds. This chemical energy is converted into cellular energy that is then utilized to perform work, allowing our bodies to conduct their basic functions. A unit of measurement of food energy is the calorie. On nutrition food labels the amount given for "calories" is actually equivalent to each calorie multiplied by one thousand. A kilocalorie (one thousand calories, denoted with a small "c") is synonymous with the "Calorie" (with a capital "C") on nutrition food labels. Water is also a macronutrient in the sense that you require a large amount of it, but unlike the other macronutrients it does not yield calories.

Carbohydrates

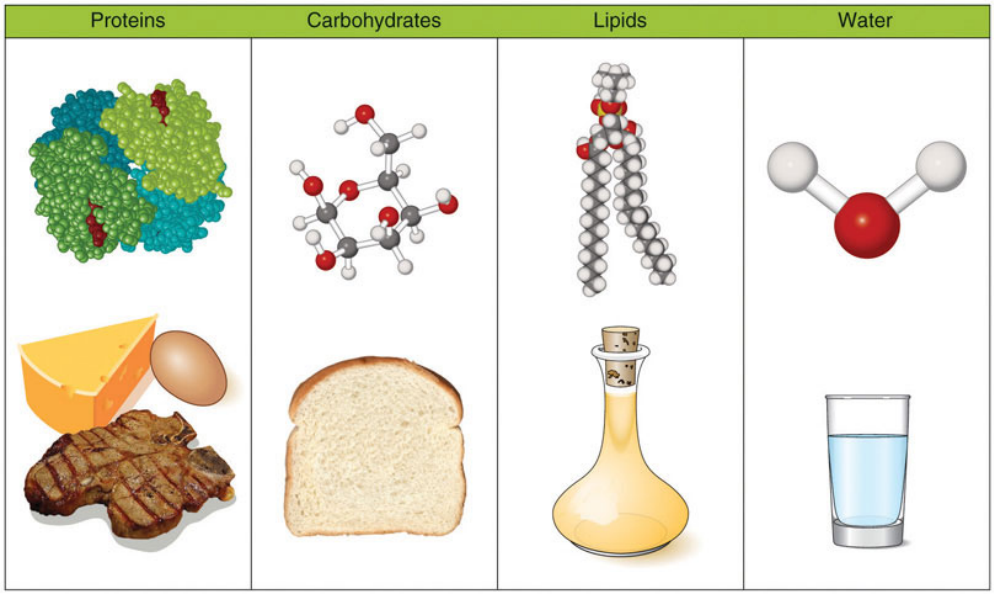
Carbohydrates[7] are molecules composed of carbon, hydrogen, and oxygen. The major food sources of carbohydrates are grains, milk, fruits, and starchy vegetables like potatoes. Nonstarchy vegetables also contain carbohydrates, but in lesser quantities. Carbohydrates are broadly classified into two forms based on their chemical structure: fast-releasing carbohydrates, often called simple sugars, and slow-releasing carbohydrates.

Fast-releasing carbohydrates consist of one or two basic units. Examples of simple sugars include sucrose, the type of sugar you would have in a bowl on the breakfast table, and glucose, the type of sugar that circulates in your blood.

6. Nutrients that are needed in large amounts. Includes carbohydrates, lipids, proteins, and water.

7. Organic molecules composed of carbon, hydrogen, and oxygen. There are two basic forms: simple sugars and complex sugars.

Figure 1.4 *The Macronutrients: Carbohydrates, Lipids, Protein, and Water*



Slow-releasing carbohydrates are long chains of simple sugars that can be branched or unbranched. During digestion, the body breaks down all slow-releasing carbohydrates to simple sugars, mostly glucose. Glucose is then transported to all our cells where it is stored, used to make energy, or used to build macromolecules. Fiber is also a slow-releasing carbohydrate, but it cannot be broken down in the human body and passes through the digestive tract undigested unless the bacteria that inhabit the gut break it down.

One gram of carbohydrates yields four kilocalories of energy for the cells in the body to perform work. In addition to providing energy and serving as building blocks for bigger macromolecules, carbohydrates are essential for proper functioning of the nervous system, heart, and kidneys. As mentioned, glucose can be stored in the body for future use. In humans, the storage molecule of carbohydrates is called glycogen and in plants it is known as starches. Glycogen and starches are slow-releasing carbohydrates.

Lipids

8. A family of organic compounds composed of carbon, hydrogen, and oxygen. They are insoluble in water. The three main types of lipids are triglycerides, phospholipids, and sterols.

Lipids[8] are also a family of molecules composed of carbon, hydrogen, and oxygen, but unlike carbohydrates, they are insoluble in water. Lipids are found predominately in butter, oils, meats, dairy products, nuts, and seeds, and in many processed foods. The three main types of lipids are triglycerides (triacylglycerols),

phospholipids, and sterols. The main job of lipids is to store energy. Lipids provide more energy per gram than carbohydrates (nine kilocalories per gram of lipids versus four kilocalories per gram of carbohydrates). In addition to energy storage, lipids serve as cell membranes, surround and protect organs, aid in temperature regulation, and regulate many other functions in the body.

Proteins

Proteins[9] are macromolecules composed of chains of subunits called amino acids. Amino acids are simple subunits composed of carbon, oxygen, hydrogen, and nitrogen. The food sources of proteins are meats, dairy products, seafood, and a variety of different plant-based foods, most notably soy. The word protein comes from a Greek word meaning "of primary importance," which is an apt description of these macronutrients; they are also known colloquially as the "workhorses" of life. Proteins provide four kilocalories of energy per gram; however providing energy is not protein's most important function. Proteins provide structure to bones, muscles and skin, and play a role in conducting most of the chemical reactions that take place in the body. Scientists estimate that greater than one-hundred thousand different proteins exist within the human body.

Water

There is one other nutrient that we must have in large quantities: water. Water does not contain carbon, but is composed of two hydrogens and one oxygen per molecule of water. More than 60 percent of your total body weight is water. Without it, nothing could be transported in or out of the body, chemical reactions would not occur, organs would not be cushioned, and body temperature would fluctuate widely. On average, an adult consumes just over two liters of water per day from food and drink. According to the "rule of threes," a generalization supported by survival experts, a person can survive three minutes without oxygen, three days without water, and three weeks without food. Since water is so critical for life's basic processes, the amount of water input and output is supremely important, a topic we will explore in detail in Chapter 7 "Nutrients Important to Fluid and Electrolyte Balance".

Micronutrients

Micronutrients[10] are nutrients required by the body in lesser amounts, but are still essential for carrying out bodily functions. Micronutrients include all the essential minerals and vitamins. There are sixteen essential minerals and thirteen vitamins (See Table 1.1 "Minerals and Their Major Functions" and Table 1.2 "Vitamins and Their Major Functions" for a complete list and their major functions). In contrast to carbohydrates, lipids, and proteins, micronutrients are not directly used for making

9. Macromolecules composed of chains of organic monomeric subunits, called amino acids. Amino acids are simple monomers composed of carbon, oxygen, hydrogen, and nitrogen.

10. Nutrients needed in smaller amounts. Includes vitamins and minerals.

energy, but they assist in the process as being part of enzymes (i.e., coenzymes). Enzymes are proteins that catalyze chemical reactions in the body and are involved in all aspects of body functions from producing energy, to digesting nutrients, to building macromolecules. Micronutrients play many roles in the body.

Minerals

Minerals are solid inorganic substances that form crystals and are classified depending on how much of them we need. Trace minerals, such as molybdenum, selenium, zinc, iron, and iodine, are only required in a few milligrams or less and macrominerals, such as calcium, magnesium, potassium, sodium, and phosphorus, are required in hundreds of milligrams. Many minerals are critical for enzyme function, others are used to maintain fluid balance, build bone tissue, synthesize hormones, transmit nerve impulses, contract and relax muscles, and protect against harmful free radicals.

Table 1.1 Minerals and Their Major Functions

Minerals	Major Functions
Macro	
Sodium	Fluid balance, nerve transmission, muscle contraction
Chloride	Fluid balance, stomach acid production
Potassium	Fluid balance, nerve transmission, muscle contraction
Calcium	Bone and teeth health maintenance, nerve transmission, muscle contraction, blood clotting
Phosphorus	Bone and teeth health maintenance, acid-base balance
Magnesium	Protein production, nerve transmission, muscle contraction
Sulfur	Protein production
Trace	
Iron	Carries oxygen, assists in energy production
Zinc	Protein and DNA production, wound healing, growth, immune system function
Iodine	Thyroid hormone production, growth, metabolism
Selenium	Antioxidant
Copper	Coenzyme, iron metabolism
Manganese	Coenzyme

Minerals	Major Functions
Fluoride	Bone and teeth health maintenance, tooth decay prevention
Chromium	Assists insulin in glucose metabolism
Molybdenum	Coenzyme

Vitamins

The thirteen vitamins are categorized as either water-soluble or fat-soluble. The water-soluble vitamins are vitamin C and all the B vitamins, which include thiamine, riboflavin, niacin, pantothenic acid, pyroxidine, biotin, folate and cobalamin. The fat-soluble vitamins are A, D, E, and K. Vitamins are required to perform many functions in the body such as making red blood cells, synthesizing bone tissue, and playing a role in normal vision, nervous system function, and immune system function.

Vitamin deficiencies can cause severe health problems. For example, a deficiency in niacin causes a disease called pellagra, which was common in the early twentieth century in some parts of America. The common signs and symptoms of pellagra are known as the "4D's—diarrhea, dermatitis, dementia, and death." Until scientists found out that better diets relieved the signs and symptoms of pellagra, many people with the disease ended up in insane asylums awaiting death (see Note 1.19 "Video 1.1"). Other vitamins were also found to prevent certain disorders and diseases such as scurvy (vitamin C), night blindness (vitamin A), and rickets (vitamin D).

Video 1.1

Pellagra

(click to see video)

This video provides a brief history of Dr. Joseph Goldberger's discovery that pellagra was a diet-related disease.

Table 1.2 Vitamins and Their Major Functions

Vitamins	Major Functions
Water-soluble	
B_1 (thiamine)	Coenzyme, energy metabolism assistance

Vitamins	Major Functions
B_2 (riboflavin)	Coenzyme, energy metabolism assistance
B_3 (niacin)	Coenzyme, energy metabolism assistance
B_5 (pantothenic acid)	Coenzyme, energy metabolism assistance
B_6 (pyroxidine)	Coenzyme, amino acid synthesis assistance
Biotin	Coenzyme
Folate	Coenzyme, essential for growth
B_{12} (cobalamin)	Coenzyme, red blood cell synthesis
C	Collagen synthesis, antioxidant
Fat-soluble	
A	Vision, reproduction, immune system function
D	Bone and teeth health maintenance, immune system function
E	Antioxidant, cell membrane protection
K	Bone and teeth health maintenance, blood clotting

Food Quality

One measurement of food quality is the amount of nutrients it contains relative to the amount of energy it provides. High-quality foods are nutrient dense, meaning they contain lots of the nutrients relative to the amount of calories they provide. Nutrient-dense foods are the opposite of "empty-calorie" foods such as carbonated sugary soft drinks, which provide many calories and very little, if any, other nutrients. Food quality is additionally associated with its taste, texture, appearance, microbial content, and how much consumers like it.

Food: A Better Source of Nutrients

It is better to get all your micronutrients from the foods you eat as opposed to from supplements. Supplements contain only what is listed on the label, but foods contain many more macronutrients, micronutrients, and other chemicals, like antioxidants that benefit health. While vitamins, multivitamins, and supplements are a $20 billion industry in this country and more than 50 percent of Americans purchase and use them daily, there is no consistent evidence that they are better than food in promoting health and preventing disease. Dr. Marian Neuhouser, associate of the Fred Hutchinson Cancer Research Center in Seattle, says that "...scientific data are lacking on the long-term health benefits of supplements. To our surprise, we found that multivitamins did not lower the risk of the most

common cancers and also had no impact on heart disease."Woodward, K. "Multivitamins Each Day Will Not Keep Common Cancers Away; Largest Study of Its Kind Provides Definitive Evidence that Multivitamins Will Not Reduce Risk of Cancer or Heart Disease in Postmenopausal Women." Fred Hutchinson Cancer Research Center. *Center News* 16 (February 2009). http://www.fhcrc.org/about/pubs/center_news/online/2009/02/multivitamin_study.html

KEY TAKEAWAYS

- Foods contain nutrients that are essential for our bodies to function.
- Four of the classes of nutrients required for bodily function are needed in large amounts. They are carbohydrates, lipids, proteins, and water, and are referred to as macronutrients.
- Two of the classes of nutrients are needed in lesser amounts, but are still essential for bodily function. They are vitamins and minerals.
- One measurement of food quality is the amount of essential nutrients a food contains relative to the amount of energy it has (nutrient density).

DISCUSSION STARTERS

1. Make a list of some of your favorite foods and visit the "What's In the Foods You Eat?" search tool provided by the USDA. What are some of the nutrients found in your favorite foods?

   http://www.ars.usda.gov/Services/docs.htm?docid=17032
2. Have a discussion in class on the "progression of science" and its significance to human health as depicted in the video on pellagra (see Note 1.19 "Video 1.1").

1.3 The Broad Role of Nutritional Science

LEARNING OBJECTIVE

1. Provide an example of how the scientific method works to promote health and prevent disease.

How to Determine the Health Effects of Food and Nutrients

Similar to the method by which a police detective finally charges a criminal with a crime, nutritional scientists discover the health effects of food and its nutrients by first making an observation. Once observations are made, they come up with a hypothesis, test their hypothesis, and then interpret the results. After this, they gather additional evidence from multiple sources and finally come up with a conclusion on whether the food suspect fits the claim. This organized process of inquiry used in forensic science, nutritional science, and every other science is called the **scientific method**[11].

Below is an illustration of the scientific method at work—in this case to prove that iodine is a nutrient.Zimmerman, M.B. "Research on Iodine Deficiency and Goiter in the 19th and Early 20th Centuries." *J Nutr* 138, no. 11 (November 2008): 2060–63. http://jn.nutrition.org/content/138/11/2060.full' Carpenter, K.J. "David Marine and the Problem of Goiter." *J Nutr* 135, no.4 (April 2005): 675–80. http://jn.nutrition.org/content/135/4/675.full?sid=d06fdd35-566f -42a2-a3fd-efbe0736b7ba In 1811, French chemist Bernard Courtois was isolating saltpeter for producing gunpowder to be used by Napoleon's army. To carry out this isolation he burned some seaweed and in the process observed an intense violet vapor that crystallized when he exposed it to a cold surface. He sent the violet crystals to an expert on gases, Joseph Gay-Lussac, who identified the crystal as a new element. It was named iodine, the Greek word for violet. The following scientific record is some of what took place in order to conclude that iodine is a nutrient.

Observation. Eating seaweed is a cure for goiter, a gross enlargement of the thyroid gland in the neck.

Hypothesis. In 1813, Swiss physician Jean-Francois Coindet hypothesized that the seaweed contained iodine and he could use just iodine instead of seaweed to treat his patients.

11. The process of inquiry that involves making an observation, coming up with a hypothesis, conducting a test of that hypothesis, evaluating results, gathering more supporting evidence, and coming up with a conclusion.

Experimental test. Coindet administered iodine tincture orally to his patients with goiter.

Interpret results. Coindet's iodine treatment was successful.

Gathering more evidence. Many other physicians contributed to the research on iodine deficiency and goiter.

Hypothesis. French chemist Chatin proposed that the low iodine content in food and water of certain areas far away from the ocean were the primary cause of goiter and renounced the theory that goiter was the result of poor hygiene.

Experimental test. In the late 1860s the program, "The stamping-out of goiter," started with people in several villages in France being given iodine tablets.

Results. The program was effective and 80 percent of goitrous children were cured.

Hypothesis. In 1918, Swiss doctor Bayard proposed iodizing salt as a good way to treat areas endemic with goiter.

Experimental test. Iodized salt was transported by mules to a small village at the base of the Matterhorn where more than 75 percent of school children were goitrous. It was given to families to use for six months.

Results. The iodized salt was beneficial in treating goiter in this remote population.

Experimental test. Physician David Marine conducted the first experiment of treating goiter with iodized salt in America in Akron, Ohio.

Results. This study conducted on over four-thousand school children found that iodized salt prevented goiter.

Conclusions. Seven other studies similar to Marine's were conducted in Italy and Switzerland that also demonstrated the effectiveness of iodized salt in treating goiter. In 1924, US public health officials initiated the program of iodizing salt and started eliminating the scourge of goiterism. Today more than 70 percent of American households use iodized salt and many other countries have followed the same public health strategy to reduce the health consequences of iodine deficiency.

Evidence-Based Approach to Nutrition

It took more than one hundred years from iodine's discovery as an effective treatment for goiter until public health programs recognized it as such. Although a lengthy process, the scientific method is a productive way to define essential nutrients and determine their ability to promote health and prevent disease. The scientific method is part of the overall evidence-based approach to designing nutritional guidelines. An evidence-based approach to nutrition includes:Briss, P.A., et al. "Developing an Evidence-Based Guide to Community Preventive Services—Methods." *Am J Prev Med* 18, no. 1S (2000): 35–43.' Myers, E. "Systems for Evaluating Nutrition Research for Nutrition Care Guidelines: Do They Apply to Population Dietary Guidelines?" *J Am Diet Assoc* 103, no. 12, supplement 2 (December 2003): 34–41.

- Defining the problem or uncertainty (e.g., the rate of colon cancer is higher in people who eat red meat)
- Formulating it as a question (e.g., Does eating red meat contribute to colon cancer?)
- Setting criteria for quality evidence
- Evaluating the body of evidence
- Summarizing the body of evidence and making decisions
- Specifying the strength of the supporting evidence required to make decisions
- Disseminating the findings

The Food and Nutrition Board of the Institute of Medicine, a nonprofit, nongovernmental organization, constructs its nutrient recommendations (i.e., Dietary Reference Intakes, or DRI) using an evidence-based approach to nutrition. The entire procedure for setting the DRI is documented and made available to the public. The same approach is used by the USDA and HHS, which are departments of the US federal government. The USDA and HHS websites are great tools for discovering ways to optimize health; however, it is important to gather nutrition information from multiple resources as there are often differences in opinion among various scientists and public health organizations. While the new *Dietary Guidelines*, published in 2010, have been well-received by some, there are nongovernmental public health organizations that are convinced that some pieces of the guidelines may be influenced by lobbying groups and/or the food industry. For example, the Harvard School of Public Health (HSPH) feels the government falls short by being "too lax on refined grains."The Harvard School of Public Health. "New US Dietary Guidelines: Progress, Not Perfection." © 2012 The President and Fellows of Harvard College. http://www.hsph.harvard.edu/nutritionsource/what-should-you-eat/dietary-guidelines -2010/index.html The guidelines recommend

getting at least *half* of grains from whole grains—according to the HSPH this still leaves too much consumption of refined grains.

For a list of reliable sources that advocate good nutrition to promote health and prevent disease using evidence-based science see Table 1.3 "Web Resources for Nutrition and Health". In Chapter 2 "Achieving a Healthy Diet", we will further discuss distinguishing criteria that will enable you to wade through misleading nutrition information and instead gather your information from reputable, credible websites and organizations.

Table 1.3 Web Resources for Nutrition and Health

Organization	Website
Governmental	
US Department of Agriculture	http://www.usda.gov/wps/portal/usda/usdahome
USDA Center for Nutrition Policy and Promotion	http://www.cnpp.usda.gov/
US Department of Health and Human Services	http://www.hhs.gov/
Centers for Disease Control and Prevention	http://www.cdc.gov/
Food and Drug Administration	http://www.fda.gov/
Healthy People	http://www.healthypeople.gov/2020/default.aspx
Office of Disease Prevention and Health Promotion	http://odphp.osophs.dhhs.gov/
Health Canada	http://www.hc-sc.gc.ca/
International	
World Health Organization	http://www.who.int/en/
Food and Agricultural Organization of the United Nations	http://www.fao.org/
Nongovernmental	
Harvard School of Public Health	http://www.hsph.harvard.edu/nutritionsource/index.html
Mayo Clinic	http://www.mayoclinic.com/
Linus Pauling Institute	http://lpi.oregonstate.edu/

Organization	Website
American Society for Nutrition	http://www.nutrition.org/
American Medical Association	http://www.ama-assn.org/
American Diabetes Association	http://www.diabetes.org/
The Academy of Nutrition and Dietetics	http://www.eatright.org/
Institute of Medicine: Food and Nutrition	http://www.iom.edu/Global/Topics/Food-Nutrition.aspx
Dietitians of Canada	http://www.dietitians.ca/

Types of Scientific Studies

There are many types of scientific studies that can be used to provide supporting evidence for a particular hypothesis. The various types of studies include epidemiological studies, interventional clinical trials, and randomized clinical interventional trials.

Epidemiological studies[12] are observational studies and are often the front-line studies for public health. The CDC defines epidemiological studies as scientific investigations that define frequency, distribution, and patterns of health events in a population. Thus, these studies describe the occurrence and patterns of health events over time. The goal of an epidemiological study is to find factors associated with an increased risk for a health event, though these sometimes remain elusive. An example of an epidemiological study is the Framingham Heart Study, a project of the National Heart, Lung and Blood Institute and Boston University that has been ongoing since 1948. This study first examined the physical health and lifestyles of 5,209 men and women from the city of Framingham, Massachusetts and has now incorporated data from the children and grandchildren of the original participants. One of the seminal findings of this ambitious study was that higher cholesterol levels in the blood are a risk factor for heart disease.The Framingham Heart Study, a project of the National Heart, Lung, and Blood Institute and Boston University. "History of the Framingham Heart Study." © 2012 Framingham Heart Study. http://www.framinghamheartstudy.org/about/history.html Epidemiological studies are a cornerstone for examining and evaluating public health and some of their advantages are that they can lead to the discovery of disease patterns and risk factors for diseases, and they can be used to predict future healthcare needs and provide information for the design of disease prevention strategies for entire populations. Some shortcomings of epidemiological studies are that investigators cannot control environments and lifestyles, a specific group of people studied may not be an accurate depiction of an entire population, and these types of scientific studies cannot directly determine if one variable causes another.

12. Scientific investigations that define frequency, distribution, and patterns of health events in a population.

Interventional clinical trial studies[13] are scientific investigations in which a variable is changed between groups of people. When well done, this type of study allows one to determine causal relationships. An example of an interventional clinical trial study is the Dietary Approaches to Stop Hypertension (DASH) trial published in the April 1997 issue of *The New England Journal of Medicine*.Appel, L. J., et al. "A Clinical Trial of the Effects of Dietary Patterns on Blood Pressure.," *N Engl J Med* 336 (April 1997): 1117–24. http://www.nejm.org/doi/full/10.1056/NEJM199704173361601 In this study, 459 people were randomly assigned to three different groups; one was put on an average American control diet, a second was put on a diet rich in fruits and vegetables, and the third was put on a combination diet rich in fruits, vegetables, and low-fat dairy products with reduced saturated and total fat intake. The groups remained on the diets for eight weeks. Blood pressures were measured before starting the diets and after eight weeks. Results of the study showed that the group on the combination diet had significantly lower blood pressure at the end of eight weeks than those who consumed the control diet. The authors concluded that the combination diet is an effective nutritional approach to treat high blood pressure. The attributes of high-quality clinical interventional trial studies are:

- those that include a control group, which does not receive the intervention, to which you can compare the people who receive the intervention being tested;
- those in which the subjects are randomized into the group or intervention group, meaning a given subject has an equal chance of ending up in either the control group or the intervention group. This is done to ensure that any possible confounding variables are likely to be evenly distributed between the control and the intervention groups;
- those studies that include a sufficient number of participants.

What are confounding variables? These are factors other than the one being tested that could influence the results of the study. For instance, in the study we just considered, if one group of adults did less physical activity than the other, then it could be the amount of physical activity rather than the diet being tested that caused the differences in blood pressures among the groups.

The limitations of these types of scientific studies are that they are difficult to carry on for long periods of time, are costly, and require that participants remain compliant with the intervention. Furthermore, it is unethical to study certain interventions. (An example of an unethical intervention would be to advise one group of pregnant mothers to drink alcohol to determine the effects of alcohol intake on pregnancy outcome, because we know that alcohol consumption during pregnancy damages the developing fetus.)

13. Scientific investigations in which a variable is changed between groups of people.

Randomized clinical interventional trial studies[14] are powerful tools to provide supporting evidence for a particular relationship and are considered the "gold standard" of scientific studies. A randomized clinical interventional trial is a study in which participants are assigned by chance to separate groups that compare different treatments. Neither the researchers nor the participants can choose which group a participant is assigned. However, from their limitations it is clear that epidemiological studies complement interventional clinical trial studies and both are necessary to construct strong foundations of scientific evidence for health promotion and disease prevention.

Other scientific studies used to provide supporting evidence for a hypothesis include laboratory studies conducted on animals or cells. An advantage of this type of study is that they typically do not cost as much as human studies and they require less time to conduct. Other advantages are that researchers have more control over the environment and the amount of confounding variables can be significantly reduced. Moreover, animal and cell studies provide a way to study relationships at the molecular level and are also helpful in determining the exact mechanism by which a specific nutrient causes a change in health. The disadvantage of these types of studies are that researchers are not working with whole humans and thus the results may not be relevant. Nevertheless, well-conducted animal and cell studies that can be repeated by multiple researchers and obtain the same conclusion are definitely helpful in building the evidence to support a scientific hypothesis.

Evolving Science

Science is always moving forward, albeit sometimes slowly. One study is not enough to make a guideline or a recommendation or cure a disease. Science is a stepwise process that builds on past evidence and finally culminates into a well-accepted conclusion. Unfortunately, not all scientific conclusions are developed in the interest of human health and it is important to know where a scientific study was conducted and who provided the money. Indeed, just as an air quality study paid for by a tobacco company diminishes its value in the minds of readers, so does one on red meat performed at a laboratory funded by a national beef association.

Science can also be contentious even amongst experts that don't have any conflicting financial interests. To see scientists debating over the nutritional guidelines, watch Note 1.27 "Video Link 1.2". Contentious science is actually a good thing as it forces researchers to be of high integrity, well-educated, well-trained, and dedicated. It also instigates public health policy makers to seek out multiple sources of evidence in order to support a new policy. Agreement involving many experts across multiple scientific disciplines is necessary for recommending dietary changes to improve health and prevent disease. Although a somewhat slow process,

14. Scientific investigations which incorporate a change in the variable being tested between groups of people and are therefore capable of determining a causal relationship.

it is better for our health to allow the evidence to accumulate before incorporating some change in our diet.

Video Link 1.2

The Experts Debate

This webcast from March 29, 2011 demonstrates how science is always evolving and how debate among nutrition science experts influences policy decisions.

http://www.hsph.harvard.edu/forum/boosting-vitamin-d-not-enough-or-too-much.cfm

Source: Harvard School of Public Health, in collaboration with Reuters.

Nutritional Science Evolution

One of the newest areas in the realm of nutritional science is the scientific discipline of nutritional genetics, also called nutrigenomics. Genes are part of DNA and contain the genetic information that make up all our traits. Genes are codes for proteins and when they are turned "on" or "off," they change how the body works. While we know that health is defined as more than just the absence of disease, there are currently very few accurate genetic markers of good health. Rather, there are many more genetic markers for disease. However, science is evolving and nutritional genetics aims to identify what nutrients to eat to "turn on" healthy genes and "turn off" genes that cause disease. Eventually this field will progress so that a person's diet can be tailored to their genetics. Thus, your DNA will determine your optimal diet.

Video 1.2

Nutrigenomics

(click to see video)

A dietitian describes the new scientific discipline of nutrigenomics and its potential impact on diet and health.

Using Science and Technology to Change the Future

As science evolves, so does technology. Both can be used to create a healthy diet, optimize health, and prevent disease. Picture yourself not too far into the future: you are wearing a small "dietary watch" that painlessly samples your blood, and downloads the information to your cell phone, which has an app that evaluates the nutrient profile of your blood and then recommends a snack or dinner menu to assure you maintain adequate nutrient levels. What else is not far off? How about another app that provides a shopping list that adheres to all dietary guidelines and is emailed to the central server at your local grocer who then delivers the food to your home? The food is then stored in your smart fridge which documents your daily diet at home and delivers your weekly dietary assessment to your home computer. At your computer, you can compare your diet with other diets aimed at weight loss, optimal strength training, reduction in risk for specific diseases or any other health goals you may have. You may also delve into the field of nutritional genetics and download your gene expression profiles to a database that analyzes yours against millions of others.

Figure 1.5 The "Smart Fridge"

Source: http://www.yankodesign.com/2010/05/28/smart-fridge-is-your-new-recipe-card/.

KEY TAKEAWAYS

- The scientific method is an organized process of inquiry used in nutritional science to determine if the food suspect fits the claim.
- The scientific method is part of the overall evidence-based approach to designing nutritional guidelines that are based on facts.
- There are different types of scientific studies—epidemiological studies, randomized clinical interventional trial studies, and laboratory animal and cell studies—which all provide different, complementary lines of evidence.
- It takes time to build scientific evidence that culminates as a commonly accepted conclusion.
- Agreement of experts across multiple scientific disciplines is a necessity for recommending dietary changes to improve health and help to prevent disease.
- Science is always evolving as more and more information is collected.

DISCUSSION STARTERS

1. What are some of the ways in which you think like a scientist and use the scientific method in your everyday life? Any decision-making process uses at least pieces of the scientific method. Think about some of the major decisions you have made in your life and the research you conducted that supported your decision. For example, what computer brand do you own? Where is your money invested? What college do you attend?
2. Do you use technology, appliances, and/or apps that help you to optimize your health?

1.4 Health Factors and Their Impact

LEARNING OBJECTIVES

1. Explain the role that genetics, environment, life cycle, and lifestyle play in health status.
2. Describe economic, social, cultural, and emotional determinants that affect personal choices of foods.

In addition to nutrition, health is affected by genetics, the environment, life cycle, and lifestyle. These factors are referred to as "determinants" of health and they all interact with each other. For example, family income influences the food choices available and the quantity and quality of food that can be purchased, which of course affects nutrition. Except for nutrition and lifestyle, these factors can be difficult or impossible to change.

Genetics

Everyone starts out in life with the genes handed down to them from the families of their mother and father. **Genes**[15] are responsible for your many traits as an individual and are defined as the sequences of DNA that code for all the proteins in your body. The expression of different genes can determine the color of your hair, skin, and eyes, and even if you are more likely to be fat or thin and if you have an increased risk for a certain disease. The sequence of DNA that makes up your genes determines your genetic makeup, also called your **genome**[16], which is inherited from your mother and father. In 2003, the Human Genome Project was completed and now the entire sequence of DNA in humans is known. It consists of about three billion individual units and contains between twenty-five and thirty thousand genes. The human genome that was sequenced was taken from a small population of donors and is used as a reference DNA sequence for the entire population. Each of us has a similar but unique DNA sequence. Only identical twins and cloned animals have the exact same DNA sequence.

15. The sequences of DNA that code for all the proteins in your body.

16. Entire genetic information contained in an individual which is inherited from their parents.

Identical twins are the only individuals in the world that have identical DNA, sharing the same genotype. However, their phenotype is different, meaning that their identical DNA is expressed differently.

© Shutterstock

Now that we understand the map of the human genome, let's enter the fields of nutrigenomics and epigenetics. Recall that **nutrigenomics**[17] is an emerging scientific discipline aimed at defining healthy genes and not-so-healthy genes and how nutrients affect them. Currently, scientists cannot change a person's DNA sequence. But they have discovered that chemical reactions in the body can turn genes "on" and "off," causing changes in the amounts and types of proteins expressed. **Epigenetics**[18] is another rapidly advancing scientific field in which researchers study how chemical reactions turn genes "on" and "off" and the factors that influence the chemical reactions. Some of these factors are now known to be nutrients. Researchers at the Genetic Science Learning Center at the University of Utah conducted an experiment in which some pregnant mice were fed a diet containing folate, choline, vitamin B_{12}, and betaine, and other pregnant mice were fed a diet that did not contain these nutrients and chemicals. Both groups of pregnant mice were also fed bisphenol A, a chemical in plastic, which alters DNA by inhibiting a specific chemical reaction. The mice born from the mother fed the supplemented diet were brown, thin, and healthy. The mice born from the mother fed the unsupplemented diet were yellow, fat, and unhealthy. This is a dramatic example of how nutrients change not the sequence of DNA, but which genes are expressed. These two mice look different, but have identical DNA sequences. Thus, not only do the things you eat determine your health, but so do the things your mother ate during pregnancy. Moreover, other studies have demonstrated what your dad ate—and what your grandmother ate while she was pregnant with your mother!—also can affect your gene expression and, consequently, your health. Does this make it OK for you to blame your mother and father for all of your shortcomings? No. Genetics are important in determining your health, but they are certainly not the only determinant.

17. An emerging scientific discipline that studies how nutrients affect gene expression.

18. A rapidly advancing scientific field, in which researchers study how non-gene factors affect gene expression.

Interactive 1.2

This is a good animation of the central foundation of modern biology. Turn "on" a gene, make messenger RNA, and make protein. Spin the dial all the way to the left to turn off the expression, and then slowly move it to the right.

http://learn.genetics.utah.edu/content/epigenetics/control/

Source: Genetic Science Learning Center at the University of Utah.

Video 1.3

Diet during Pregnancy

(click to see video)

Watch as Jen discovers how what you eat during pregnancy affects the health of your baby.

The Life Cycle

The **life cycle**[19] of human beings originates from a fertilized egg, which develops into a fetus that is eventually born as a baby. A baby develops into a child, transitions through the wonderful phase of adolescence, becomes an adult, and then advances into old age and eventually death (Figure 1.6 "The Life Cycle: The Forward March to Old Age and Ultimately Death"). The current average life expectancy in America is approaching eighty. To see how this compares with other countries, see Note 1.39 "Interactive 1.3".

19. The stages of life one passes through until death.

Interactive 1.3

Visit this public database from the World Bank to learn how the life expectancy in America differs from those in other countries.

http://www.google.com/publicdata?ds=wb-wdi&met_y=sp_dyn_le00_in&idim=country:USA&dl=en&hl=en&q=america+average+life+expectancy

Figure 1.6 *The Life Cycle: The Forward March to Old Age and Ultimately Death*

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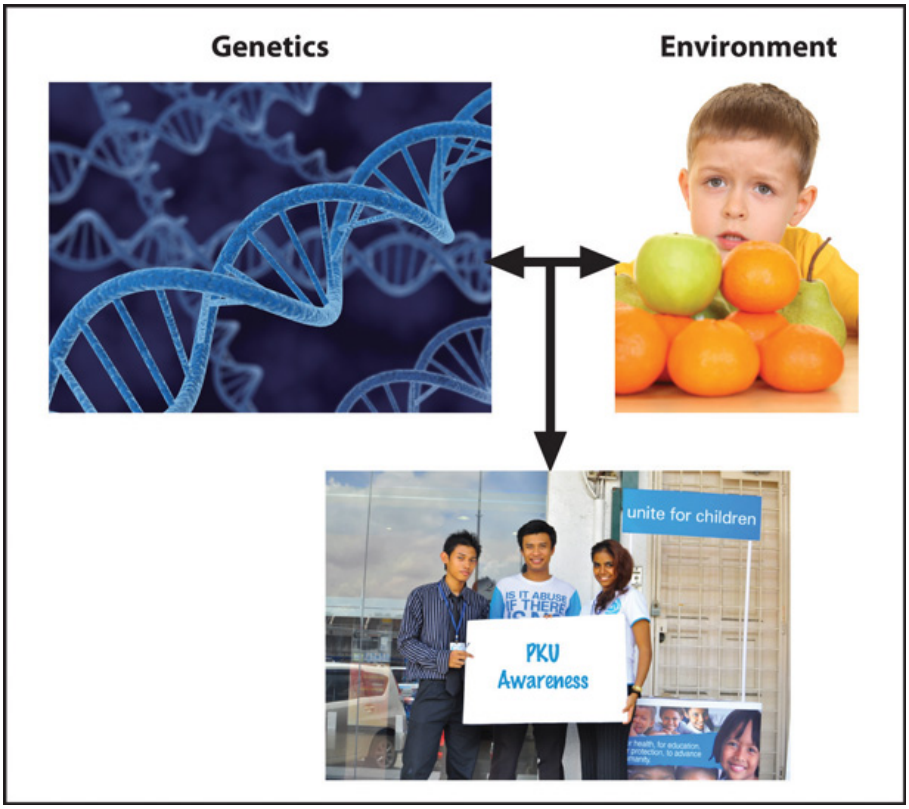
A person's stage of life influences their health and nutritional requirements. For example, when you are an adolescent, your bones grow quickly. More calcium, a bone-building nutrient, is required in the diet during this life stage than at other ages. As you get older, the aging process affects how your body functions. One effect of aging, apparently earlier in women than in men, is the deterioration of bone tissue. As a result, women over age fifty-one need more calcium in their diet than younger adult women. Another life-cycle stage, pregnancy, requires several adjustments to nutrition compared to nonpregnant women. It is recommended that

a pregnant woman consume more protein than a nonpregnant woman to support growth and development, and to consume more of some vitamins, such as folate, to prevent certain birth defects. The USDA provides information on healthy diets for many different stages of the life cycle on their website. Healthy aging requires eating a diet that matches one's life stages to support the body's specific physiological requirements. What else is known to help a person age slowly and gracefully? Diets high in vegetables and fruits are associated with increased longevity and a decreased risk of many diseases.

Environment



The interplay of genetics and environment can determine the consequences of disease.

Sources: http://topnews.co.uk/214471-rare-disorder-known-phenylketonuria *and* http://www.georgiapku.org/AboutUs.html. *© Shutterstock*

Your environment has a large influence on your health, genetics, life cycle, and lifestyle. Scientists say that the majority of your expressed traits are a product of your genes and environment, of which nutrition is a component. An example of this interaction can be observed in people who have the rare genetic disorder, phenylketonuria (PKU). The clinical signs of PKU are mental retardation, brain

damage, and seizures and are caused by the build-up of the amino acid phenylalanine and its metabolites (breakdown products produced during metabolism) in the body. The high level of phenylalanine in a person who has PKU is the result of a change in the gene that encodes for an enzyme that converts phenylalanine into the amino acid tyrosine. This genetic change, called a mutation, causes the enzyme to not function properly. In this country and many others all newborn babies are screened for PKU in order to diagnose and treat the disease before the development of mental retardation and brain damage. Once diagnosed, PKU is treated by strict adherence to a diet low in phenylalanine, consisting mostly of fruits, vegetables, and grains. Adhering to this diet for life allows an individual with PKU to lead a normal life without suffering the consequences of brain damage, mental retardation, or seizures. In the example of PKU, the consequences of a genetic mutation are modified by diet. Thus, a person's genes can make them more susceptible to a particular disease, or cause a disease, and their environment can decrease or increase the progression and severity of the condition.

Socioeconomic Status

Multiple aspects of a person's environment can affect nutrition, which in turn affects health. One of the best environmental predictors of a population's health is socioeconomic status. **Socioeconomic status**[20] is a measurement made up of three variables: income, occupation, and education. Socioeconomic status affects nutrition by influencing what foods you can afford and consequently, food choice and food quality. Nutrition and health are generally better in populations that have higher incomes, better jobs, and more education. On the other hand, the burden of disease is highest in the most disadvantaged populations. A commentary in the *Journal of the American Medical Association* reports that the lower life expectancy of populations of lower socioeconomic status is largely attributable to increased death from heart disease.Fiscella, K. and D. Tancredi. "Socioeconomic Status and Coronary Heart Disease Risk Prediction." *JAMA* 300, no. 22 (2008): 2666–68. The American Heart Association states that having a healthy diet is one of the best weapons to fight heart disease and it is therefore essential that all socioeconomic status groups have access to high-quality, nutrient-dense foods. The disparities in nutrition and health in America are directly related to the disparity in socioeconomic status. Other dimensions that affect health disparity are race, ethnic group, sex, sexual identity, age, disability, and geographic location. The issue of inequitable health among Americans is recognized by the federal government and one of the overarching goals of Healthy People 2020, a large program managed by the HHS, is to "Achieve health equity, eliminate disparities, and improve the health of all groups." To work toward this monumentous goal, the HHS is actively tracking disease patterns, chronic conditions, and death rates among the many different types of people that live in the United States. This will be further discussed in Chapter 2 "Achieving a Healthy Diet".

20. A measurement dependent on three variables; income, occupation, and education.

Interactive 1.4

To see the differences in causes of death for different sexes, races, and age groups, visit the website of Healthy People and compare the top ten causes of death for different populations.

http://www.healthypeople.gov/2020/default.aspx

Lifestyle

One facet of lifestyle is your dietary habits. Recall that we discussed briefly how nutrition affects health. A greater discussion of this will follow in subsequent chapters in this book as there is an enormous amount of information regarding this aspect of lifestyle. Dietary habits include what a person eats, how much a person eats during a meal, how frequently meals are consumed, and how often a person eats out at restaurants. Other aspects of **lifestyle**[21] include physical activity level, recreational drug use, and sleeping patterns, all of which play a role in health and impact nutrition. Following a healthy lifestyle improves your overall health.

In 2008, the HHS released the *Physical Activity Guidelines for Americans*. The HHS states that "Being physically active is one of the most important steps that Americans of all ages can take to improve their health. The *2008 Physical Activity Guidelines for Americans* provides science-based guidance to help Americans aged six and older improve their health through appropriate physical activity." The guidelines recommend exercise programs for people in many different stages of their lifecycle and for pregnant women and adults and children who have disabilities. The HHS reports that there is strong evidence that increased physical activity decreases the risk of early death, heart disease, stroke, Type 2 diabetes, high blood pressure, and certain cancers; prevents weight gain and falls; and improves cognitive function in the elderly. Also unveiled recently are the *Canadian Physical Activity Guidelines*, which are available at the website of The Canadian Society for Exercise Physiology (http://www.csep.ca/english/view.asp?x=804).

21. Components of lifestyle are dietary habits, physical activity level, recreational drug use, and sleeping patterns, all of which play a role in health and impact nutrition.

Interactive 1.5

Go to the HHS website to access the entire *2008 Physical Activity Guidelines for Americans*.

http://www.health.gov/PAGuidelines/default.aspx

Recreational Drug Use

Recreational drug use, which includes tobacco-smoking and alcohol consumption along with narcotic and other illegal drug use, has a large impact on health. Smoking cigarettes causes lung cancer, eleven other types of cancer, heart disease, and several other disorders or diseases that markedly decrease quality of life and increase mortality. In the United States, smoking causes more than four hundred thousand deaths every single year, which is far more than deaths associated with any other lifestyle component.Centers for Disease Control and Prevention. "Smoking and Tobacco Use." Last updated March 21, 2011. http://www.cdc.gov/tobacco/data_statistics/fact_sheets/health_effects/tobacco_related_mortality/index.htm Also, according to the CDC, excessive alcohol intake causes an estimated seventy-five thousand deaths per year.Centers for Disease Control and Prevention. "Alcohol and Drug Use." Last updated June 7, 2012. http://www.cdc.gov/healthyyouth/alcoholdrug/ Staying away from excessive alcohol intake lowers blood pressure, the risk from injury, heart disease, stroke, liver problems, and some types of cancer. Abstaining from alcohol also aids in weight loss and increases the money in your wallet. While heavy drinking of alcoholic beverages is associated with several bad health effects, consuming alcohol in moderation has been found to promote health such as reducing the risk for heart disease and Type 2 diabetes in some people. The HHS defines drinking in moderation as no more than one drink a day for women and two drinks a day for men.

Illicit and prescription drug abuse are associated with decreased health and is a prominent problem in the United States. The health effects of drug abuse can be far-reaching including increased risk for stroke, heart disease, cancer, lung disease, and liver disease.

Sleeping Patterns

Inadequate amounts of sleep, or not sleeping well, can also have remarkable effects on a person's health. In fact, sleeping can affect your health just as much as diet or

exercise. At least 10 percent of Americans have chronic insomnia.National Sleep Foundation. “Can’t Sleep? What to Know about Insomnia.” Accessed February 12, 2012. http://www.sleepfoundation.org/article/sleep-related-problems/insomnia-and-sleep. Scientific studies have shown that insufficient sleep increases the risk for heart disease, Type 2 diabetes, obesity, and depression. Abnormal breathing during sleep, a condition called sleep apnea, is also linked to an increased risk for chronic disease.

Interactive 1.6

Go to the HHS website and discover the many tools at your fingertips to live a healthier lifestyle.

http://www.healthfinder.gov/prevention/

Nutrition, Genetics, Environment, and Lifestyle Interact to Affect Health

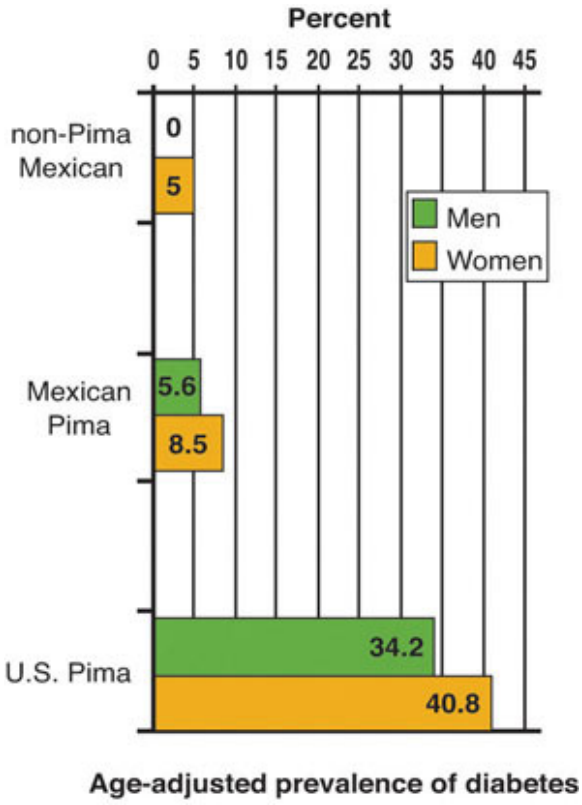
The Pima Indians who inhabit parts of southern Arizona and the Pima Indians that live across the border in Mexico are genetically and culturally similar, but there are vast differences in the health of these two populations. In America, the Pima Indians have the highest rate of obesity and Type 2 diabetes compared to any other ethnic group. However, the Pima Indians who live in Mexico do not share these same health problems because of a complex interplay between nutrition, genetics, environment, and lifestyle. Over one hundred years ago, the Pima Indians were farmers, hunters, and gatherers and their diets consisted of about 70 percent carbohydrate, 15 percent protein, and 10 to 15 percent fat. Typical of the lives of farmers, hunters, and gatherers a century ago, they lived through times of feast and times of famine. The geneticist James Neel proposed in 1962 that the Pima Indians carried a “thrifty gene” that makes them very efficient at storing fat during times of plenty so they do not starve when food is scarce.

After World War II, the Pima Indians in America either went back to reservations in southern Arizona or moved to the cities for work. They rapidly adopted the American diet and lifestyle and consumed high-fat, processed foods and refined grains and were more sedentary than their counterparts in Mexico, who retained their more traditional diet and lifestyle. Today, the typical American Pima Indian diet obtains more than 40 percent of calories from fat. The “thrifty gene” in the American Pima Indian population increased their susceptibility to the consequences

of the high-fat American diet and sedentary lifestyle because they were genetically better at storing fat than others. The story of the Pima Indians and the difference between the health of their populations in America and Mexico demonstrates the interactions between nutrition, genetics, environment, and lifestyle. Indeed, preliminary studies suggest that when American Pima Indians switch back to the diets of their ancestors and consume beans, corn, grains, and greens and other low-fat, high-fiber plant foods, the benefits are weight loss and reduced risk of chronic disease. The health status of American Pima Indians is considered “a canary in the coal mine, ” meaning they provide a warning to the American people.

Although the health consequences of the American diet and lifestyle in Pima Indians appeared rapidly in their population, all Americans that partake in the current trends of American diet and lifestyle are at risk. On the lighter side (literally!), the new studies that show changing back to more traditional diets markedly improved the health of the American Pima Indians suggest that all Americans can reduce their risk for diet-related diseases even when their genetic susceptibility for these diseases is high.

Figure 1.7 *The Interplay of Nutrition, Genetics, Environment, and Lifestyle Affects Health*



Pima Indians living in America are genetically similar to those who live in Mexico, but differences in their nutrition, environment, and lifestyle changes their health.

Source: http://paleobioticslab.com/general-interest-articles/so-go-the-pimas-so-go-the-rest-of-us/.

Tools for Change

Heed the warning of the Pima Indians and seek out ways to establish a more traditional dietary pattern. The American diet in the nineteenth century consisted of less meat, less processed food, and more home-grown fruits, vegetables, and whole grains. Think of ways to include these types of foods in your diet or partake in some of the traditional foods of a particular ethnic group in your community. Visit the following websites to find out the unique foods of some traditional diets.

Traditional Mediterranean diet: http://www.oldwayspt.org/mediterraneandiet

Native Tech: http://www.nativetech.org/recipes/index.php

Traditional foods, with recipes, by country: http://www.foodbycountry.com/index.html

Personal Choice: The Challenge of Choosing Foods

Holiday foods tastefully depict cultural and religious traditions.

© Shutterstock

From visiting websites about traditional foods of different cultures and ethnic groups, you may have noticed that a few more things besides environment and lifestyle that influence the foods you choose to eat. Different foods affect energy level, mood, how much is eaten, how long before you eat again, and if cravings are satisfied. We have talked about some of the physical effects of food on your body, but there are other effects too. Food regulates your appetite and how you feel. Multiple studies have demonstrated that some high-fiber foods and high-protein foods decrease appetite by slowing the digestive process and prolonging the feeling of being full. The effects of individual foods and

nutrients on mood are not backed by consistent scientific evidence, but in general most studies support that healthier diets are associated with a decrease in depression and improved well-being. To date, science has not been able to track the exact path in the brain that occurs in response to eating a particular food, but it is quite clear that foods, in general, stimulate emotional responses in people.

Food also has psychological, cultural, and religious significance, so your personal choices of food affect your body, mind, and soul. The social implications of food have a great deal to do with what people eat, as well as how and when. Special events in individual lives—from birthdays to funerals—are commemorated with equally special foods. Being aware of these forces can help people make healthier food choices—and still honor the traditions and ties they hold dear. Typically, eating kosher food means a person is Jewish; eating fish on Fridays during Lent means a person is Catholic; fasting during the ninth month of the Islamic calendar means a person is Muslim. On New Year's Day, people from New England like to combine pork and sauerkraut as a way to eat their way to luck. Several hundred miles away in the southern United States, people eat Hoppin' John, a favorite local dish made with black-eyed peas and pork, while fish is the "lucky" food of choice for Japanese Americans. National food traditions are carried to other countries when people immigrate. American cuisine would not be what it is today without the contributions of Italian, Chinese, Mexican, and other immigrants.

Factors that Drive Food Choices

Along with these influences, a number of other factors affect the dietary choices individuals make, including:

- **Taste, texture, and appearance.** Individuals have a wide range of tastes which influence their food choices, leading some to dislike milk and others to hate raw vegetables. Some foods that are very healthy, such as tofu, may be unappealing at first to many people. However, creative cooks can adapt healthy foods to meet most peoples' taste.
- **Economics.** Access to fresh fruits and vegetables may be scant, particularly for those who live in economically disadvantaged or remote areas, where cheaper food options are limited to convenience stores and fast food.
- **Early food experiences.** People who were not exposed to different foods as children, or who were forced to swallow every last bite of overcooked vegetables, may make limited food choices as adults.
- **Habits.** It's common to establish eating routines, which can work both for and against optimal health. Habitually grabbing a fast food sandwich for breakfast can seem convenient, but might not offer

substantial nutrition. Yet getting in the habit of drinking an ample amount of water each day can yield multiple benefits.

- **Culture.** The culture in which one grows up affects how one sees food in daily life and on special occasions.
- **Geography.** Where a person lives influences food choices. For instance, people who live in Midwestern US states have less access to seafood than those living along the coasts.
- **Advertising.** The media greatly influences food choice by persuading consumers to eat certain foods.
- **Social factors.** Any school lunchroom observer can testify to the impact of peer pressure on eating habits, and this influence lasts through adulthood. People make food choices based on how they see others and want others to see them. For example, individuals can purchase cheap and fast pizzas or opt for high-end versions at fancy restaurants.
- **Health concerns.** Some people have significant food allergies, to lactose or peanuts for example, and need to avoid those foods. Others may have developed health issues, which require them to follow a low-salt diet. In addition, people who have never worried about their weight have a very different approach to eating than those who have long struggled with excess pounds.
- **Emotions.** There is a wide range in how emotional issues affect eating habits. When faced with a great deal of stress, some people tend to overeat, while others find it hard to eat at all.
- **Green food/Sustainability choices.** Based on a growing understanding of diet as a public and personal issue, more and more people are starting to make food choices based on their environmental impact. Realizing that their food choices help shape the world, many individuals are opting for a vegetarian diet, or, if they do eat animal products, striving to find the most “cruelty-free” options possible. Purchasing local and organic food products and items grown through sustainable products also helps shrink the size of one’s dietary footprint.

KEY TAKEAWAYS

In this section, you discovered that there are many determinants that affect your health status. You can change some of them and others you cannot. All the determinants of health interact together in influencing your health.

- The expression of genes determines all of your traits including your risk for certain diseases. Nutrients can change the way genes are turned "on" and "off," consequently affecting health.
- Certain stages of life require changes in nutrition to maintain bodily functions, such as growing.
- The traits that a person has are largely a product of their genes and environment. One aspect of a person's environment is socioeconomic status, which is dependent on income, occupation, and education. Socioeconomic status is one of the best environmental predictors of a population's health.
- Besides dietary habits, other components of lifestyle which affect health are physical activity level, recreational drug use, and sleeping patterns.
- Nutrition, genetics, environment, and lifestyle interplay on health.
- Cultural and religious tradition, along with social values can affect food choices. The foods you choose to eat affect your appetite and feelings. Numerous factors other than nutrition drive food choices.

DISCUSSION STARTERS

1. What types of diseases and/or conditions are present in your family?
2. Discuss the different cultures and religions that are represented by the people in your classroom and learn the different foods that they choose to eat.

1.5 Assessing Personal Health

LEARNING OBJECTIVES

1. Discuss ways of assessing your personal health status and your diet.
2. Set a goal to adopt, maintain, or improve a nutrition-related practice.
3. Formulate an effective, long-term, personal health and nutrition plan.

You may remember that when you were younger your mother or grandmother made you swallow that teaspoonful of cod liver oil because she said it was good for you. You don't have to have a PhD to know some of the basic ways you can adapt your life to be healthier. However, the mainstream media inundates the American population with health cures and tips, making it confusing to develop the best plan for your health. This section will equip you with tools to assess and improve your health. To find some other reliable sources on health see Note 1.49 "Interactive 1.7".

Interactive 1.7

The American Association for the Advancement of Science has listed the top ten resources on the internet for consumer health. Forget the blogs and discover sources that use science to back up their information on promoting health and preventing disease.

http://www.healthlit.org/health_resources/top_10_sites.htm

Personal Health Assessment

One of the easiest places to begin a personal health assessment is by examining the results from your last physical. Often a person will leave the doctor's office without these results. Remember that the results belong to you and having this information on hand provides you with much of what you need to keep track of your health. During a physical, after obtaining weight and height measurements, a nurse will typically examine blood pressure. Blood pressure is a measurement of the forces in the arteries that occur during each heart beat. It is a principle vital sign and an indicator of cardiovascular health. A desirable blood pressure is 120 over 80 mmHg.

In most circumstances a physical includes blood tests, which measure many health indicators, and you have to request the results. Once you have the results in hand, it is good practice to file them in a binder so you can compare them from year to year. This way you can track your blood-cholesterol levels and other blood-lipid levels and blood-glucose levels. These are some of the more general measurements taken, but in many instances blood tests also examine liver and kidney function, vitamin and mineral levels, hormone levels, and disease markers. Your doctor uses all of these numbers to assess your health and you can use them to play a more active role in keeping track of your health.

Hearing and vision are additionally part of a general health assessment. If you wear glasses, contacts, or a hearing aid you already are aware of how important it is to know the results of these exams. If you have not experienced vision or hearing problems yet your likelihood of experiencing them markedly increases over the age of forty. Another component of overall health is oral health. The health of your teeth, gums, and everything else in your mouth are an integral component of your overall health. This becomes apparent when a person experiences a tooth infection, which if left untreated significantly impairs physical, mental, and social well-being.

Don't forget to get the results of your physical the next time you visit your doctor. They will help you keep track of your health.

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Other indicators of health that you can measure yourself are body mass index (BMI) and fitness. BMI refers to an individual's body weight (in kilograms, or kg) divided by the square of their height (in meters) and the unit of measurement is kg/m^2. You can calculate this yourself or use one of the many BMI calculators on the web (see Note 1.50 "Interactive 1.8"). BMI is a standardized measurement that indicates if a person is underweight, of normal weight, overweight, or obese and is based on data from the average population. It has some limitations. One limitation is that it does not take into account how much of your weight is made up of muscle mass, which weighs more than fat tissue. BMI and other measurements of body composition and fitness are more fully discussed in Chapter 11 "Energy Balance and Body Weight".

This personal health assessment has focused primarily on physical health, but remember that mental and social well-being also affect health. During a physical, a doctor will ask how you are feeling, if you are depressed, and if you are experiencing behavioral problems. Be prepared to answer these questions truthfully, so that your doctor can develop a proper treatment plan to manage these aspects of health. Note 1.50 "Interactive 1.8" provides some tools to assess your mental and social well-being.

Taking charge of your health will pay off and equip you with the knowledge to better take advantage of your doctor's advice during your next physical. Health calculators, such as those that calculate BMI, ideal weight, target heart rate among many others, and personal health assessments will help you to take charge of your health, but they should not take the place of visiting your doctor.

Interactive 1.8

One of the better websites for assessing your health is available at the Institute for Good Medicine from the Pennsylvania Medical Society.

http://www.myfamilywellness.org/MainMenuCategories/YouYourPhysician/YourHealthToolkit

Dietary Assessment

The first step in assessing your diet is to find out if the foods you eat are good for your health and provide you with all the nutrients you need. Begin by recording in a journal what you eat every day, including snacks and beverages. Then visit the USDA website, http://www.choosemyplate.gov/myplate/index.aspx, which has various tools to help you assess your diet. You can track calories over time, diet quality, and find many other tools to evaluate your daily food consumption. The questions these tools can help answer include: How much food do you have to eat to match your level of activity? How many calories should you eat? What are the best types of food to get the most nutrients? What nutrients are contained in different foods? How do you plan a menu that contains all the nutrients you need? Make the first step and assess your diet. This book will provide you with interactive resources, videos, and audio files to empower you to create a diet that improves your health.

Family Medical History

Because genetics play a large role in defining your health it is a good idea to take the time to learn some of the diseases and conditions that may affect you. To do this, you need to record your family's medical history. Start by simply drawing a chart that details your immediate family and relatives. Many families have this and you may have a good start already. The next time you attend a family event start filling in the blanks. What did people die from? What country did Grandpa come from? While this may be a more interesting project historically, it can also provide

you with a practical tool to determine what diseases you might be more susceptible to. This will allow you to make better dietary and lifestyle changes early on to help prevent a disease from being handed down from your family to you. It is good to compile your information from multiple relatives.

Lifestyle Assessment

A lifestyle assessment includes evaluating your personal habits, level of fitness, emotional health, sleep patterns, and work-life balance. Many diseases are preventable by simply staying away from certain lifestyles. Don't smoke, don't drink excessively, and don't do recreational drugs. Instead, make sure you exercise. Find out how much to exercise by reading the *2008 Physical Activity Guidelines for Americans*. There is a wealth of scientific evidence that increased physical activity promotes health, prevents disease, and is a mood enhancer. Emotional health is often hard to talk about; however a person's quality of life is highly affected by emotional stability. Harvard's Women's Health Watch notes six reasons to get enough sleep: Sleep promotes healthy brain function, while lack of sleep can cause weight gain and increase appetite, decrease safety (falling asleep while driving), make a person moody and irritable, decrease health of the cardiovascular system and prevent the immune system from functioning well.Harvard Health Publications. "Importance of Sleep: Six Reasons Not to Scrimp on Sleep." *Harvard's Women's Health Watch* (January 2006). © 2000–2012 Harvard University. http://www.health.harvard.edu/press_releases/importance_of_sleep_and_health Finding balance between work and life is a difficult and continuous process involving keeping track of your time, taking advantage of job flexibility options, saying no, and finding support when you need it. Work-life balance can influence what you eat too.

KEY TAKEAWAYS

This section equips you with some tools to assess your lifestyle and make changes towards a healthier one.

- **Step 1.** Take charge of tracking your personal health.
- **Step 2.** Assess your diet and identify where it can be changed to promote health and prevent disease.
- **Step 3.** Start finding out the medical history of your family and identify the diseases you may be more susceptible to getting.
- **Step 4.** Assess your lifestyle by evaluating your personal habits, emotional health, sleep patterns, and work-life balance.
- **Step 5.** Start living a healthier life.

DISCUSSION STARTERS

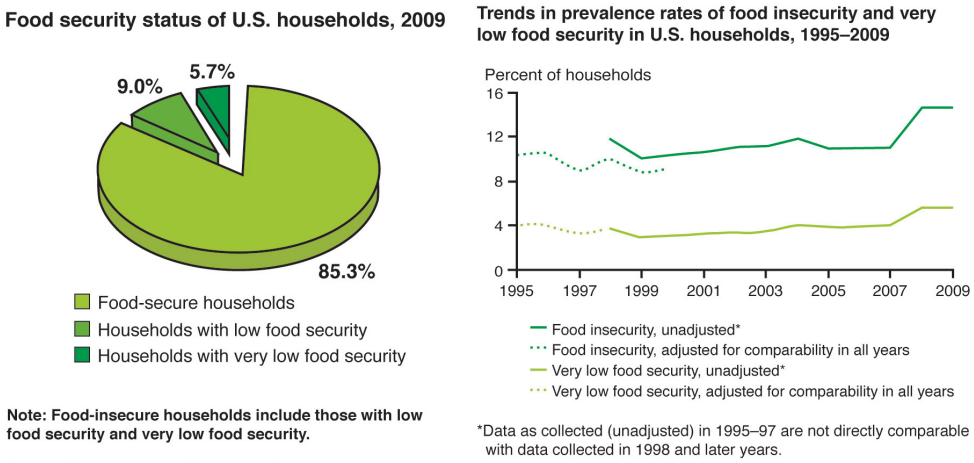
1. What websites in Note 1.50 "Interactive 1.8" did you find to be the most helpful in the assessment of your health?
2. Share your comments on these tools with your classmates and get their opinions, too.

1.6 A Fresh Perspective: Sustainable Food Systems

LEARNING OBJECTIVE

1. Discuss some approaches to building a sustainable food system in your community.

Figure 1.8 *Food Security Status in the United States*



Building a sustainable food system will help enforce measures to ensure that everyone on the planet has enough food to eat.

Source: Calculated by ERS using data from the December 2009 Current Population Survey Food Security Supplement.

22. The biological and physical environments and their interactions with the community of organisms that inhabit it, and also the interactions among the organisms.

23. Describes the variety of approaches aimed at improving our way of life. Sustainability promotes the development of conditions under which people and nature can interact harmoniously. It is based upon the principle that everything needed for human survival depends upon the natural environment.

The science of nutrition includes the study of how organisms obtain food from their environment. An **ecosystem**[22] is defined as the biological and physical environments and their interactions with the community of organisms that inhabit those environments as well as the interactions among the organisms. Human nutrition and the health of the world's ecosystem are interdependent, meaning that what we eat and where we get it from affects the world. In turn the health of the earth influences our health. The term **sustainability**[23] is used to indicate the variety of approaches aimed at improving our way of life. Sustainability promotes the development of conditions under which people and nature can interact harmoniously. It is based upon the principle that everything needed for human survival depends upon the natural environment. A major theme of sustainability is to ensure that the resources needed for human and environmental health will

continue to exist. A healthy ecosystem, one that is maintained over time, is harmonious and allows for social and economic fulfillment for present and future generations. Nutritious foods come from our ecosystem and to ensure its availability for generations to come, it must be produced and distributed in a sustainable way. The American Public Health Association (APHA) defines a **sustainable food system**[24] as "one that provides healthy food to meet current food needs while maintaining healthy ecosystems that can also provide food for generations to come with minimal negative impact to the environment."American Public Health Association. "Towards a Healthy, Sustainable Food System." *Policy Statement Database*. Policy no. 200712 (November 6, 2007). http://www.apha.org/advocacy/policy/policysearch/default.htm?id=1361 It also states that the attributes of a sustainable food system are:

- availability
- accessibility
- affordability to all
- humane
- just

A sustainable food system does not just include the food and those who consume the food, but also those that produce the food, like farmers and fishermen, and those who process, package, distribute, and regulate food. Unfortunately, we have a long way to go to build a sustainable food system.

The Challenges

The most prominent challenge to building a sustainable food system is to make food available and accessible to all. The Food and Agricultural Organization of the United Nations (FAO) states the right to food is a fundamental human right and its mission is to assist in building a food-secure world. **Food security**[25] in America is defined as the "access by all people at all times to enough food for an active, healthy life."US Department of Agriculture, Economic Research Service. "Food Security in the United States: Key Statistics and Graphics." Last updated June 4, 2012. http://www.ers.usda.gov/Briefing/FoodSecurity/stats_graphs.htm#food_secure As of 2009, 14.9 percent of households, or 17.4 million people in the United States, had very low or low food security and these numbers have risen in recent years (Figure 1.9 "Food Insecurity: A Global Perspective").Food and Agricultural Organization of the United Nations. "Food Security: Concepts and Measurement." In *Corporate Document Repository*, ID: 144369. 2003. http://www.fao.org/docrep/005/y4671e/y4671e06.htm

24. A system that can meet the needs of the current generation while providing food for generations to come without negatively impacting the environment.

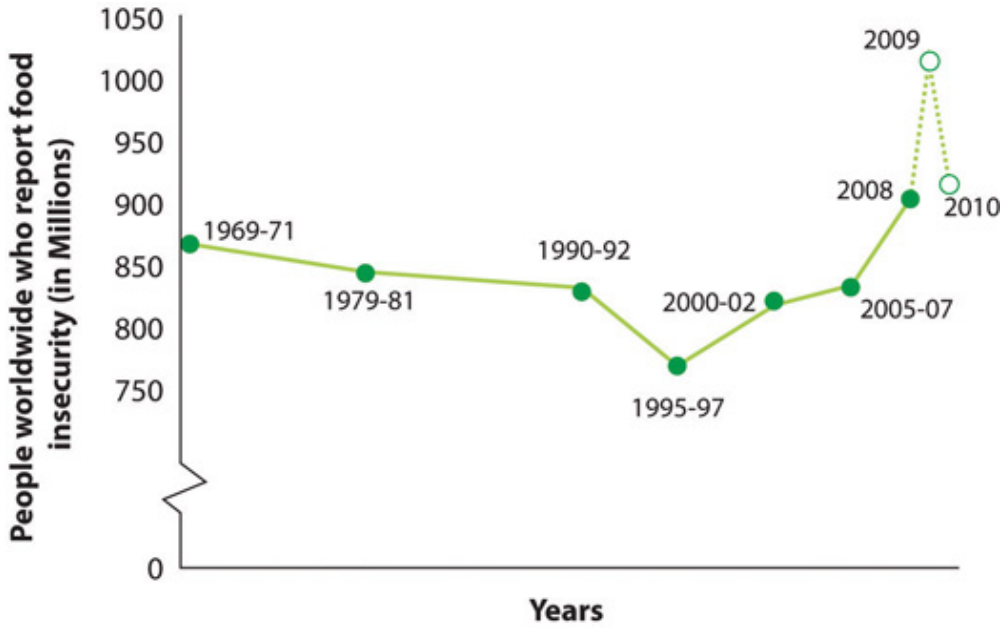
25. A state in which all persons in a community's population obtain a nutritionally adequate diet that is culturally acceptable throughout the year that is not dependent on emergency aid sources, but more so from local production.

Food security is defined by the FAO as existing "when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food which meets their dietary needs and food preferences for an active and healthy life."Food and Agriculture Organization of the United Nations. "How Does International Price Volatility Affect Domestic Economies and Food Security? In *The State of Food Insecurity in the World*. 2011. http://www.fao.org/publications/sofi/en/ The FAO estimates that 925 million worldwide were undernourished in 2010. Although there was a recent decline in overall food insecurity (attributable mostly to a decline in undernourished people in Asia), the number of undernourished people world-wide is still higher than it was in 1970, despite many national and international goals to reduce it.

Another challenge to building a sustainable food system is to supply high-quality nutritious food. The typical American diet does not adhere to dietary guidelines and recommendations, is unhealthy, and thus costs this country billions of dollars in healthcare. The average American diet contains too many processed foods with added sugars and saturated fats and not enough fruits, vegetables, and whole grains. Moreover, the average American takes in more kilocalories each day than ever before. This shift of the population toward unhealthy, high-calorie diets has fueled the obesity and diet-related disease crisis in this nation. Overall the cost of food for the average American household has declined since the 1970s; however, there has been a growth of "food deserts." A **food desert**[26] is a location that does not provide access to affordable, high-quality, nutritious food. One of the best examples of a "food desert" is in Detroit, Michigan. The lower socioeconomic status of the people who live in this city does not foster the building of grocery stores in the community. Therefore, the most accessible foods are the cheap, high-caloric ones sold in convenience stores. As a result, people who live in Detroit have some of the highest incidences of obesity, Type 2 diabetes, and cardiovascular disease in the country.

26. A location that does not provide access to affordable nutritious food.

Figure 1.9 Food Insecurity: A Global Perspective



Source: Calculated by ERS based on Current Population Survey Food Security Supplement data.

A fourth challenge to building a sustainable food system is to change how we produce, process, and distribute food. Large agribusiness, complex industrial processing, and massive retail conglomerations distort the connection we have between the food on our plate and where it came from. More food is being produced in this nation than ever before, which might sound good at first. However, some factors that have contributed to higher food production include using genetically engineered plants, excessive use of herbicides and pesticides, and the selective promotion of only a few crops by the policy of crop-specific subsidies (money given to farmers by the federal government). The subsidies are given toward the support of only about eight crops, most notably corn and soybeans. This policy diminishes the variety of crops, decreases biodiversity among crops, and supports large agribusiness while disadvantaging small- and medium-sized farms. Additionally, the whole system of food production, processing, and distribution is lengthy, requiring a great deal of energy and fossil fuels, and promotes excessive use of chemicals to preserve foods during transportation and distribution. In fact, the current US food system uses approximately 22 percent of the energy in this country and is responsible for at least 20 percent of greenhouse gas emissions.Canning, P. et al."Energy Use in the US Food System." US Department of Agriculture, *Economic Research Report, no. ERR-94* (March 2010). http://www.ers.usda.gov/Publications/ERR94/ERR94_ReportSummary.pdf

Solutions to the Challenges

While these challenges are daunting there are many potential solutions that are gaining momentum in the United States. The APHA advocates expanding the infrastructure for locally grown food, improving access to healthy and local food for low-income Americans, providing education on food origin and production, building up the livelihoods of local farmers, and using sustainable farming methods. Detroit is currently a "food desert," but there is a fantastic example of how to positively impact the growth of a sustainable food system within the city. It is called the Eastern Market and it is a six-block inner city market with over 250 vendors marketing local produce, meat, seafood, plants, fresh-cut flowers and much, much more. Unlike many urban farmers' markets it sells foods that are of better quality and lower prices than grocery stores. Its forty-thousand visitors every Saturday demonstrate its success as a community-based way to foster good nutrition, good health, and social interaction.

Tools for Change

You can do your part in building a sustainable environment by literally starting in your own backyard.

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Ten Steps You Can Take to Help Build a Sustainable Food System in Your Community

1. Eat a "low-carbon diet." This is one where the foods that you eat require less energy and fuel to produce, process, and distribute than other foods.
2. Join a community-based farmers' market.
3. Have a garden at home and join a network of home gardeners. Find out how by visiting the USDA website on gardening: http://www.usda.gov/wps/portal/usda/usdahome?navid=GARDENING&parentnav=CONSUMER_CITIZEN&navtype=RT and the National Garden Association, http://www.garden.org/.
4. Compost your food and garden waste. Learn some of the essentials of composting by visiting "Composting at home," a fact sheet

provided by Ohio State University (http://ohioline.osu.edu/hyg-fact/1000/1189.html).

5. Buy local food—make at least 10 percent of your food purchases local and share what you know about local food with friends and family.
6. Pool your resources with family and friends to purchase locally.
7. Drink tap water instead of bottled water.
8. When purchasing foods, choose the ones with less packaging.
9. Support state initiatives that support local farmers and build infrastructure to sell more healthy food.
10. When dining out, ask what nutrients are in the food and where the food labels are on the menu (to encourage the restaurants to label). Also, visit the restaurant's website as the information may be posted there with a space for comments.

These are some great steps to build a more sustainable food system for you and your family, friends, neighborhood, community, city, state, nation, and world. For more solutions, watch Note 1.60 "Video 1.4". Throughout this book we will highlight multiple steps you can take toward building a sustainable food system in the Tools for Change sections, so stay tuned.

Video 1.4

Sustainable Food Systems

(click to see video)

This link brings you to an educational video on sustainable food systems.

KEY TAKEAWAYS

- Sustainability promotes the development of conditions under which people and nature can interact harmoniously. It is based upon the principle that everything needed for human survival depends upon the natural environment. A sustainable food system includes not only the food and those who consume the food, but also those who produce food (such as farmers and fishermen), and process, package, distribute, and regulate food.
- The challenges to building a sustainable food system are many, from providing affordable and accessible food, to supplying nutritious, high-quality, low-cost food regardless of socioeconomic status, to changing the ways foods are produced, processed, and distributed.
- There are many solutions to the challenges of building a sustainable flood system. Some of the solutions are to: expand the infrastructure for locally grown food, improve access to healthy and local food for low-income Americans, provide education on food origin and production, build up the livelihoods of local farmers, and use sustainable farming methods.
- You can take action individually and locally to help build a sustainable food system.

DISCUSSION STARTERS

1. Share with each other in the classroom some of the things you might have already done to help build a sustainable food system in your community.
2. Form debate teams in the classroom and have a formal debate on the topic of the regulation of food. One side must present the reasons it is beneficial for the government to regulate food. The other side will argue the reasons it is better for people to grow their food locally.

1.7 End-of-Chapter Exercises

IT'S YOUR TURN

1. You are writing a short article for the *Daily News*. Explain how health means much more than a mere absence of disease.
2. Create a table that summarizes the six classes of nutrients and their major functions.
3. List five ideas on how to change the nutrition of Americans to protect their health and the health of the planet.

APPLY IT

1. Explore the nutritional and health information provided by the USDA, the HSS, and the IOM. Make a pros and cons list on how helpful the information from each of these sources was to you.
2. Revisit the photographs of the inner contents of refrigerators by Mark Menjivar. Describe how factors associated with a person's environment, lifestyle, and culture may affect the personal food choices in at least six different refrigerators.
3. Write a paragraph on your opinion of the role of the federal government in promoting health and preventing disease in Americans.

EXPAND YOUR KNOWLEDGE

1. Conduct an assessment of your diet. Begin by recording what you eat every day, including snacks and beverages, in a journal. Then visit the website, http://www.choosemyplate.gov/myplate/index.aspx, which has tools to help you assess your diet. Calculate your average daily calorie consumption.
2. Conduct an informal survey of five of your friends and family members. Create a questionnaire with ten to fifteen questions pertaining to their perception of food, their favorite food shows, what restaurants they frequent, what they purchase from the grocery store each week, etc. Ask questions about their general eating habits and record the answers. Next, get a camera and take pictures of the insides of their refrigerators. What have you learned about their eating habits? What advice would you give them? Review all the material and put it together in a report. Be prepared to share your findings.

3. Define eight steps your community can take to build a more sustainable food system. Visit the websites of Toronto's and California's plans to help provide you with some good ideas to accomplish the challenge.

   Toronto's plan for a sustainable food system:
   http://wx.toronto.ca/inter/health/food.nsf/Resources/340ACEEDBF1B2D6085257738000B22F2/$file/Cultivating%20Food%20Connections%20report.pdf

   California's plan for a sustainable food system:
   http://www.vividpicture.net/

Chapter 2

Achieving a Healthy Diet

Big Idea

The dietary toolkit contains numerous ideas to help you achieve a healthy diet.

Let's talk about a toolkit for a healthy diet. The first thing in it would be the Recommended Daily Allowances (RDAs). Then we could add the Dietary Reference Intakes (DRIs), the Estimated Average Requirements (EARs), and the Tolerable Upper Limits (ULs). All of these tools are values for important nutrients, calculated to meet the health needs of different age groups. But long before the dietary toolkit full of acronyms such as DRI, RDA, EAR, and UL, daily standards were created with the single goal of keeping workers alive and toiling in the factories and workhouses of the early Industrial Revolution. In the late nineteenth century powerhouse tycoons operated without fear of legal consequences and paid their workers as little as possible in order to maximize their own profits. Workers could barely afford housing, and depended on what their bosses fed them at the workhouses to fend off starvation.

Living conditions in those days show that the term "starvation wages" was not just a figure of speech. Here's a typical day's menu:

- **Breakfast.** 1 pint porridge, one 6-ounce piece of bread.
- **Lunch.** Beef broth one day, boiled pork and potatoes the next.
- **Dinner.** 1 pint porridge, one 6-ounce piece of bread.

Without programs like food stamps, workers and military personnel often had to accept whatever meager rations were given to them by their employers.

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As public awareness about these working conditions grew, so did public indignation. Experts were eventually called in to create the first dietary guidelines, which

were designed only to provide a typical individual with what they needed to survive each day, and no more. It wasn't until World War I that the British Royal Society first made recommendations about the nutrients people needed to be healthy, as opposed to merely surviving. They included ideas we now take for granted, such as making fruit and vegetables part of the diet and giving milk to children. Since then, most governments have established their own dietary standards. Food is a precious commodity, like energy, and controlling the way it is distributed confers power. Sometimes this power is used to influence other countries, as when the United States withholds food aid from countries with regimes of which it disapproves. Governments can also use their power over food to support their most fragile citizens with food relief programs, such as the Supplemental Nutrition Assistance Program (SNAP) and the Women, Infants, and Children Supplemental Food Program (WIC).

The US government has also established dietary standards to help citizens follow a healthy diet. The first of these were the Recommended Daily Allowances (RDAs), published in 1943 because of the widespread food shortages caused by World War II. During the war, the government rationed sugar, butter, milk, cheese, eggs, coffee, and canned goods. Limited transportation made it hard to distribute fruits and vegetables. To solve this problem, the government encouraged citizens to plant "victory gardens" to produce their own fruits and vegetables. More than twenty million people began planting gardens in backyards, empty lots, and on rooftops. Neighbors pooled their resources and formed cooperatives, planting in the name of patriotism.

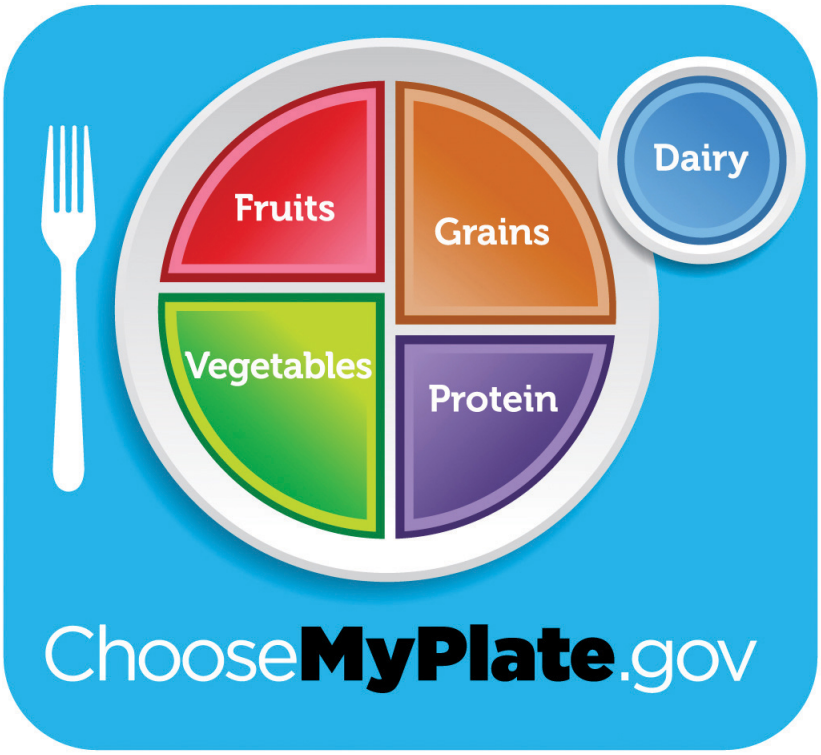
Today in the United States, there are various measures used to maintain access to nutritious, safe, and sufficient food to the citizenry. Many of these dietary guidelines are provided by the government, and are found at the Food and Drug Administration's (FDA) new website, ChooseMyPlate.gov. We call this collection of guidelines the "dietary toolkit."

A key part of First Lady Michelle Obama's healthy eating campaign is the new My Food Plate. This new icon is easier to understand than the 2005 MyPyramid, focuses on food, and can be used without a computer.

You Decide

How will you use the dietary toolkit?

The government works to provide citizens with information, guidance, and access to healthy foods. How will you decide which information to follow? What are the elements of a healthy diet, and how do you figure out ways to incorporate them into your personal diet plan? The dietary toolkit can be likened to a mechanics toolkit, with every tool designed for a specific task(s). Likewise, there are many tools in the dietary toolkit that can help you build, fix, or maintain your diet for good health. In this chapter you will learn about many of the tools available to you.



Today, the US government sets dietary guidelines that provide evidence-based nutrition information designed to improve the health of the population.

Source: US Department of Agriculture.

2.1 A Healthy Philosophy toward Food

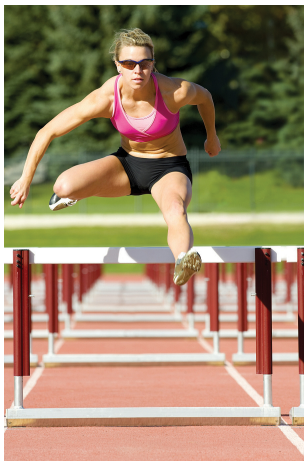
LEARNING OBJECTIVE

1. Explain why nutrition is important to health.

"Tell me what you eat, and I will tell you what you are" wrote the French lawyer and politician, Antheime Brillat-Savarin in his book, *Physiologie du Gout, ou Meditations de Gastronomie Transcendante*, in 1826. Almost one hundred years later, nutritionist Victor Lindlahr wrote in an ad in 1923, "Ninety percent of the diseases known to man are caused by cheap foodstuffs. You are what you eat." Today, we know this phrase simply as, "You are what you eat."Phrase Finder. Accessed July 6, 2011. http://www.phrases.org.uk/meanings/you%20are%20what%20you%20eat.html

Good nutrition equates to receiving enough (but not too much) of the macronutrients (proteins, carbohydrates, fats, and water) and micronutrients (vitamins and minerals) so that the body can stay healthy, grow properly, and work effectively. The phrase "you are what you eat" refers to the fact that your body will respond to the food it receives, either good or bad. Processed, sugary, high-fat, and excessively salted foods leave the body tired and unable to perform effectively. By contrast, eating fresh, natural whole foods fuels the body by providing what it needs to produce energy, promote metabolic activity, prevent micronutrient deficiencies, ward off chronic disease, and to promote a sense of overall health and well-being.

Table 2.1 Why Nutrition Is Important to Health



Nutrition provides the body with the nutrients it needs to perform all activities, from taking a breath to strenuous athletic activity.

© Dreamstime

Protein	Necessary for tissue formation, cell reparation, and hormone and enzyme production. It is essential for building strong muscles and a healthy immune system.
Carbohydrates	Provide a ready source of energy for the body and provide structural constituents for the formation of cells.
Fat	Provides stored energy for the body, functions as structural components of cells and also as signaling molecules for proper cellular communication. It provides insulation to vital organs and works to maintain body temperature.
Vitamins	Regulate body processes and promote normal body-system functions.
Minerals	Regulate body processes, are necessary for proper cellular function, and comprise body tissue.
Water	Transports essential nutrients to all body parts, transports waste products for disposal, and aids with body temperature maintenance.

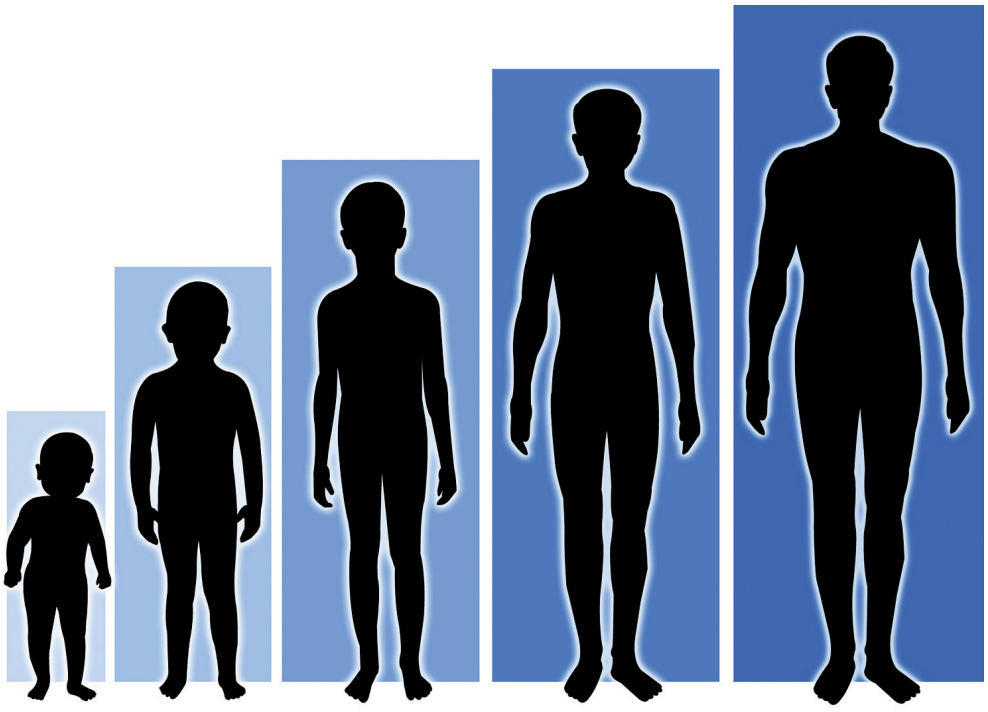
Undernutrition, Overnutrition, and Malnutrition

For many, the word “malnutrition” produces an image of a child in a third-world country with a bloated belly, and skinny arms and legs. However, this image alone

is not an accurate representation of the state of malnutrition. For example, someone who is 150 pounds overweight can also be malnourished. **Malnutrition**[1] refers to one not receiving *proper* nutrition and does not distinguish between the consequences of *too many* nutrients or the *lack* of nutrients, both of which impair overall health. **Undernutrition**[2] is characterized by a lack of nutrients and insufficient energy supply, whereas **overnutrition**[3] is characterized by excessive nutrient and energy intake. Overnutrition can result in **obesity**[4], a growing global health threat. Obesity is defined as a metabolic disorder that leads to an overaccumulation of fat tissue.

Although not as prevalent in America as it is in developing countries, undernutrition is not uncommon and affects many subpopulations, including the elderly, those with certain diseases, and those in poverty. Many people who live with diseases either have no appetite or may not be able to digest food properly. Some medical causes of malnutrition include cancer, inflammatory bowel syndrome, AIDS, Alzheimer's disease, illnesses or conditions that cause chronic pain, psychiatric illnesses, such as anorexia nervosa, or as a result of side effects from medications. Overnutrition is an epidemic in the United States and is known to be a risk factor for many diseases, including Type 2 diabetes, cardiovascular disease, inflammatory disorders (such as rheumatoid arthritis), and cancer.

Growth and Development



Proper growth throughout the life stages depends upon proper nutrition.

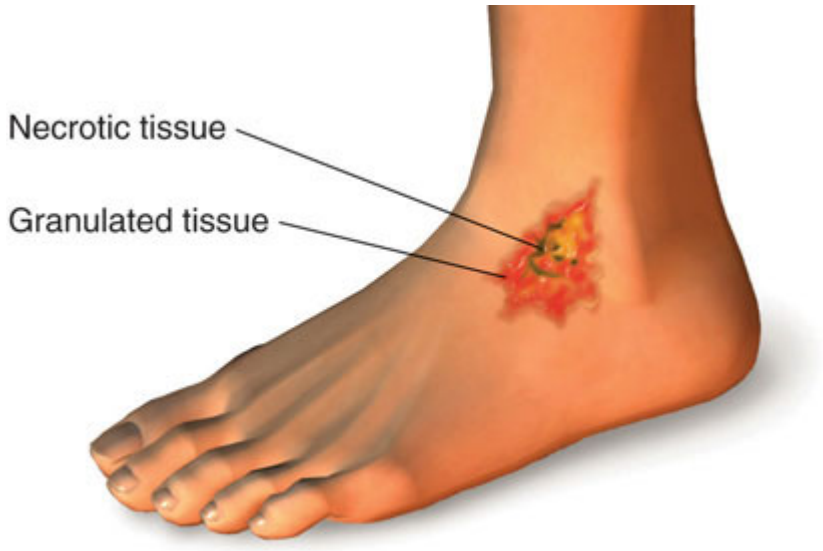
1. A condition where one does not receive proper amounts of nutrients. This condition may have resulted from an inadequate or unbalanced diet, digestive and absorption problems, or other medical issues.
2. A condition where a person is not consuming enough nutrients, which leads to malnutrition.
3. A condition where a person is consuming too much food and too many nutrients, which may lead to malnutrition.
4. A metabolic disorder that leads to the overaccumulation of fat tissue, compromising overall health.

© Dreamstime

From birth to adulthood, nutrients fuel proper growth and function of all body cells, tissue, and systems. Without proper amounts of nutrients, growth and development are stunted. Some nutrient deficiencies manifest right away, but sometimes the effects of undernutrition aren't seen until later in life. For example, if children do not consume proper amounts of calcium and vitamin D, peak bone mass will be reduced compared to what it would be had adequate amounts of these nutrients been consumed. When adults enter old age without adequate bone mass, they are more susceptible to osteoporosis, putting them at risk for bone fractures. Therefore, it is vital to build bone strength through proper nutrition during youth because it cannot be done in later life.MedicineNet.com. "Nutrients for the Growing Years." Last reviewed August 13, 2003. http://www.medicinenet.com/script/main/art.asp?articlekey=10054.

The Healing Process

With all wounds, from a paper cut to major surgery, the body must heal itself. Healing is facilitated through proper nutrition,MacKay, D., ND, and A. L. Miller, ND. "Nutritional Support for Wound Healing." *Alternative Medicine Review* 8, no. 4 (2003): 359–77. while malnutrition inhibits and complicates this vital process. The following nutrients are important for proper healing:



Healing, a critical function of a healthy body, is facilitated by adequate nutrition.

- **Vitamin A.** Helps to enable the epithelial tissue (the thin outer layer of the body and the lining that protects your organs) and bone cells form.
- **Vitamin C.** Helps form collagen, an important protein in many body tissues.
- **Protein.** Facilitates tissue formation.
- **Fats.** Play a key role in the formation and function of cell membranes.
- **Carbohydrates.** Fuel cellular activity, supplying needed energy to support the inflammatory response that promotes healing.

Now that we have discussed the importance of proper nutrition for your body to perform normal tissue growth, repair, and maintenance, we will discuss ways of achieving a healthy diet.

KEY TAKEAWAYS

- Nutrition promotes vitality and an overall sense of health and well-being by providing the body with energy and nutrients that fuel growth, healing, and all body systems and functions. Good nutrition will also help to ward off the development of chronic disease.
- A person is malnourished by being either undernourished or overnourished. Malnutrition results when the body does not receive the required amounts of calories, fats, proteins, carbohydrates, vitamins, and minerals necessary to keep the body and its systems in good functioning order.

DISCUSSION STARTER

1. Describe what the phrase, "You are what you eat" means. Do you notice how you feel after eating certain types of foods? How might this relate to your overall health?

2.2 What Is Nutritional Balance and Moderation?

LEARNING OBJECTIVE

1. Define the components of a healthful diet.

Achieving a Healthy Diet

Achieving a healthy diet is a matter of balancing the quality and quantity of food that is eaten. There are five key factors that make up a healthful diet:

- A diet must be **adequate**[5], by providing sufficient amounts of each essential nutrient, as well as fiber and calories.
- A **balanced diet**[6] results when you do not consume one nutrient at the expense of another, but rather get appropriate amounts of all nutrients.
- **Calorie control**[7] is necessary so that the amount of energy you get from the nutrients you consume equals the amount of energy you expend during your day's activities.
- **Moderation**[8] means not eating to the extremes, neither too much nor too little.
- **Variety**[9] refers to consuming different foods from within each of the food groups on a regular basis.

A healthy diet is one that favors whole foods. As an alternative to modern processed foods, a healthy diet focuses on "real" fresh whole foods that have been sustaining people throughout the millenniums. Whole foods supply the needed vitamins, minerals, protein, carbohydrates, fats, and fiber that are essential to good health. Commercially prepared and fast foods are often lacking nutrients and often contain inordinate amounts of sugar, salt, saturated and trans fats, all of which are associated with the development of diseases such as atherosclerosis, heart disease, stroke, cancer, obesity, high cholesterol, diabetes, and other illnesses. A balanced diet is a mix of food from the different food groups (vegetables, legumes, fruits, grains, protein foods, and dairy).

Adequacy

An adequate diet is one that favors nutrient-dense foods. **Nutrient-dense foods**[10] are defined as foods that contain many essential nutrients per calorie. Nutrient-

5. A dietary term signifying a diet that provides all nutrients, fiber, and energy in amounts sufficient to maintaining good health and body weight.
6. A balanced diet supplies various types of foods in proportion to one another. With balance, foods rich in one nutrient leave room for foods that are rich in other nutrients.
7. Controlling energy intake so that energy requirements are being met but not exceeded.
8. Not eating to the extremes, neither too much nor too little.
9. Consuming an abundance of foods from different food groups on a regular basis.
10. Foods that contain many nutrients per calorie.

dense foods are the opposite of "empty-calorie" foods, such as sugary carbonated beverages, which are also called "nutrient-poor." Nutrient-dense foods include fruits and vegetables, lean meats, poultry, fish, low-fat dairy products, and whole grains. Choosing more nutrient-dense foods will facilitate weight loss, while simultaneously providing all necessary nutrients.

Tools for Change

Does your diet contain nutrient-dense foods? Record your eating habits for one week. Note the sugary, fatty, and calorie-heavy foods you most often consume. Look at Table 2.2 "The Smart Choice: Nutrient-Dense Food Alternatives" to decide what you can substitute those foods with.

Table 2.2 The Smart Choice: Nutrient-Dense Food Alternatives

Instead of...	Replace with...
Sweetened fruit yogurt	Plain fat-free yogurt with fresh fruit
Whole milk	Low-fat or fat-free milk
Cheese	Low-fat or reduced-fat cheese
Bacon or sausage	Canadian bacon or lean ham
Sweetened cereals	Minimally sweetened cereals with fresh fruit
Apple or berry pie	Fresh apple or berries
Deep-fried French fries	Oven-baked French fries or sweet potato baked fries
Fried vegetables	Steamed or roasted vegetables
Sugary sweetened soft drinks	Seltzer mixed with 100 percent fruit juice
Recipes that call for sugar	Experiment with reducing amount of sugar and adding spices (cinnamon, nutmeg, etc...)

Source: US Department of Agriculture. "Food Groups." http://www.choosemyplate.gov/food-groups/.

Balance

Balance the foods in your diet. Achieving balance in your diet entails not consuming one nutrient at the expense of another. For example, calcium is essential for healthy teeth and bones, but too much calcium will interfere with iron absorption. Most foods that are good sources of iron are poor sources of calcium, so in order to get the necessary amounts of calcium and iron from your diet, a proper balance between food choices is critical. Another example is that while sodium is a vital nutrient, an overabundance of it can contribute to congestive heart failure and chronic kidney disease. Remember, everything must be consumed in the proper amounts.

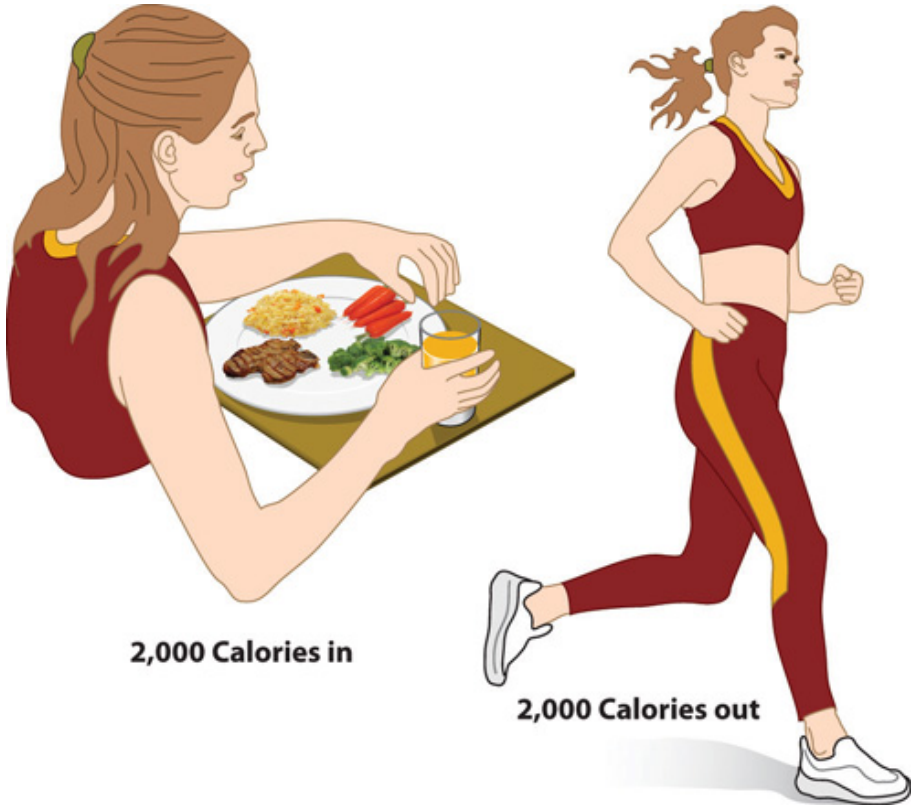
With careful planning, a balanced diet providing optimal nutrition can be achieved and maintained.

© Shutterstock

Moderation

Eat in moderation. Moderation is crucial for optimal health and survival. Burgers, French fries, cake, and ice cream each night for dinner will lead to health complications. But as part of an otherwise healthful diet and consumed only on a weekly basis, this should not have too much of an impact on overall health. If this is done once per month, it will have even less of an impact upon overall health. It's important to remember that eating is, in part, about enjoyment and indulging with a spirit of moderation. This fits within a healthy diet.

Calorie Control



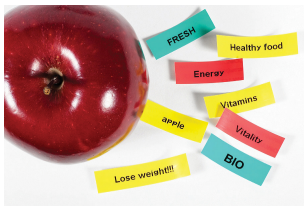
The number of calories consumed should always match the number of calories being expended by the body to maintain a healthy weight.

© Networkgraphics

Monitor food portions. For optimum weight maintenance, it is important to ensure that energy consumed from foods meets the energy expenditures required for body functions and activity. If not, the excess energy contributes to gradual, steady weight gain. In order to lose weight, you need to ensure that more calories are burned than consumed. Likewise, in order to gain weight, calories must be eaten in excess of what is expended daily.

Variety

Variety involves eating different foods from all the food groups. Eating a varied diet helps to ensure that you receive all the nutrients necessary for a healthy diet. One of the major drawbacks of a monotonous diet is the risk of consuming too much of some nutrients and not enough of others. Trying new foods can also be a source of pleasure—you never know what foods you might like until you try them.



Scientific evidence confirms that a diet full of fresh whole foods reduces the risks for developing chronic disease and helps maintain a healthy weight.

© Dreamstime

Table 2.3 Food Choices for a Healthful Diet

Grain	Vegetable	Fruit	Dairy	Protein
Whole-grain products, brown rice, quinoa, barley, buckwheat, millet, wild rice, oats, rye berries, sorghum, bulgur, kasha, farrow, wheat berries, corn, amaranth, spelt, Teff	**Dark green:** broccoli, collards, kale, romaine lettuce, spinach, turnip greens, watercress	apples, apricots, bananas	all fluid milk (fat free, low-fat, reduced-fat, whole milk, lactose-free), fortified soy milk, yogurt	**Meats:** beef, ham, lamb, pork, veal
	Red and orange: Acorn squash, butternut squash, carrots, pumpkin, red peppers, sweet potatoes	**Berries:** strawberries, blueberries, raspberries, cherries, grapefruit, kiwi fruit, lemons, limes, mangoes	**Hard natural cheeses:** cheddar, mozzarella, Swiss, parmesan	**Poultry:** chicken, goose, turkey, duck
	Beans and peas: Black beans, black-eyed peas, chickpeas, kidney beans, lentils, navy beans, pinto	**Melons:** cantaloupe, honey dew, watermelon	**Soft cheeses:** ricotta, cottage	**Eggs**

Grain	Vegetable	Fruit	Dairy	Protein
	beans, soybeans, split peas, white beans			
	Starchy: Cassava, green bananas, green peas, green lima beans, plantains, potatoes, taro, water chestnuts	**Other fruits:** nectarines, oranges, peaches, pears, papaya, pineapple, plums, prunes		**Beans and peas:** (see vegetable column)
	Other vegetables: Asparagus, avocado, bean sprouts, beets, Brussels sprouts, cabbage, cauliflower, celery, eggplant, green beans, green peppers, mushrooms, okra, onions, parsnips			**Nuts and seeds:** almonds, cashews, hazelnuts, peanuts, pecans, pistachios, pumpkin seeds, sesame seeds, sunflower seeds, walnuts
				Seafood: catfish, cod, flounder, haddock, halibut, herring, mackerel, pollock, porgy, salmon, sea bass, snapper, swordfish, trout, tuna
				Shellfish: scallops, muscles, crab, lobster

Source: Adapted from http://www.choosemyplate.gov/food-groups/protein-foods.html.

Video Link 2.1

Different Types of Grains

In this video, a registered dietitian discusses the benefits of eating whole grains.

http://www.ehow.com/video_4983984_different-types-grains.html

Developing a healthful diet can be rewarding, but be mindful that all of the principles presented must be followed to derive maximal health benefits. For instance, introducing variety in your diet can still result in the consumption of too many high-calorie, nutrient-poor foods and inadequate nutrient intake if you do not also employ moderation and calorie control. Using all of these principles together will afford you lasting health benefits.

Widening your food palate will increase your intake of vital nutrients.

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KEY TAKEAWAYS

- A healthful diet is adequate in providing proper amounts of nutrient-dense foods, is balanced in relation to food types so that one nutrient is not consumed at the expense of another, practices calorie control by supplying food energy to match energy output, is moderate in unwanted constituents, and draws from a variety of nutritious foods.
- Nutrient-dense foods contribute to daily nutritional requirements while limiting caloric intake, thus allowing people to either lose weight safely or to maintain a healthy weight.

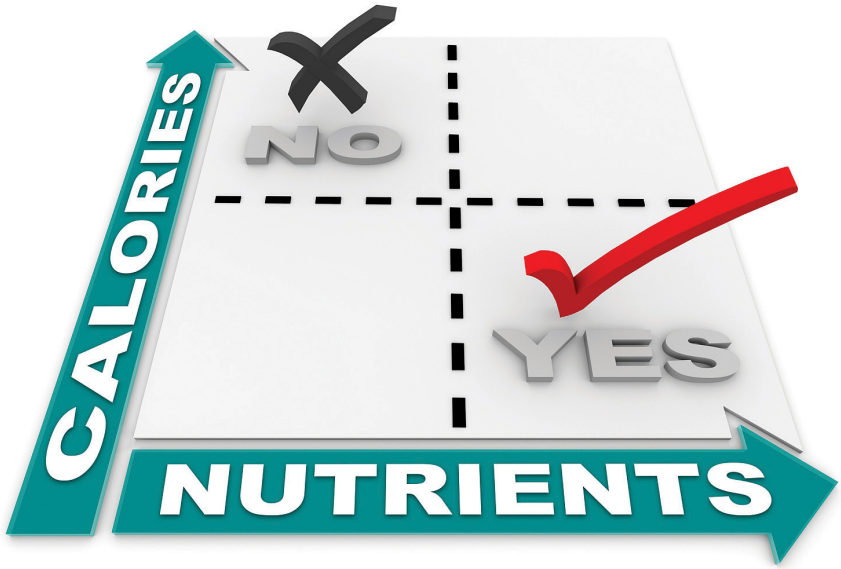
DISCUSSION STARTERS

1. Discuss the principles of a healthy diet. How can you employ these principles in your diet, if you are not already?
2. Review the list of grains in Table 2.3 "Food Choices for a Healthful Diet". Pick one that you have not tried before. Make a dish using this grain. Discuss with your classmates your experience eating this new food.

2.3 Understanding the Bigger Picture of Dietary Guidelines

LEARNING OBJECTIVE

1. Describe the major themes of the *2010 Dietary Guidelines for Americans*.



Dietary guidelines help people to stay on a healthful track by drawing attention to the overall scope of their diet and lifestyle.

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The first US dietary recommendations were set by the National Academy of Sciences in 1941. The recommended dietary allowances (RDA) were first established out of concern that America's overseas World War II troops were not consuming enough daily nutrients to maintain good health. The first Food and Nutrition Board was created in 1941, and in the same year set recommendations for the adequate intakes of caloric energy and eight essential nutrients. These were disseminated to

officials responsible for food relief for armed forces and civilians supporting the war effort. Since 1980, the dietary guidelines have been reevaluated and updated every five years by the advisory committees of the US Department of Agriculture (USDA) and the US Department of Health and Human Services (HHS). The guidelines are continually revised to keep up with new scientific evidence-based conclusions on the importance of nutritional adequacy and physical activity to overall health. While dietary recommendations set prior to 1980 focused only on preventing nutrient inadequacy, the current dietary guidelines have the additional goals of promoting health, reducing chronic disease, and decreasing the prevalence of overweight and obesity.

Why Are Guidelines Needed?

The major theme of the 2010 Dietary Guidelines for Americans is an adequate diet combined with proper exercise.

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Instituting nation-wide standard policies provides consistency across organizations and allows health-care workers, nutrition educators, school boards, and elder-care facilities to improve nutrition and subsequently the health of their respective populations. At the same time, the goal of the *2010 Dietary Guidelines* is to provide packaged informative guidelines that will help any interested person in obtaining optimal nutritional balance and health. The seventh edition of the *Dietary Guidelines* was released in 2010 and focuses mainly on combating the obesity epidemic. USDA secretary Tom Vilsack says, "The bottom line is that most Americans need to trim their waistlines to reduce the risk of developing diet-related chronic disease. Improving our eating habits is not only good for every individual and family, but also for our country." The *Dietary Guidelines* are formulated by the Food and Nutrition Board of the Institute of Medicine (IOM) from the review of thousands of scientific journal articles by a consensus panel consisting of more than two thousand nutrition experts with the overall mission of improving the health of the nation.Johnson, T.D. "Online Only: New Dietary Guidelines Call for Less Salt, Fewer Calories, More Exercise." *Nation's Health* 41, no. 2 (March 2011): E6. http://thenationshealth.aphapublications.org/content/41/2/E6.full.

Major Themes of the *2010 Dietary Guidelines*

The *2010 Dietary Guidelines* consists of four major action steps for the American public to improve the overall health of the country. These steps are as follows:

1. Reduce the incidence and prevalence of overweight and obesity of the US population by reducing overall calorie intake and increasing physical activity.
2. Shift food intake patterns to a diet that emphasizes vegetables, cooked dry beans, and peas, fruits, whole grains, nuts, and seeds. In addition, increase the intake of seafood and fat-free and low-fat milk and milk products and consume only moderate amounts of lean meats, poultry, and eggs.
3. Significantly reduce intake of foods containing solid fats and added sugars (SoFAS) because these dietary components contribute excess calories and few, if any, nutrients. In addition, reduce sodium intake and lower intake of refined grains that are coupled with added sugar, solid fat, and sodium.
4. Meet the *2008 Physical Activity Guidelines for Americans*. (http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/PolicyDoc/Chapter1.pdf)

We will discuss the highlights of each chapter of the *2010 Dietary Guidelines*; however if you are interested in reading more, visit the USDA website, http://www.cnpp.usda.gov/DGAs2010 -PolicyDocument.htm.

How should you develop a healthy eating plan to best achieve your goals of losing weight, gaining weight, or maintaining weight? We will start with some basics and move on to healthy eating patterns.

To achieve the goal of reducing caloric intake, the *2010 Dietary Guidelines* promote the following:

1. Increase intake of whole grains, fruits, and vegetables.
2. Reduce intake of sugar-sweetened beverages.
3. Monitor intake of 100 percent fruit juice for children and adolescents, especially those who are overweight or obese.
4. Monitor calorie intake from alcoholic beverages for adults.

Foods and Food Components to Reduce

Table 2.4 A Little Less of These, Please

Dietary Constituent	Health Implications	Recommendations
Excess sodium	High blood pressure	Limit intake to 2,300 mg daily

Dietary Constituent	Health Implications	Recommendations
Too much saturated fat	Cardiovascular disease	Limit intake to < 10 percent of total calories
Trans fats	Cardiovascular disease	Minimal, if any consumption
Excess cholesterol	Atherosclerosis	Limit intake to below 300 mg daily
SoFAS (solid fats and added sugars)	Obesity, Type 2 diabetes	Avoid if possible
Too much alcohol	Impaired liver function, impaired motor function	No more than one drink per day for women; No more than two drinks per day for men

High consumptions of certain foods, such as those high in saturated or trans fat, sodium, added sugars, and refined grains may contribute to the increased incidence of chronic disease. Additionally, excessive consumption of these foods replaces the intake of more nutrient-dense foods.

The average person consumes 3,400 milligrams of sodium per day, mostly in the form of table salt. The *2010 Dietary Guidelines* recommend that Americans reduce their daily sodium intake to less than 2,300 milligrams. If you are over the age of fifty-one, are African American, or have cardiovascular risk factors, such as high blood pressure or diabetes, sodium intake should be reduced even further to 1,500 milligrams. The *Dietary Guidelines* also recommend that less than 10 percent of calories come from saturated fat, and that fat calories should be obtained by eating foods high in unsaturated fatty acids. Cholesterol intake should be decreased to below 300 milligrams per day and trans fatty acid consumption kept to a bare minimum. The *Dietary Guidelines* stresses the importance of limiting the consumption of foods with refined grains and added sugars, and introduce the new term, **SoFAS**[11], which is an acronym for *solid fats and added sugars*, both of which are to be avoided in a healthy diet plan.Nelson, J. and K. Zeratsky. “Dietary Guidelines Connect SoFAS and Weight Gain.” Mayo Clinic, *Nutrition-Wise* (blog). August 25, 2010. http://www.mayoclinic.com/health/dietary-guidelines/MY01417. Moreover, if alcohol is consumed, it should be consumed only in moderation, which for women it is not more than one drink per day and for men is not more than two drinks per day. The macronutrients protein, carbohydrates, and fats contribute considerably to total caloric intake. The IOM has made recommendations for different age groups on the percentage of total calories that should be obtained from each macronutrient class (Table 2.5 "Recommendations for Macronutrient Intake As Percentage of Total Calories").

11. An acronym for solid fats and added sugars.

Table 2.5 Recommendations for Macronutrient Intake As Percentage of Total Calories

Age Group	Protein (%)	Carbohydrates (%)	Fat (%)
Children (1–3)	5–20	45–65	30–40
Children and Adolescents (4–18)	10–30	45–65	25–35
Adults (>19)	10–35	45–65	20–35

Source: *2010 Dietary Guidelines*.

Foods and Nutrients to Increase

The typical American diet lacks sufficient amounts of vegetables, fruits, whole grains, and high-calcium foods, causing concern for deficiencies in certain nutrients important for maintaining health. The *2010 Dietary Guidelines* provide the following suggestions on food choices to achieve a healthier diet:

1. Eat a variety of vegetables, especially dark green, red, and orange vegetables.
2. Choose at least half of your grains consumed from whole-grain foods.
3. For dairy products, eat the low-fat versions.
4. Don't get your protein only from red meats; choose instead seafood, poultry, eggs, beans, peas, nuts, seeds, and soy products.
5. Replace butter with oils.
6. Choose foods dense in the nutrients potassium, calcium, and vitamin D.
7. Increase intake of dietary fiber.

Building Healthy Eating Patterns

Fresh vegetables and olive oil are examples of foods emphasized in

The *2010 Dietary Guidelines* recommend that people make an effort to reduce their caloric consumption, reduce the intake of nutrient-poor foods, and increase the intake of nutrient-dense foods. To accomplish these tasks it is necessary to incorporate moderation and variety. The goal is not only choosing specific foods for your diet, but also the development of a healthy eating pattern. Several studies provide good evidence that certain dietary patterns increase overall health and decrease the risk of chronic disease. The Dietary Approaches to Stop Hypertension trial, or DASH, reports

the DASH and Mediterranean diets.

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that men and women who consumed more than eight servings per day of fruits and vegetables had lower blood pressures than a control group that consumed under four servings per day of fruits and vegetables.Sacks, F.M, et al., "Effects on Blood Pressure of Reduced Dietary Sodium and the Dietary Approaches to Stop Hypertension (DASH) Diet." *N Engl J Med*. 344, no. 1 (January 2001): 3–10. http://www.nejm.org/doi/full/10.1056/NEJM200101043440101. Other studies investigating the benefits of the DASH diet have also found it to be protective against cardiovascular disease and decrease overall mortality. Another well-known diet is the Mediterranean diet. In general, the Mediterranean diet is described as one that emphasizes fruits, vegetables, whole grains, and nuts, and olive oil as a replacement for butter. Few meats and high-fat dairy products are eaten. Observational studies have linked the Mediterranean diet to reduced cardiovascular disease and decreased mortality. Vegetarian diets, which emphasize many of the same foods as the DASH and Mediterranean diets have also been linked to a decrease in incidences of some chronic diseases.

KEY TAKEAWAYS

- US dietary guidelines are based on evolving scientific evidence and are updated every five years. The goals of the *2010 Dietary Guidelines* are to prevent nutrient inadequacy, promote health, reduce chronic disease, and decrease the prevalence of overweight and obesity.
- To have a healthy eating pattern, reduce the intake of sodium, saturated and trans fats, cholesterol, added sugars, and refined grains. Increase the consumption of fruits, vegetables, low-fat dairy products, dietary fiber, and oils.
- Healthy eating patterns prevent chronic disease and provide nutrient adequacy.

DISCUSSION STARTER

1. Discuss with your classmates suggestions from the *2010 Dietary Guidelines* that you should incorporate into your diet. How can you align your personal dietary goals with these recommendations?

2.4 National Goals for Nutrition and Health: Healthy People 2020

LEARNING OBJECTIVES

1. State the Healthy People 2020 nutrition- and weight-status goals.
2. List three related objectives for the Healthy People 2020 program.

Video 2.1

Preparing for the Next Decade: A 2020 Vision for Healthy People

(click to see video)

The Healthy People 2020 program, launched in 2010, is a ten-year national program instituted by the US government with objectives aimed toward improving the health of all Americans. Similar to the *2010 Dietary Guidelines*, it has been established to promote longer lives free of preventable disease, disability, injury, and premature death. With a revived intent on identifying, measuring, tracking, and reducing health disparities through a "determinants of health approach," Healthy People 2020 will strive to create the social and physical environments that promote good health for all and to promote quality of life, healthy development, and healthy behaviors across all life stages. This means that the understanding of what makes and keeps people healthy is consistently refined. The **determinants of health approach**[12] reflects the evidence from outside factors that greatly affect the health of individuals.US Department of Health and Human Services. "About Healthy People." Last updated March 29, 2012. http://www.healthypeople.gov/2020/about/default.aspx It takes into consideration the circumstances in which people are born, live, work, and age. It also reflects the conditions that shape their circumstances such as money, power, and resources at the local, national, and global levels. Social determinants of health are primarily accountable for the lack of fair health opportunities and the unjust differences in health status that exist within and between countries.World Health Organization. "Social Determinants of Health." © 2012. http://www.who.int/social_determinants/en/.

12. These are the conditions reflective of the circumstances in which people are born, live, work, and age. It assesses the conditions that shape circumstances such as money, power, and resources at the local, national and global levels.

Helping People Make Healthy Choices

It is not just ourselves, the food industry, and federal government that shape our choices of food and physical activity, but also our sex, genetics, disabilities, income, religion, culture, education, lifestyle, age, and environment. All of these factors

must be addressed by organizations and individuals that seek to make changes in dietary habits. The socioeconomic model incorporates all of these factors and is used by health-promoting organizations, such as the USDA and the HHS to determine multiple avenues through which to promote healthy eating patterns, to increase levels of physical activity, and to reduce the risk of chronic disease for all Americans. Lower economic prosperity influences diet specifically by lowering food quality, decreasing food choices, and decreasing access to enough food. As a result of the recent financial crisis in America the number of people who struggle to have enough to eat is rising and approaching fifty million. In response to these recent numbers, USDA Secretary Tom Vilsack said, "These numbers are a wake-up call...for us to get very serious about food security and hunger, about nutrition and food safety in this country."Amy Goldstein, "Hunger a Growing Problem in America, USDA Reports," *Washington Post*, 17 November 2009. http://www.washingtonpost.com/wp-dyn/content/article/2009/11/16/AR2009111601598.html.

The socioeconomic model helps organizations and the government to plan and promote effective healthy-eating programs tailored to specific populations.

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Video 2.2

Determinants of Health Approach in Healthy People 2020

(click to see video)

Goals for Nutrition and Weight Status

While Healthy People 2020 has many goals and objectives, we are going to focus on the two goals for nutrition and weight status. They are to promote health and reduce the risk of developing chronic diseases by encouraging Americans to consume healthful diets and to achieve and maintain healthy body weights. Nutrition criteria are reflective of a solid scientific foundation for health and weight management. Emphasis is on modifying individual behavior patterns and habits, and having policies and environments that will support these behaviors in various settings, such as schools and local community-based organizations.

Healthy People 2020 has defined their mission as:

- Identify nationwide health improvement priorities
- Increase public awareness and understanding of the determinants of health, disease, and disability, and the opportunities for progress
- Provide measurable objectives and goals that are applicable at the national, state, and local levels
- Engage multiple sectors to take actions to strengthen policies and improve practices that are driven by the best knowledge
- Identify critical research, evaluation, and data-collection needs

One of the ways that Healthy People 2020 strives to promote good health and nutrition is by bringing together multiple agencies and groups dedicated to achieving the Healthy People 2020 nationwide objectives.

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Healthy People 2020 has set key recommendations as follows:

- Consume a variety of nutrient-dense foods within and across the food groups, especially whole grains, fruits, vegetables, low-fat or fat-free milk or milk products, and lean meats and other protein sources

- Limit the intake of saturated fat and trans fats, cholesterol, added sugars, sodium (salt), and alcohol
- Limit caloric intake to meet caloric needsUS Department of Health and Human Services. "Nutrition and Weight Status." HealthyPeople.gov. Last updated May 1, 2012. http://healthypeople.gov/2020/topicsobjectives2020/overview.aspx?topicid=29

Consuming nutrient-dense foods and limiting portion sizes of food will contribute to weight management. Avoiding excessive amounts of anything allows room for many food types in the diet.

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Tools for Change

If you wait many hours between meals, there is a good chance you will overeat. To refrain from overeating try consuming small meals at frequent intervals throughout the day as opposed to two or three large meals. Eat until you are satisfied, not until you feel "stuffed." Eating slowly and savoring your food allows you to both enjoy what you eat and have time to realize that you are full before you get overfull. Your stomach is about the size of your fist but it expands if you eat excessive amounts of food at one sitting. Eating smaller meals will diminish the size of your appetite over time so you will feel satisfied with smaller amounts of food.

Benefits of Following the Healthy People 2020 Goals

Nutrition and weight status are important to children's growth and development. In addition, healthy eating habits will decrease risks for developing chronic health conditions such as obesity, malnutrition, anemia, cardiovascular disease, high blood pressure, dyslipidemia (poor lipid profiles), Type 2 diabetes, osteoporosis, dental disease, constipation, diverticular disease, and certain types of cancer.National Digestive Disease Information Clearinghouse, a service of National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health. "Am I at Risk for Type 2 Diabetes?" *NIH Publication No. 09-4805* (November 2008). Last updated December 6, 2011. http://diabetes.niddk.nih.gov/dm/pubs/riskfortype2/.

Meeting the recommended intake for energy needs by adopting a balanced eating regimen as promoted by the USDA's My Food Plate tool will assist people in losing and maintaining weight and in improving overall health.

Following the 2010 Dietary Guidelines will promote nutrition, weight loss, and weight maintenance as well as the reduction of chronic disease.

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Objectives Related to the Healthy People 2020 Goals

Seven out of every ten deaths in the United States are caused by chronic diseases, such as heart disease, cancer, and diabetes, and three-quarters of the country's health spending goes toward the cost of treating these diseases. Helping people lose weight, maintain a healthy weight, and prevent chronic disease by improving dietary habits requires providing education about food and nutrition, assuring access to healthier food options, and promoting the desire and ability to become physically active. Some of the Healthy People 2020 program's related objectives are discussed below.

1. **Improve health, fitness, and quality of life through daily physical activity.** The Healthy People 2020 objectives for physical activity are based on the *2008 Physical Activity Guidelines for Americans*, and reflect the strong scientific evidence supporting the benefits of physical activity. More than 80 percent of the current US population, from youth to adults, is not meeting these guidelines. Healthy People 2020 highlights the way that one's level of physical activity is affected by environmental factors such as the availability of safe sidewalks, bike lanes, trails, and parks. It also highlights the legislative policies that improve access to facilities that promote physical activity. Understanding that personal, social, economic, and environmental barriers to physical activity all have a part in determining a population's physical activity level, is an important part of being able to provide interventions that foster physical activity. Consistent physical activity is necessary for preventing chronic disease, improving bone health, decreasing body fat, and preventing an early death.

Video 2.3

Active versus Sedentary Lifestyles

(click to see video)

This video provides a short overview of leading an active life versus a sedentary life.

1. **Increase the quality, availability, and effectiveness of educational and community-based programs designed to prevent disease and injury, improve health, and enhance quality of life.** Healthy eating is a learned behavior. By increasing the number of community-based programs (schools, workplace, health-care facilities, local community groups) that offer guidance for healthy eating and lifestyle choices, people of all ages will learn good eating habits and will gain access to good food choices to help improve their diet and overall health.
2. **Improve the development, health, safety, and well-being of adolescents and young adults.** Adolescents (ten to nineteen years of age) and young adults (twenty to twenty-four years of age) constitute 21 percent of the population of the United States. The financial burdens of preventable health problems and associated long-term costs of chronic diseases in this demographic group have the potential to be vast, and will be the result of attitudes and behaviors initiated during adolescence. For example, the annual adult health-related financial burden of cigarette smoking, which usually starts by age eighteen, is $193 billion.Adhikari, B. et al. "Smoking-Attributable Mortality, Years of Potential Life Lost, and Productivity Losses—United States, 2000–2004." *MMWR CDC Surveill Summ* 57, no. 45 (November 14, 2008): 1226–8. http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5745a3.htm.

1. **Reduce the consumption of calories from SoFAS in the population aged two years and older.** A diet high in SoFAS contributes to excessive weight gain and poor health. Added sugars provide no nutritional value to foods. Excessive fat and sugar intake promotes tooth decay, obesity, Type 2 diabetes, unhealthy cholesterol levels, and heart disease. Being overweight increases susceptibility for developing high blood pressure, diabetes, cardiovascular diseases, and certain types of cancer. The evidence is clear that many chronic diseases are linked to unhealthy dietary patterns. Excessive consumption of SoFAS, in combination with the lack of plant-based foods, may contribute to higher rates of developing chronic diseases.

Healthy children will lead to a healthy adult population with less disease, lower healthcare costs, and increased longevity.

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For more information on Healthy People 2020 and its related objectives for nutrition and weight status, please visit the website http://www.healthypeople.gov/2020.

KEY TAKEAWAYS

- Healthy People 2020 is a health initiative with a ten-year objective of helping Americans improve health and well-being, and to live long, healthy lives. Among its many objectives are to promote health and reduce the risk of developing chronic diseases by encouraging Americans to consume healthful diets and to achieve and maintain healthy body weights.
- The goals of Healthy People 2020 are founded upon a determinants of health approach, which means they are reflective of the circumstances in which people are born, live, and work, as well as the conditions that shape their circumstances such as money, power, and resources at the local, national, and global levels. Diet patterns are influenced by genetics, environment, and cultural values. All of these things must be considered to provide the optimal approach to improving the health of the American population.
- Decreasing caloric intake and increasing physical activity are important strategies in achieving the goals of the Healthy People 2020 program.

DISCUSSION STARTERS

1. Think of fun ways to increase physical activity in your life. Watch the video below for ideas.

   How to Avoid a Sedentary Lifestyle

   (click to see video)

2. Review some of the Healthy People 2020 nutrition and physical activity program objectives. What objectives would you like to see enacted in your community? Why is this important to you?

   http://www.healthypeople.gov/2020

2.5 Recommendations for Optimal Health

LEARNING OBJECTIVES

1. Design a quality diet plan using MyPlate Daily Food Plan.
2. State recommendation(s) for fruit and vegetable consumption and list the potential benefits of this eating program.

For many years, the US government has been encouraging Americans to develop healthful dietary habits. In 1992 the food pyramid was introduced, and in 2005 it was updated. This was the symbol of healthy eating patterns for all Americans. However, some felt it was difficult to understand, so in 2011, the pyramid was replaced with Choose MyPlate.

The Choose MyPlate program uses a tailored approach to give people the needed information to help design a healthy diet. The plate is divided according to the amount of food and nutrients you should consume for each meal. Each food group is identified with a different color, showing the food variety that all plates must have. Aside from educating people about the type of food that is best to support optimal health, the new food plan offers the advice that it is okay to enjoy food, just eat less of it.US Department of Agriculture. Accessed July 22, 2012. http://www.choosemyplate.gov/.

Video 2.4

Introducing the New Food Icon: MyPlate

(click to see video)

This video provides an introduction to the new MyPlate food guide.

Building a Healthy Plate: Choose Nutrient-Rich Foods

Planning a healthy diet using the MyPlate approach is not difficult. According to the icon, half of your plate should have fruits and vegetables, one-quarter should have whole grains, and one-quarter should have protein. Dairy products should be low-fat or non-fat. The ideal diet gives you the most nutrients within the fewest calories. This means choosing nutrient-rich foods.

Fill half of your plate with red, orange, and dark green vegetables and fruits, such as kale, collard greens, tomatoes, sweet potatoes, broccoli, apples, oranges, grapes, bananas, blueberries, and strawberries in main and side dishes. Vary your choices to get the benefit of as many different vegetables and fruits as you can. You may choose to drink fruit juice as a replacement for eating fruit. (As long as the juice is 100 percent fruit juice and only half your fruit intake is replaced with juice, this is an acceptable exchange.) For snacks, eat fruits, vegetables, or unsalted nuts.

Fill a quarter of your plate with whole grains such as 100 percent whole-grain cereals, breads, crackers, rice, and pasta. Half of your daily grain intake should be whole grains. Read the ingredients list on food labels carefully to determine if a food is comprised of whole grains.

Tools for Change

Consider the information in this video:

Buying Local: The Importance of Locally Produced and Organically Grown Foods to Local Economy

(click to see video)

Identify which vegetables and fruits are in season and local to your area. By consuming in-season, local foods you cut down on transportation costs (emission and financial) and you are likely to get fresher produce. You also support your local farms by purchasing their produce.

Select a variety of protein foods to improve nutrient intake and promote health benefits. Each week, be sure to include a nice array of protein sources in your diet, such as nuts, seeds, beans, legumes, poultry, soy, and seafood. The recommended consumption amount for seafood for adults is two 4-ounce servings per week. When choosing meat, select lean cuts. Be conscious to prepare meats using little or no added saturated fat, such as butter.

If you enjoy drinking milk or eating milk products, such as cheese and yogurt, choose low-fat or nonfat products. Low-fat and nonfat products contain the same amount of calcium and other essential nutrients as whole-milk products, but with much less fat and calories. Calcium, an important mineral for your body, is also available in lactose-free and fortified soy beverage and rice beverage products. You can also get calcium in vegetables and other fortified foods and beverages.

Make sure at least half of your daily grain intake comes from whole-grain foods.

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Oils are essential for your diet as they contain valuable essential fatty acids, but the type you choose and the amount you consume is important. Be sure the oil is plant-based rather than based on animal fat. You can also get oils from many types of fish, as well as avocados, and unsalted nuts and seeds. Although oils are essential for health they do contain about 120 calories per tablespoon. It is vital to balance oil consumption with total caloric intake. The Nutrition Facts label provides the information to help you make healthful decisions.

Remember to vary your selections of protein. Lentils contain good amounts of protein and make great meals. Try using lentils or beans as a meat substitute each week.

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In short, substituting vegetables and fruit in place of unhealthy foods is a good way to make a nutrient-poor diet healthy again. Vegetables are full of nutrients and antioxidants that help promote good health and reduce the risk for developing chronic diseases such as stroke, heart disease, high blood pressure, Type 2 diabetes, and certain types of cancer. Regularly eating fresh fruits and vegetables will boost your overall health profile.

Discretionary Calories

When following a balanced, healthful diet with many nutrient-dense foods, you may consume enough of your daily nutrients before you reach your daily calorie limit. The remaining calories are discretionary (to be used according to your best judgment). To find out your discretionary calorie allowance, add up all the calories you consumed to achieve the recommended nutrient intakes and then subtract this number from your recommended daily caloric allowance. For example, someone who has a recommended 2,000-calorie per day diet may eat enough nutrient-dense foods to meet requirements after consuming only 1,814 calories. The remaining 186 calories are discretionary. These calories may be obtained from eating an additional piece of fruit, adding another teaspoon of olive oil on a salad or butter on a piece of bread, adding sugar or honey to cereal, or consuming an alcoholic beverage.US

Department of Agriculture. "MyPyramid Education Framework." Accessed July 22, 2012. http://www.choosemyplate.gov

The amount of discretionary calories increases with physical activity level and decreases with age. For most physically active adults, the discretionary calorie allowance is, at most, 15 percent of the recommended caloric intake. By consuming nutrient-dense foods, you afford yourself a discretionary calorie allowance.

Table 2.6 Sample Menu Plan Containing 2,000 Calories

Meal	Calories	Total Meal/Snack Calories
Breakfast		
1 scrambled egg	92	
with sliced mushrooms and spinach	7	
½ whole-wheat muffin	67	
1 tsp. margarine-like spread	15	
1 orange	65	
8 oz. low-sodium tomato juice	53	299
Snack		
6 oz. fat-free flavored yogurt	100	
with ½ c. raspberries	32	132
Lunch		
1 sandwich on pumpernickel bread	160	
with smoked turkey deli meat,	30	
4 slices tomato	14	
2 lettuce leaves	3	
1 tsp. mustard	3	
1 oz. baked potato chips	110	
½ c. blueberries, with 1 tsp. sugar	57	
8 oz. fat-free milk	90	467
Snack		
1 banana	105	

Meal	Calories	Total Meal/Snack Calories
7 reduced-fat high-fiber crackers	120	225
Dinner		
1 c. Greek salad (tomatoes, cucumbers, feta)	150	
with 5 Greek olives,	45	
with 1.5 tsp. olive oil	60	
3 oz. grilled chicken breast	150	
½ c. steamed asparagus	20	
with 1 tsp. olive oil,	40	
with 1 tsp. sesame seeds	18	
½ c. cooked wild rice	83	
with ½ c. chopped kale	18	
1 whole-wheat dinner roll	4	
with 1 tsp. almond butter	33	691
(Total calories from all meals and snacks = 1,814)		
Discretionary calorie allowance: 186		

Healthy Eating Index

To assess whether the American diet is conforming to the *2010 Dietary Guidelines*, the Center for Nutrition Policy and Promotion (CNPP), a division of the USDA, uses a standardized tool called the **Healthy Eating Index (HEI)**[13].US Department of Agriculture. "Healthy Eating Index." Last modified March 14, 2012. http://www.cnpp.usda.gov/healthyeatingindex.htm. The first HEI was developed in 1995 and revised in 2006. This tool is a simple scoring system of dietary components. The data for scoring diets is taken from national surveys of particular population subgroups, such as children from low-income families or Americans over the age of sixty-five. Diets are broken down into several food categories including milk, whole fruits, dark green and orange vegetables, whole grains, and saturated fat, and then a score is given based on the amount consumed. For example, a score of ten is given if a 2,000-kilocalorie diet includes greater than 2.6 cups of milk per day. If less than 10 percent of total calories in a diet are from saturated fat, a score of eight is given. All of the scores are added up from the different food categories and the diets are given a HEI score. Using this standardized diet-assessment tool at different times, every ten years for instance, the CNPP can determine if the eating habits of certain groups of the American

13. A standardized tool based on a simple scoring system of dietary components used to assess whether the diets of Americans are improving and adhering to the dietary guidelines.

population are getting better or worse. The HEI tool provides the federal government with information to make policy changes to better the diets of American people. For more information on the HEI, visit this website: http://www.cnpp.usda.gov/healthyeatingindex.htm.

KEY TAKEAWAYS

- The Food Pyramid has been replaced by MyPlate, a system that was designed to be easier to implement. The new MyPlate encourages all plates to be filled with fruits and vegetables (50 percent), protein (25 percent), and grains (25 percent). Half of daily grain intake should be from whole-grain sources. Dairy choices should be switched to low-fat or non-fat sources.
- A diet rich in fresh fruits and vegetables will help you lose and/or maintain weight, will lower your risk for stroke, heart disease, high blood pressure, Type 2 diabetes, and certain types of cancer, and will boost your overall health profile.
- By choosing nutrient-dense foods, you may have discretionary calories to "spend" at the end of the day.

DISCUSSION STARTER

1. As you analyze the new MyPlate, how do your regular dietary habits compare to this new format? What changes, if any, will you have to make to your breakfast? Lunch? Dinner?

2.6 Understanding Daily Reference Intakes

LEARNING OBJECTIVE

1. Use the Dietary Reference Intakes to determine daily nutrient recommendations.

Dietary Reference Intakes (DRI)[14] are the recommendation levels for specific nutrients and consist of a number of different types of recommendations. This DRI system is used in both the United States and Canada.

Daily Reference Intakes: A Brief Overview

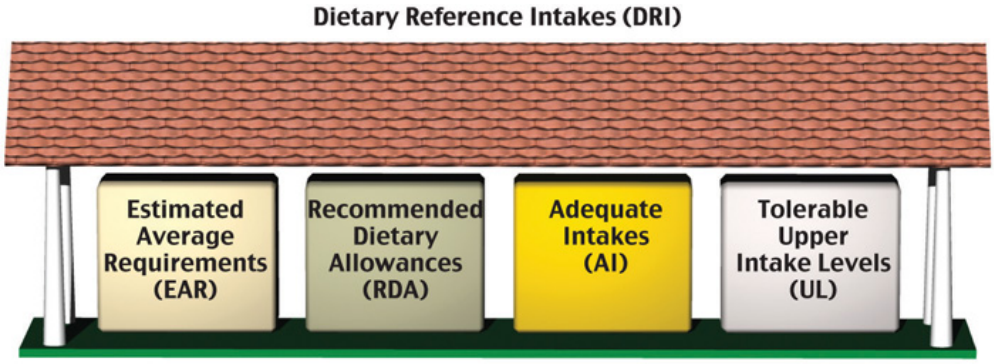
"Dietary Reference Intakes" (DRI) is an umbrella term for four reference values:

- **Estimated Average Requirements (EAR)**[15]
- **Recommended Dietary Allowances (RDA)**[16]
- **Adequate Intakes (AI)**[17]
- **Tolerable Upper Intake Levels (UL)**[18]

The DRIs are not minimum or maximum nutritional requirements and are not intended to fit everybody. They are to be used as guides only for the majority of the healthy population.Deng, S., B. J. West, and C. J. Jensen. "A Quantitative Comparison of Phytochemical Components in Global Noni Fruits and Their Commercial Products." *Food Chemistry* 122, no. 1 (September 1, 2010): 267–70. http://www.sciencedirect.com/science/article/pii/S0308814610001111.

DRIs are important not only to help the average person determine whether their intake of a particular nutrient is adequate, they are also used by health-care professionals and policy makers to determine nutritional recommendations for special groups of people who may need help reaching nutritional goals. This includes people who are participating in programs such as the Special Supplemental Food Program for Women, Infants, and Children. The DRI is not appropriate for people who are ill or malnourished, even if they were healthy previously.

14. A set of nutrient recommendations that includes the Estimated Average Requirements (EAR), Recommended Dietary Allowances (RDA), Adequate Intakes (AI), Tolerable Upper Intake Levels (UL) and Acceptable Macronutrient Distribution Range (AMDR).
15. Average daily intake levels for nutrients estimated to meet the needs of 50 percent of the target group. Used in nutrition research and policy-making. EARs form the basis for which RDA values are set.
16. Based upon the EAR, these are nutrient-intake goals designed to meet the requirements of 97 to 98 percent of the target group for a given nutrient.
17. If scientific data is insufficient to establish an EAR value, an AI is established based on the scientific data that is available. As with the RDA, the AI serves a nutrient-intake goal.
18. The highest average daily nutrient-intake level at which a nutrient can be consumed before it poses a risk of toxicity.



The DRIs are inclusive of all four reference values.

© Networkgraphics

Determining Dietary Reference Intakes

Each DRI value is derived in a different way. See below for an explanation of how each is determined:

1. **Estimated Average Requirements.** The EAR for a nutrient is determined by a committee of nutrition experts who review the scientific literature to determine a value that meets the requirements of 50 percent of people in their target group within a given life stage and for a particular sex. The requirements of half of the group will fall below the EAR and the other half will be above it. It is important to note that, for each nutrient, a specific bodily function is chosen as the criterion on which to base the EAR. For example, the EAR for calcium is set using a criterion of maximizing bone health. Thus, the EAR for calcium is set at a point that will meet the needs, with respect to bone health, of half of the population. EAR values become the scientific foundation upon which RDA values are set.
2. **Recommended Daily Allowances.** Once the EAR of a nutrient has been established, the RDA can be mathematically determined. While the EAR is set at a point that meets the needs of half the population, RDA values are set to meet the needs of the vast majority (97 to 98 percent) of the target healthy population. It is important to note that RDAs are not the same thing as individual nutritional requirements. The actual nutrient needs of a given individual will be different than the RDA. However, since we know that 97 to 98 percent of the population's needs are met by the RDA, we can assume that if a person is consuming the RDA of a given nutrient, they are most likely meeting their nutritional need for that nutrient. The important thing to remember is that the RDA is

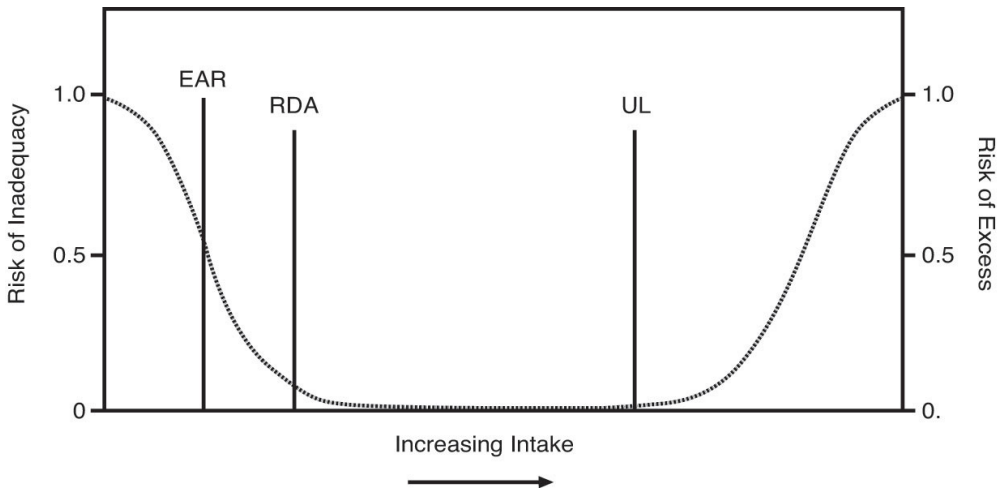
meant as a *recommendation* and meeting the RDA means it is very likely that you are meeting your actual *requirement* for that nutrient.

Understanding the Difference

There is a distinct difference between a requirement and a recommendation. For instance, the DRI for vitamin D is a *recommended* 600 international units each day. However, in order to find out your true personal *requirements* for vitamin D, a blood test is necessary. The blood test will provide an accurate reading from which a medical professional can gauge your required daily vitamin D amounts. This may be considerably more or less than the DRI, depending on what your level actually is.

1. **Adequate Intake.** AIs are created for nutrients when there is insufficient consistent scientific evidence to set an EAR for the entire population. As with RDAs, AIs can be used as nutrient-intake goals for a given nutrient. For example, there has not been sufficient scientific research into the particular nutritional requirements for infants. Consequently, all of the DRI values for infants are AIs derived from nutrient values in human breast milk. For older babies and children, AI values are derived from human milk coupled with data on adults. The AI is meant for a healthy target group and is not meant to be sufficient for certain at-risk groups, such as premature infants.
2. **Tolerable Upper Intake Levels.** The UL was established to help distinguish healthful and harmful nutrient intakes. Developed in part as a response to the growing usage of dietary supplements, ULs indicate the highest level of continuous intake of a particular nutrient that may be taken without causing health problems. When a nutrient does not have any known issue if taken in excessive doses, it is not assigned a UL. However, even when a nutrient does not have a UL it is not necessarily safe to consume in large amounts.

Figure 2.1 *DRI Graph*



This graph illustrates the risks of nutrient inadequacy and nutrient excess as we move from a low intake of a nutrient to a high intake. Starting on the left side of the graph, you can see that when you have a very low intake of a nutrient, your risk of nutrient deficiency is high. As your nutrient intake increases, the chances that you will be deficient in that nutrient decrease. The point at which 50 percent of the population meets their nutrient need is the EAR, and the point at which 97 to 98 percent of the population meets their needs is the RDA. The UL is the highest level at which you can consume a nutrient without it being too much—as nutrient intake increases beyond the UL, the risk of health problems resulting from that nutrient increases.

Source: Institute of Medicine. © 2012 National Academy of Sciences. All Rights Reserved. http://www.iom.edu.

1. **Acceptable Macronutrient Distribution Ranges.** The **Acceptable Macronutrient Distribution Range (AMDR)**[19] is the calculated range of how much energy from carbohydrates, fats, and protein is recommended for a healthy diet. People who do not reach the AMDRs for their target group increase their risk of developing health complications. See Chapter 10 "Nutrients Important for Metabolism and Blood Function" for more information on calculating requirements.

Table 2.7 AMDR Values for Adults

Nutrient	Value (percentage of Calories)
Fat	20.0–35.0
Carbohydrate	45.0–65.0
Protein	10.0–35.0

19. The value of the energy-yielding nutrients carbohydrates, protein, and fat, expressed as percentages of total daily calorie intake, sufficient to provide total adequate energy needs; staying within the AMDR is associated with reducing the risks for developing chronic disease.

Nutrient	Value (percentage of Calories)
Polyunsaturated fatty acids	5.0–10.0
Linolenic acid	0.6–1.2

Source: Food and Nutrition Board of the Institute of Medicine. Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids. (Washington, DC: National Academies Press, 2002).

Tips for Using the Dietary Reference Intakes to Plan Your Diet

You can use the DRIs to help assess and plan your diet. Keep in mind when evaluating your nutritional intake that the values established have been devised with an ample safety margin and should be used as guidance for optimal intakes. Also, the values are meant to assess and plan average intake over time; that is, you don't need to meet these recommendations every single day—meeting them on average over several days is sufficient.

KEY TAKEAWAYS

- Nutrient-intake recommendations set for healthy people living in the United States and Canada are known as Dietary Reference Intakes.
- The DRIs includes the AI, EAR, RDA, and UL for micronutrients and the AMDR ranges for energy-yielding macronutrients. The DRI provide a set of standards for researchers and government policy-makers, and specifies nutrient consumption guidelines for individuals.

DISCUSSION STARTER

1. Why do you think it is important for the government to set the DRI standards? How will you use this information for your personal dietary choices?

2.7 Discovering Nutrition Facts

LEARNING OBJECTIVE

1. Use the Nutrition Facts panel to discover the nutritional information of food.

The Labels on Your Food

Understanding the significance of dietary guidelines and how to use DRIs in planning your nutrient intakes can make you better equipped to select the right foods the next time you go to the supermarket.

In the United States, the Nutrition Labeling and Education Act passed in 1990 and came into effect in 1994. In Canada, mandatory labeling came into effect in 2005. As a result, all packaged foods sold in the United States and Canada must have nutrition labels that accurately reflect the contents of the food products. There are several mandated nutrients and some optional ones that manufacturers or packagers include. Table 2.8 "Mandatory and Optional Inclusions on Nutrition Labels" lists the mandatory and optional inclusions.

Table 2.8 Mandatory and Optional Inclusions on Nutrition Labels

Mandatory Inclusion	Optional Inclusion
Total Calories	Calories from saturated fats
Calories from fat	Polyunsaturated fat
Total fat	Monounsaturated fat
Saturated fat	Potassium
Cholesterol	Soluble fiber
Total carbohydrates	Sugar alcohol
Dietary fiber	Other carbohydrates
Sugars	Percent of vitamin A present as beta-carotene
Vitamins A and C	Other essential vitamins and minerals
Calcium	

Mandatory Inclusion	Optional Inclusion
Iron	

Source: US Food and Drug Administration. “Food Labeling Guide.” Last updated February 10, 2012. http://www.fda.gov.

There are other types of information that are required by law to appear somewhere on the consumer packaging. They include:

- Name and address of the manufacturer, packager, or distributor
- Statement of identity, what the product actually is
- Net contents of the package: weight, volume, measure, or numerical count
- Ingredients, listed in descending order by weight
- Nutrient information of serving size and daily valuesUS Food and Drug Administration. “Food Labeling.” http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/FoodLabelingNutrition/FoodLabelingGuide/default.htm

The **Nutrition Facts panel**[20] provides a wealth of information about the nutritional content of the product. The information also allows shoppers to compare products. Because the serving sizes are included on the label, you can see how much of each nutrient is in each serving to make the comparisons. Knowing how to read the label is important because of the way some foods are presented. For example, a bag of peanuts at the grocery store may seem like a healthy snack to eat on the way to class. But have a look at that label. Does it contain one serving, or multiple servings? Unless you are buying the individual serving packages, chances are the bag you picked up is at least eight servings, if not more.

According to the 2010 health and diet survey released by the FDA, 54 percent of first-time buyers of a product will check the food label and will use this information to evaluate fat, calorie, vitamin, and sodium content.US Food and Drug Administration. “Survey Shows Gain in Food-Label Use, Health/Diet Awareness.” March 2, 2010. http://www.fda.gov/ForConsumers/ConsumerUpdates/ucm202611.htm#FoodLabelHighlights. The survey also notes that more Americans are using food labels and are showing an increased awareness of the connection between diet and health. Having reliable food labels is a top priority of the FDA, which has a new initiative to prepare guidelines for the food industry to construct “front of package” labeling that will make it even easier for Americans to choose healthy foods. Stay tuned for the newest on food labeling by visiting the FDA website: http://www.fda.gov/Food/LabelingNutrition/default.htm.

20. Found on most packaged foods, it contains specific amounts of nutrients and also compares the amounts of nutrients in the food and the recommended intake values. These comparisons are reported as percent DV.

Video Link 2.2

The Food Label and You

The FDA has prepared a new video about nutrition labeling that is packed with helpful information. You can watch the full-length video or individual segments.

http://www.fda.gov/Food/ResourcesForYou/Consumers/NFLPM/default.htm

Reading the Label

The first part of the Nutrition Facts panel gives you information on the serving size and how many servings are in the container. For example, a label on a box of crackers might tell you that twenty crackers equals one serving and that the whole box contains 10 servings. All other values listed thereafter, from the calories to the dietary fiber, are based on this one serving. On the panel, the serving size is followed by the number of calories and then a list of selected nutrients. You will also see "Percent Daily Value" on the far right-hand side. This helps you determine if the food is a good source of a particular nutrient or not. The **Daily Value (DV)**[21] represents the recommended amount of a given nutrient based on the RDI of that nutrient in a 2,000-kilocalorie diet (Figure 2.2 "Determining Your Nutrient Allowances per Day"). The **percentage of Daily Value (percent DV)**[22] represents the proportion of the total daily recommended amount that you will get from one serving of the food. For example, in the food label in Figure 2.2 "Determining Your Nutrient Allowances per Day", the percent DV of calcium for one serving of macaroni-and-cheese is 20 percent, which means that one serving of macaroni and cheese provides 20 percent of the daily recommended calcium intake. Since the DV for calcium is 1,000 milligrams, the food producer determined the *percent* DV for calcium by taking the calcium content in milligrams in each serving, and dividing it by 1,000 milligrams, and then multiplying it by 100 to get it into percentage format. Whether you consume 2,000 calories per day or not you can still use the percent DV as a target reference.

Generally, a percent DV of 5 is considered low and a percent DV of 20 is considered high. This means, as a general rule, for fat, saturated fat, trans fat, cholesterol, or sodium, look for foods with a low percent DV. Alternatively, when concentrating on essential mineral or vitamin intake, look for a high percent DV. To figure out your fat allowance remaining for the day after consuming one serving of macaroni-and-

21. Based upon the RDI of a specific nutrient in a 2,000 kilocalorie diet.

22. The percentage of the amount of the nutrient in relationship to the DV. They are applicable only for a 2,000-calorie daily diet (not 2,500 calories).

cheese, look at the percent DV for fat, which is 18 percent, and subtract it from 100 percent. To know this amount in grams of fat, read the footnote of the food label to find that the recommended maximum amount of fat grams to consume per day for a 2,000 kilocalories per day diet is 65 grams. Eighteen percent of sixty-five equals about 12 grams. This means that 53 grams of fat are remaining in your fat allowance. Remember, to have a healthy diet the recommendation is to eat less than this amount of fat grams per day, especially if you want to lose weight.

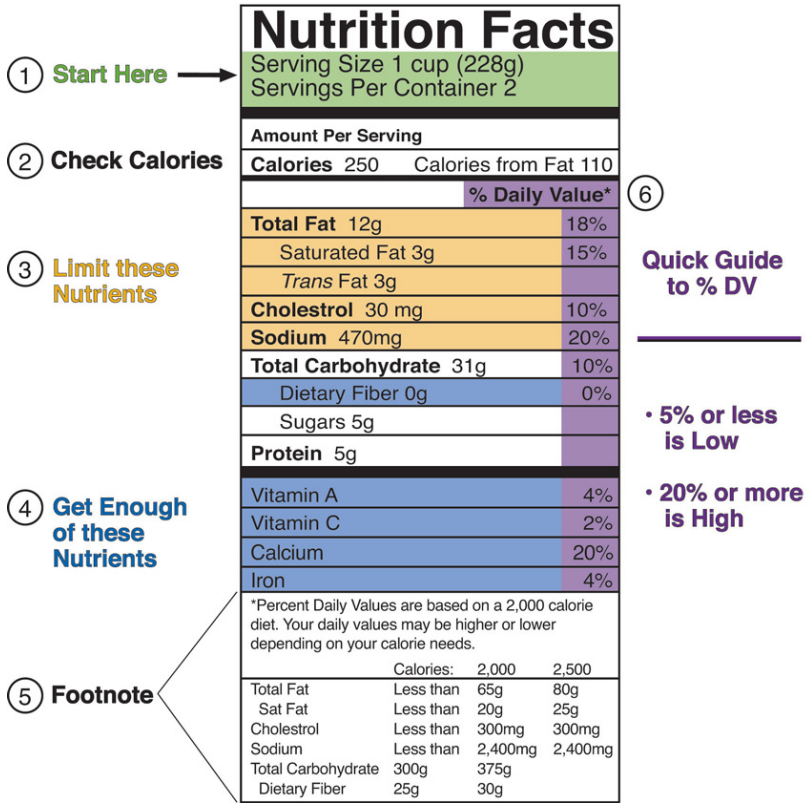
Table 2.9 DVs Based on a Caloric Intake of 2,000 Calories (For Adults and Children Four or More Years of Age)

Food Component	DV
Total fat	65 g
Saturated fat	20 g
Cholesterol	300 mg
Sodium	2,400 mg
Potassium	3,500 mg
Total carbohydrate	300 g
Dietary fiber	25 g
Protein	50 g
Vitamin A	5,000 IU
Vitamin C	60 mg
Calcium	1,000 mg
Iron	18 mg
Vitamin D	400 IU
Vitamin E	30 IU
Vitamin K	80 micrograms µg
Thiamin	1.5 mg
Riboflavin	1.7 mg
Niacin	20 mg
Vitamin B_6	2 mg
Folate	400 µg
Vitamin B_{12}	6 µg

Food Component	DV
Biotin	300 µg
Pantothenic acid	10 mg
Phosphorus	1,000 mg
Iodine	150 µg
Magnesium	400 mg
Zinc	15 mg
Selenium	70 µg
Copper	2 mg
Manganese	2 mg
Chromium	120 µg
Molybdenum	75 µg
Chloride	3,400 mg

Source: FDA, http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/FoodLabelingNutrition/FoodLabelingGuide/ucm064928.htm.

Figure 2.2 *Determining Your Nutrient Allowances per Day*



Pictured here is a sample label for macaroni and cheese.

Source: FDA. "How to Understand and Use the Nutrition Facts Panel." Last updated February 15, 2012. *http://www.fda.gov/food/labelingnutrition/consumerinformation/ucm078889.htm#dvs*

Of course, this is a lot of information to put on a label and some products are too small to accommodate it all. In the case of small packages, such as small containers of yogurt, candy, or fruit bars, permission has been granted to use an abbreviated version of the Nutrition Facts panel. To learn additional details about all of the information contained within the Nutrition Facts panel, see the following website: http://www.fda.gov/Food/ResourcesForYou/Consumers/NFLPM/ucm274593.htm

Video Link 2.3

How to Read Food Labels

Pay attention to the fine print when grocery shopping.

http://videos.howstuffworks.com/fit-tv/14212-diet-doctor-how-to-read-food-labels-video.htm

Claims on Labels

In addition to mandating nutrients and ingredients that must appear on food labels, any nutrient-content claims must meet certain requirements. For example, a manufacturer cannot claim that a food is fat-free or low-fat if it is not, in reality, fat-free or low-fat. Low-fat indicates that the product has three or fewer grams of fat; low salt indicates there are fewer than 140 milligrams of sodium, and low-cholesterol indicates there are fewer than 20 milligrams of cholesterol and two grams of saturated fat. See Table 2.10 "Common Label Terms Defined" for some examples.US Food and Drug Administration. “Additional Requirements for Nutrient Content Claims.” Appendix B in *Food Labeling Guide* (October 2009). http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/FoodLabelingNutrition/FoodLabelingGuide/ucm064916.htm.

Table 2.10 Common Label Terms Defined

Term	Explanation
Lean	Fewer than a set amount of grams of fat for that particular cut of meat
High	Contains more than 20% of the nutrient’s DV
Good source	Contains 10 to 19% of nutrient’s DV
Light/ lite	Contains ⅓ fewer calories or 50% less fat; if more than half of calories come from fat, then fat content must be reduced by 50% or more
Organic	Contains 95% organic ingredients

Source: US Food and Drug Administration. “Food Labeling Guide.” Last updated February 10, 2012. http://www.fda.gov.

Health Claims

Often we hear news of a particular nutrient or food product that contributes to our health or may prevent disease. A health claim is a statement that links a particular food with a reduced risk of developing disease. As such, health claims such as "reduces heart disease," must be evaluated by the FDA before it may appear on packaging. Prior to the passage of the NLEA products that made such claims were categorized as drugs and not food. All health claims must be substantiated by scientific evidence in order for it to be approved and put on a food label. To avoid having companies making false claims, laws also regulate how health claims are presented on food packaging. In addition to the claim being backed up by scientific evidence, it may never claim to cure or treat the disease. For a detailed list of approved health claims, visit: http://www.fda.gov/Food/LabelingNutrition/LabelClaims/HealthClaimsMeeting SignificantScientificAgreementSSA/default.htm#Approved_Health_Claims.

Qualified Health Claims

While health claims must be backed up by *hard* scientific evidence, qualified health claims have *supportive* evidence, which is not as definitive as with health claims. The evidence may suggest that the food or nutrient is beneficial. Wording for this type of claim may look like this: "Supportive but not conclusive research shows that consumption of EPA and DHA omega-3 fatty acids may reduce the risk of coronary artery disease. One serving of [name of food] provides [X] grams of EPA and DHA omega-3 fatty acids. [See nutrition information for total fat, saturated fat, and cholesterol content.]US Food and Drug Administration. "FDA Announces Qualified Health Claims for Omega-3 Fatty Acids." September 8, 2004. http://www.fda.gov/SiteIndex/ucm108351.htm.

Structure/Function Claims

Some companies claim that certain foods and nutrients have benefits for health even though no scientific evidence exists. In these cases, food labels are permitted to claim that you may benefit from the food because it may boost your immune system, for example. There may not be claims of diagnosis, cures, treatment, or disease prevention, and there must be a disclaimer that the FDA has not evaluated the claim.US Food and Drug Administration. "Claims That Can Be Made for Conventional Foods and Dietary Supplements." September 2003. http://www.fda.gov/Food/LabelingNutrition/LabelClaims/ucm111447.htm.

Allergy Warnings

Food manufacturers are required by the FDA to list on their packages if the product contains any of the eight most common ingredients that cause food allergies. These eight common allergens are as follows: milk, eggs, peanuts, tree nuts, fish, shellfish, soy, and wheat. (More information on these allergens will be discussed in Chapter 11 "Energy Balance and Body Weight".) The FDA does not require warnings that cross contamination may occur during packaging, however most manufacturers include this advisory as a courtesy. For instance, you may notice a label that states, "This product is manufactured in a factory that also processes peanuts." If you have food allergies, it is best to avoid products that may have been contaminated with the allergen.

KEY TAKEAWAYS

- The Nutrition Labeling and Education Act made it a law that foods sold in the United States have a food label that provides the accurate contents of nutrients within them. Canada has a similar law.
- A Nutrition Facts panel gives information on the amount of servings per container, the amount of calories per serving, and the amounts of certain nutrients.
- The percent DV is the percentage of the amount of the nutrient in the food in relationship to its recommended intake. It is a guide to help you determine if a food is a good or poor source of nutrients.
- To keep companies from making false claims, the FDA provides regulation for food manufacturers in putting labels on packages that promote health. Allergens must also be listed on food labels. Sometimes cross contamination does occur during packaging. Most food manufacturers voluntarily list this information. If you have a food allergy, it is best to avoid any product that has even had the possibility of coming in contact with a known allergen.

DISCUSSION STARTER

1. Recall the food you buy from the supermarket on a regular basis. How many of the food products you purchase regularly are nutrient-dense? How many are nutrient-poor? What foods can you substitute in place of the nutrient-poor food choices?

2.8 When Enough Is Enough

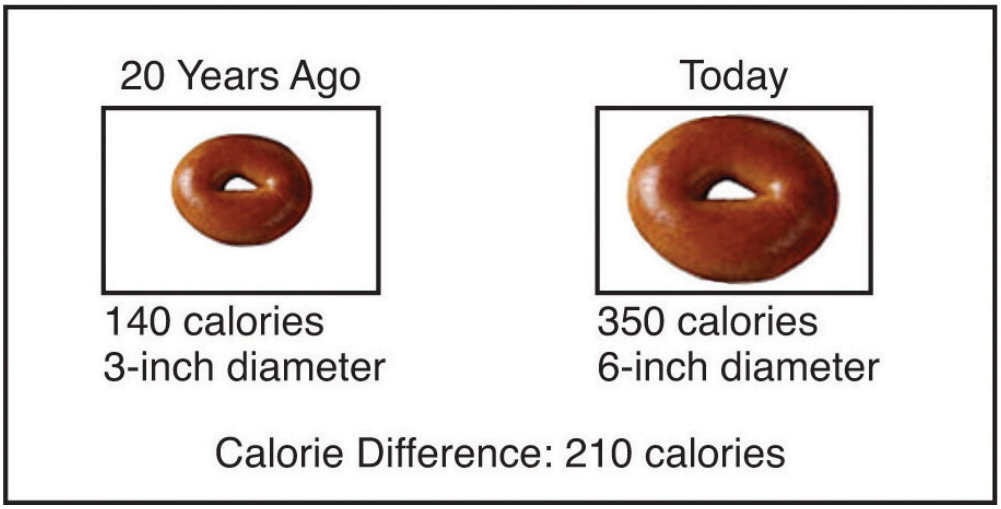
LEARNING OBJECTIVE

1. Judge food portion sizes for adequacy.

Estimating Portion Size

Have you ever heard the expression, "Your eyes were bigger than your stomach?" This means that you thought you wanted a lot more food than you could actually eat. Amounts of food can be deceiving to the eye, especially if you have nothing to compare them to. It is very easy to heap a pile of mashed potatoes on your plate, particularly if it is a big plate, and not realize that you have just helped yourself to three portions instead of one.

The food industry makes following the *2010 Dietary Guidelines* a challenge. In many restaurants and eating establishments, portion sizes have increased, use of SoFAS has increased, and consequently the typical meal contains more calories than it used to. In addition, our sedentary lives make it difficult to expend enough calories during normal daily activities. In fact, more than one-third of adults are not physically active at all.



As food sizes and servings increase it is important to limit the portions of food consumed on a regular basis.

Dietitians have come up with some good hints to help people tell how large a portion of food they really have. Some suggest using common items such as a deck of cards while others advocate using your hand as a measuring rule. See Table 2.11 "Determining Food Portions" for some examples.American Cancer Society. "Controlling Portion Sizes." Last revised January 12, 2012. http://www.cancer.org/Healthy/EatHealthyGetActive/TakeControlofYourWeight/controlling-portion-sizes.

Table 2.11 Determining Food Portions

Food Product	Amount	Object Comparison	Hand Comparison
Pasta, rice	½ c.	Tennis ball	Cupped hand
Fresh vegetables	1 c.	Baseball	
Cooked vegetables	½ c.	Cupped hand	
Meat, poultry, fish	3 oz.	Deck of cards	Palm of your hand
Milk or other beverages	1 c.	Fist	
Salad dressing	1 Tbsp.	Thumb	
Oil	1 tsp.	Thumb tip	

Video 2.5

Managing a Healthy Diet: Judging Healthy Portion Sizes

(click to see video)

A dietitian shows how to compare food sizes with hands and other objects.

MyPlate Planner

Estimating portions can be done using the MyPlate Planner. Recall that the MyPlate symbol is divided according to how much of each food group should be included with each meal. Note the MyPlate Planner Methods of Use:

- Fill half of your plate with vegetables such as carrots, broccoli, salad, and fruit.
- Fill one-quarter of your plate with lean meat, chicken, or fish (about 3 ounces)
- Fill one-quarter of your plate with a whole grain such as ⅓ cup rice
- Choose one serving of dairy

- Add margarine or oil for preparation or addition at the table

Table 2.12 Meal Planning Guidelines

Carbohydrates	Meats/Proteins	Fats	Free Foo
Choose three servings with each meal.	Choose one to three servings with each meal.	Choose one to two servings with each meal.	Use as desired.
Examples of *one* serving:	Examples of *one* serving:	Examples of *one* serving:	Examples
Breads and Starches • 1 slice bread or small roll • ⅓ c. rice or pasta • ½ c. of cooked cereal or potatoes • ¾ c. dry cereal • ½ c. corn	• 1 oz. lean meat, poultry, or fish • 1 egg • 1 oz. cheese • ¼ c. low-fat cottage cheese	• 1 tsp. margarine, oil, or mayonnaise • 1 Tbsp. salad dressing or cream cheese	**Foods with le 20 calories pe serving.*** • M ve • Su fr • B co pl
Fruits • 1 piece, such as a small pear • 1 c. fresh fruit			

Carbohydrates	Meats/Proteins	Fats	Free Foo
• ½ c. canned fruit • ½ c. fruit juice			
Milk • 1 c. skim or low fat • 1 c. unsweetened low-fat yogurt			

KEY TAKEAWAY

- Judging portion sizes can be done using your hand or household objects in comparison. It can also be done using the MyPlate guide to determine how much food is a portion for that meal.

DISCUSSION STARTER

1. Why is it important to judge portion sizes properly? Explain why it can be tricky to read food labels and figure out the caloric content for one serving.

2.9 Nutrition and the Media

LEARNING OBJECTIVE

1. List at least four sources of reliable and accurate nutrition information.

A motivational speaker once said, "A smart person believes half of what they read. An *intelligent* person knows which half to believe." In this age of information where instant Internet access is just a click away, it is easy to be misled if you do not know where to go for reliable nutrition information. There are a few websites that can be consistently relied upon for accurate material that is updated regularly.

Right information or wrong information? How can you know?

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Using Eyes of Discernment

"New study shows that margarine contributes to arterial plaque." "Asian study reveals that two cups of coffee per day can have detrimental effects on the nervous system." How do you react when you read news of this nature? Do you boycott margarine and coffee? When reading nutrition-related claims, articles, websites, or advertisements always remember that one study does not substantiate a fact. One study neither proves nor disproves anything. Readers who may be looking for complex answers to nutritional dilemmas can quickly misconstrue such statements and be led down a path of misinformation. Listed below are ways that you can develop discerning eyes when reading nutritional news.

1. The scientific study under discussion should be published in a peer-reviewed journal, such as the *Journal of the International Society of Sports Nutrition*. Question studies that come from less trustworthy sources (such as non peer-reviewed journals or websites) or that are not published.
2. The report should disclose the methods used by the researcher(s). Did the study last for three or thirty weeks? Were there ten or one hundred participants? What did the participants actually do? Did the researcher(s) observe the results themselves or did they rely on self reports from program participants?

3. Who were the subjects of this study? Humans or animals? If human, are any traits/characteristics noted? You may realize you have more in common with certain program participants and can use that as a basis to gauge if the study applies to you.
4. Credible reports often disseminate new findings in the context of previous research. A single study on its own gives you very limited information, but if a body of literature supports a finding, it gives you more confidence in it.
5. Peer-reviewed articles deliver a broad perspective and are inclusive of findings of many studies on the exact same subject.
6. When reading such news, ask yourself, "Is this making sense?" Even if coffee does adversely affect the nervous system, do you drink enough of it to see any negative effects? Remember, if a headline professes a new remedy for a nutrition-related topic, it may well be a research-supported piece of news, but more often than not it is a sensational story designed to catch the attention of an unsuspecting consumer. Track down the original journal article to see if it really supports the conclusions being drawn in the news report.

When reading information on websites, remember the following criteria for discerning if the site is valid:

1. Who sponsors the website?
2. Are names and credentials disclosed?
3. Is an editorial board identified?
4. Does the site contain links to other credible informational websites? Even better, does it reference peer-reviewed journal articles? If so, do those journal articles actually back up the claims being made on the website?
5. How often is the website updated?
6. Are you being sold something at this website?
7. Does the website charge a fee?

Trustworthy Sources

Now let's consider some reputable organizations and websites from which you can obtain valid nutrition information.

Organizations Active in Nutrition Policy and Research

- Centers for Disease Control and Prevention (CDC)
- The Academy of Nutrition and Dietetics (AND)
- US Department of Agriculture (USDA)
- US Department of Health and Human Services (HHS)
- Dietitians of Canada
- Health Canada

1. **US Department of Agriculture Food and Nutrition Information Center.** The USDA site http://fnic.nal.usda.gov has more than twenty-five hundred links to dietary, nutrition, diet and disease, weight and obesity, food-safety and food-labeling, packaging, dietary supplement and consumer questions sites. Using this interactive site, you can find tips and resources on how to eat a healthy diet, my Foodapedia, and a food planner, among other sections.
2. **The Academy of Nutrition and Dietetics (AND).** The AND promotes scientific evidenced-based, research-supported food and nutrition related information on its website, http://www.eatright.org. It is focused on informing the public about recent scientific discoveries and studies, weight-loss concerns, food safety topics, nutrition issues, and disease prevention.
3. **Department of Health and Human Services.** The HHS website, HealthFinder.gov, provides credible information about healthful lifestyles and the latest in health news. A variety of online tools are available to assist with food-planning, weight maintenance, physical activity, and dietary goals. You can also find healthful tips for all age groups, tips for preventing disease, and on daily health issues in general.
4. **Centers for Disease Control and Prevention.** The Centers for Disease Control and Prevention (http://www.cdc.gov) distributes an online newsletter called *CDC Vital Signs*. This newsletter is a valid and credible source for up-to-date public health information and data regarding food, nutrition, cholesterol, high blood pressure, obesity, teenage drinking, and tobacco usage.
5. **Dietitians of Canada.** Dietitians of Canada, http://www.dietitians.ca/, is the national professional association for dietitians. It provides trusted nutrition information to Canadians and health professionals.
6. **Health Canada.** Health Canada, http://www.hc-sc.gc.ca/index-eng.php, is the Federal department that helps Canadians improve their

health. Its website also provides information about health-related legislation.

KEY TAKEAWAY

- Reliable nutritional news will be based upon solid scientific evidence, supported by multiple studies, and published in peer-reviewed journals. Be sure the website you use for information comes from a credible and trustworthy source, such as the USDA Food and Nutrition Center, the HHS, and the CDC.

DISCUSSION STARTER

1. Discuss why it is important to get information from proper and credible sources and not to rely upon single study findings.

2.10 End-of-Chapter Exercises

IT'S YOUR TURN

1. Draw a diagram that shows the role that nutrition plays in human health.
2. Write three ways in which cultural, religious, and social values affect dietary eating patterns.
3. Compare and contrast the Nutrition Facts label on two of your favorite foods. Make a smart choice for eating the most nutrient-dense food option. Which food did you select and why?

APPLY IT

1. You have been hired to write a two-page article for a weekly magazine about why nutrition is important to health. Using simple terms and a good supply of photographs, create your article. Be prepared to share your project with the class.
2. Record a food diary this week. At the end of the week, circle the foods that contain SoFAS. Next to each food, write a substitute food to replace it. Record a food diary next week. Be sure to eat the substitute foods you have selected to replace the foods that contained the SoFAS.
3. Search the Internet for sites that claim to give you nutritional advice. Check to see who sponsors the sites and if the site is trying to sell you a product or service. Compare the information found on the sites to those recommended in this text. What similarities do you notice? What differences do you notice?

EXPAND YOUR KNOWLEDGE

1. You have just been hired at the local Boys and Girls club in an inner city neighborhood that happens to have a large high school drop-out rate. You have been put in charge of creating physical and nutritional opportunities for the community. Your goal for the first quarter is to enroll one hundred students in an exercise/nutrition program. You must develop two programs.
    - Define each program and state its objectives
    - Describe the ways in which the program will benefit participants
    - List ways in which you will encourage enrollment
    - Create a marketing flyer for each program
2. You are planning a big meal for a surprise graduation party for your friend. You expect fifty guests to attend. Using the information you have learned regarding healthy eating and food portions, plan a healthful meal. Determine how much protein, vegetables, fruits, and starch you will need to purchase to feed everyone comfortably. Write down a detailed list so that you can shop and prepare your budget accordingly. Share your results with the class.
3. You are a Registered Dietitian who has been asked to help a vegan patient adjust their eating habits to get more nutrients from their diet and halt unwanted weight loss. Develop a week's worth of meals to help this person have balance in their diet.

Chapter 3

Nutrition and the Human Body

Big Idea

Eat your way to health.

"Let food be thy medicine and medicine be thy food." These words, espoused by Greek physician Hippocrates over two thousand years ago, bear much relevance on our food choices and their connection to our health. Today, the scientific community echoes Hippocrates' statement as it recognizes some foods as *functional foods*. The Academy of Nutrition and Dietetics defines functional foods as "whole foods and fortified, enriched, or enhanced foods that have a potentially beneficial effect on health when consumed as part of a varied diet on a regular basis, at effective levels."

Do you understand the relationship between food and health?

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In the latter nineteenth century, a Russian doctor of immunology, Elie Metchnikoff, was intrigued by the healthy life spans of people who lived in the tribes of the northern Caucasus Mountains. What contributed to their long life span and their resistance to life-threatening diseases? A possible factor lay wrapped up in a leather satchel used to hold fermented milk. One legend recounts that Mohammed, the great prophet of Islam, revealed this recipe to members of the Orthodox faith on the condition that they would not tell anyone outside of the faith how to create such a good-feeling beverage. The tribes, under Mohammed's direction, combined a tiny amount of small grains that resembled white broccoli with milk in a leather satchel. This bag was hung from a doorway in a house, so that all who passed would hit the bag, mixing up the contents. The result was a refreshing, slightly carbonated, creamy beverage with tangy overtones.

Observing the connection between the beverage and longevity, Dr. Elie Metchnikoff began his research on beneficial bacteria and the longevity of life that led to his book, *The Prolongation of Life*. He studied the biological effects and chemical properties of the kefir elixir whose name came from the Turkish word "kef" or "pleasure." Intrigued, the Russian Society of Physicians went on a quest to locate the recipe in order to prescribe this drink to their patients. However, just as instructed, no one would share the recipe. As a result, the mission of obtaining this highly guarded recipe was placed on the Blandov brothers, who owned the Moscow Dairy and some holdings in the Caucasus Mountains.

The Blandov brothers had a beautiful employee, Irina Sakharova, whom they sent to the courts of the Caucasus tribe of Prince Bek-Mirza Barchorov in order to charm the recipe out of him. The prince immediately fell in love with Irina. As time went on, Irina asked the prince for some kefir grains. He refused, explaining that he was forbidden from sharing this secret and feared the consequences of violating religious law. Irina returned home when she realized that she would never pry the recipe from the prince. However, on orders from the heartbroken prince, Irina was kidnapped and brought back to marry him. She was taken aback and refused this proposal. Her refusal was rejected and the marriage was arranged. The Blandov brothers courageously stole into the tribe the night before the marriage and managed to free Irina. Insulted and still seeing a way to retrieve the kefir grains, Irina brought her case before the Russian Czar, charging the prince with kidnapping. Upon review of the evidence, it was ruled in her favor and Irina won her case. As part of her grievance repayment Irina requested some kefir grains. Bound by law, the prince had to comply. Irina gave the grains to the Blandov brothers who mass-produced kefir from these kernels. To this day, kefir is one of the most widely enjoyed beverages in Russia.

Kefir has since found its way into America, where it is marketed in several flavors and can be found at your local grocery store. It is one product of the billion-dollar functional food industry marketed with all sorts of health claims from improving digestion to preventing cancer. What is the scientific evidence that kefir is a functional food? Expert nutritionists agree that probiotics, such as kefir, reduce the symptoms of lactose intolerance and can ward off virally caused diarrhea. While some health claims remain unsubstantiated, scientific studies are ongoing to determine the validity of other health benefits of probiotics.

You Decide

Will you eat your way to health with probiotic foods?

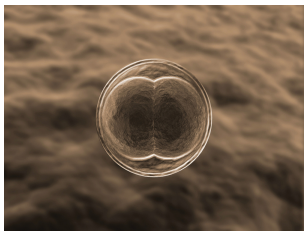
Knowing how to maintain the balance of friendly bacteria in your intestines through proper diet can promote overall health. Recent scientific studies have shown that probiotic supplements positively affect intestinal microbial flora, which in turn positively affect immune system function. As good nutrition is known to influence immunity, there is great interest in using probiotic foods and other immune-system-friendly foods as a way to prevent illness. In this chapter we will explore not only immune system function, but also all other organ systems in the human body. We will learn the process of nutrient digestion and absorption, which further reiterates the importance of developing a healthy diet to maintain a healthier you. The evidence abounds that food can indeed be “thy medicine.”

3.1 The Basic Structural and Functional Unit of Life: The Cell

LEARNING OBJECTIVES

1. Diagram the components of a cell.
2. Describe the organization of the human body.

What distinguishes a living organism from an inanimate object? A living organism conducts self-sustaining biological processes. A cell is the smallest and most basic form of life. Robert Hooke, one of the first scientists to use a light microscope, discovered the cell in 1665. In all life forms, including bacteria, plants, animals, and humans, the **cell**[1] was defined as the most basic structural and functional unit. Based on scientific observations over the next 150 years, scientists formulated the **cell theory**[2], which is used for all living organisms no matter how simple or complex. The cell theory incorporates three principles:



One cell divides into two, which begins the creation of millions of more cells that ultimately become you.

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- Cells are the most basic building units of life.
- All living things are composed of cells.
- New cells are made from preexisting cells, which divide into two.

Who you are has been determined because of two cells that came together inside your mother's womb. The two cells containing all of your genetic information (DNA) united to begin making new life. Cells divided and differentiated into other cells with specific roles that led to the formation of the body's numerous body organs, systems, blood, blood vessels, bone, tissue, and skin. As an adult, you are comprised of trillions of cells. Each of your individual cells is a compact and efficient form of life—self-sufficient, yet interdependent upon the other cells within your body to supply its needs.

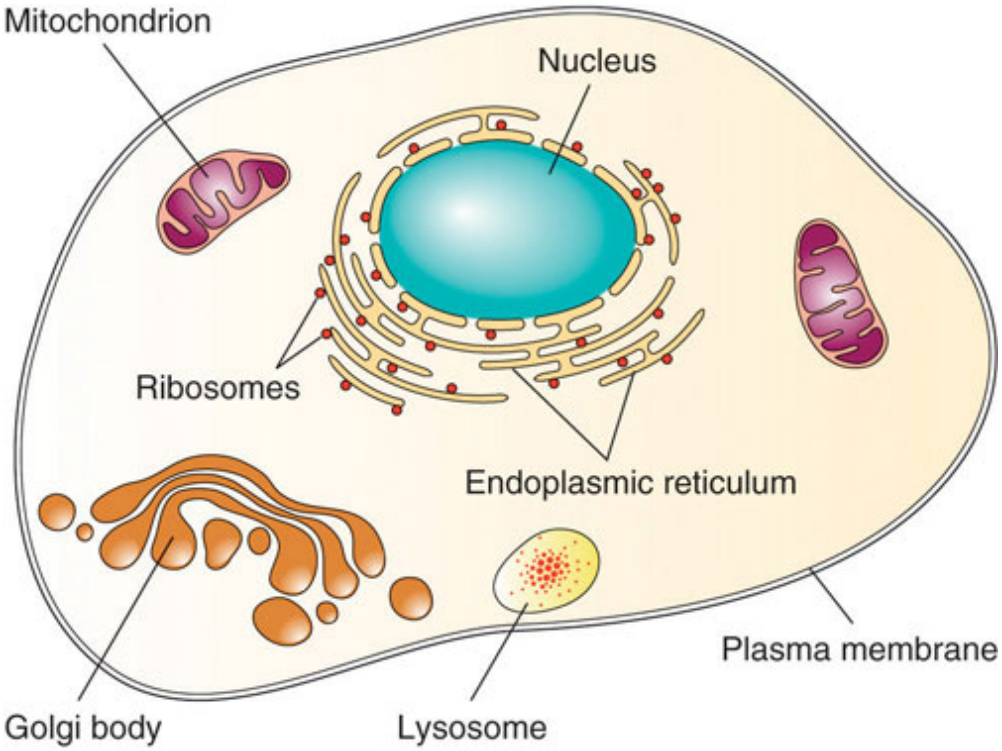
Independent single-celled organisms must conduct all the basic processes of life: it must take in nutrients (energy capture), excrete wastes, detect and respond to its environment, move, breathe, grow, and reproduce. Even a one-celled organism must be organized to perform these essential processes. All cells are organized from the atomic level to all its larger forms. Oxygen and hydrogen atoms combine to

1. Basic structural and functional unit of all life.
2. Cells are the most basic building units of life, all living things are composed of cells, and new cells are made from preexisting cells, which divide into two.

make the molecule water (H_2O). Molecules bond together to make bigger macromolecules. The carbon atom is often referred to as the backbone of life because it can readily bond with four other elements to form long chains and more complex macromolecules. Four macromolecules—carbohydrates, lipids, proteins, and nucleic acids—make up all of the structural and functional units of cells.

Although we defined the cell as the "most basic" unit of life, it is structurally and functionally complex (see Figure 3.1). A cell can be thought of as a mini-organism consisting of tiny organs called organelles. The **organelles**[3] are structural and functional units constructed from several macromolecules bonded together. A typical animal cell contains the following organelles: the nucleus (which houses the genetic material DNA), mitochondria (which generate energy), ribosomes (which produce protein), the endoplasmic reticulum (which is a packaging and transport facility), and the golgi apparatus (which distributes macromolecules). In addition, animal cells contain little digestive pouches, called lysosomes and peroxisomes, which break down macromolecules and destroy foreign invaders. All of the organelles are anchored in the cell's cytoplasm via a cytoskeleton. The cell's organelles are isolated from the surrounding environment by a plasma membrane.

Figure 3.1



The cell is structurally and functionally complex.

3. A structural or functional unit in a cell that is constructed from several macromolecules bonded together.

Video 3.1

Discovery Video: Cells

(click to see video)

This video describes the importance of cells in the human body.

Tissues, Organs, Organ Systems, and Organisms

Unicellular (single-celled) organisms can function independently, but the cells of multicellular organisms are dependent upon each other and are organized into five different levels in order to coordinate their specific functions and carry out all of life's biological processes.

- **Cells.** Cells are the basic structural and functional unit of all life. Examples include red blood cells and nerve cells.
- **Tissues. Tissues**[4] are groups of cells that share a common structure and function and work together. There are four types of human tissues: connective, which connects tissues; epithelial, which lines and protects organs; muscle, which contracts for movement and support; and nerve, which responds and reacts to signals in the environment.
- **Organs. Organs**[5] are a group of tissues arranged in a specific manner to support a common physiological function. Examples include the brain, liver, and heart.
- **Organ systems. Organ systems**[6] are two or more organs that support a specific physiological function. Examples include the digestive system and central nervous system. There are eleven organ systems in the human body (see Table 3.1 "The Eleven Organ Systems in the Human Body and Their Major Functions").
- **Organism.** An **organism**[7] is the complete living system capable of conducting all of life's biological processes.

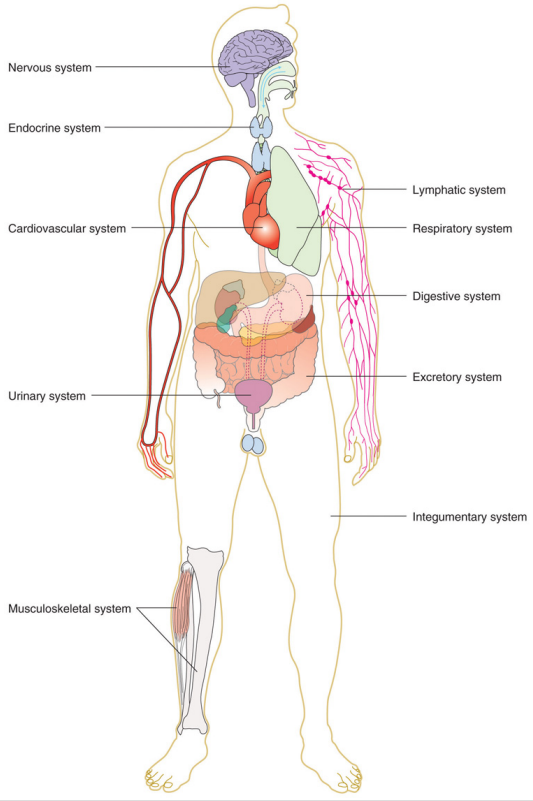
4. A group of cells that share a common structure and function and that work together.
5. A group of tissues arranged in a specific manner to support a common function.
6. Two or more organs that support a specific physiological function.
7. The complete living system capable of conducting all basic life processes.

Table 3.1 The Eleven Organ Systems in the Human Body and Their Major Functions

Organ System	Organ Components	Major Function
Circulatory	heart, blood/lymph vessels, blood, lymph	Transport nutrients and waste products

Organ System	Organ Components	Major Function
Digestive	mouth, esophagus, stomach, intestines	Digestion and absorption
Endocrine	all glands (thyroid, ovaries, pancreas)	Produce and release hormones
Immune	white blood cells, lymphatic tissue, marrow	Defend against foreign invaders
Integumentary	skin, nails, hair, sweat glands	Protective, body temperature regulation
Muscular	skeletal, smooth, and cardiac muscle	Body movement
Nervous	brain, spinal cord, nerves	Interprets and responds to stimuli
Reproductive	gonads, genitals	Reproduction and sexual characteristics
Respiratory	lungs, nose, mouth, throat, trachea	Gas exchange
Skeletal	bones, tendons, ligaments, joints	Structure and support
Urinary	kidneys, bladder, ureters	Waste excretion, water balance

Figure 3.2 Organ Systems in the Human Body

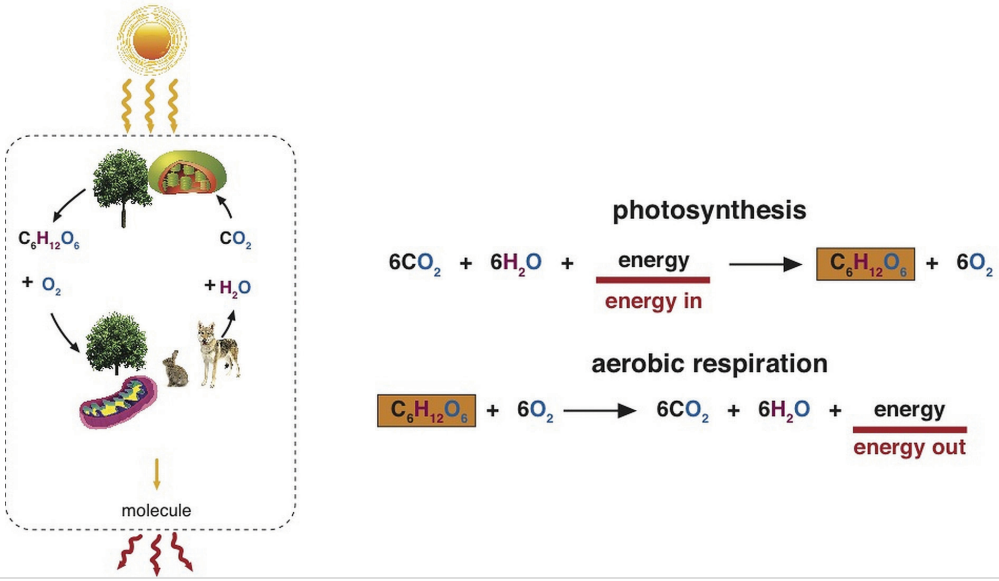


An Organism Requires Energy and Nutrient Input

Energy is required in order to build molecules into larger macromolecules, and to turn macromolecules into organelles and cells, and then turn those into tissues, organs, and organ systems, and finally into an organism. Proper nutrition provides the necessary nutrients to make the energy that supports life's processes. Your body builds new macromolecules from the nutrients in food.

Nutrient and Energy Flow

Energy is stored in a nutrient's chemical bonds. Energy comes from sunlight, which plants then capture and, via photosynthesis, use it to transform carbon dioxide in the air into the molecule, glucose. When the glucose bonds are broken, energy is released. Bacteria, plants, and animals (including humans) harvest the energy in glucose via a biological process called **cellular respiration**[8]. In this process the chemical energy of glucose is transformed into cellular energy in the form of the molecule, adenosine triphosphate (ATP). Cellular respiration requires oxygen (aerobic) and it is provided as a waste product of photosynthesis. The waste products of cellular respiration are carbon dioxide (CO_2) and water, which plants use to conduct photosynthesis again. Thus, energy is constantly cycling between plants and animals. As energy is consumed nutrients are recycled within it.



8. The process by which the stored chemical energy in nutrients is transformed into cellular energy.

Plants harvest energy from the sun and capture it in the molecule, glucose. Humans harvest the energy in glucose and capture it into the molecule, ATP.

In this section, we have learned that all life is composed of cells capable of transforming small organic molecules into energy. How do complex organisms such as humans convert the large macromolecules in the foods that we eat into molecules that can be used by cells to make cellular energy? In the next section, we will discuss the physiological process of digestion to answer this question.

KEY TAKEAWAYS

- The cell is the basic structural and functional unit of life. Cells are independent, single-celled organisms that take in nutrients, excrete wastes, detect and respond to their environment, move, breathe, grow, and reproduce. The macromolecules carbohydrates, proteins, lipids, and nucleic acids make up all of the structural and functional units of cells.
- In complex organisms, cells are organized into five levels so that an organism can conduct all basic processes associated with life.
- There are eleven organ systems in the human body that work together to support life, all of which require nutrient input.
- Energy is constantly cycling between plants and animals. As energy is consumed nutrients are recycled within it.

DISCUSSION STARTER

1. Discuss the importance of organization in the human body. If the body becomes disorganized by a disease or disorder what happens to its function? Can you think of a good example (what about leg fracture and movement)?

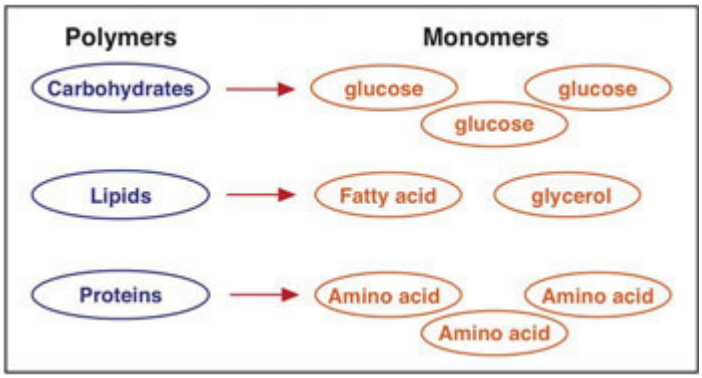
3.2 Digestion and Absorption

LEARNING OBJECTIVE

1. Sketch and label the major organs of the digestive system and state their functions.

Digestion begins even before you put food into your mouth. When you feel hungry, your body sends a message to your brain that it is time to eat. Sights and smells influence your body's preparedness for food. Smelling food sends a message to your brain. Your brain then tells the mouth to get ready, and you start to salivate in preparation for a delicious meal.

Figure 3.3 *The Digestion Process*



Digestion converts the food we eat into smaller particles, which will be processed into energy or used as building blocks.

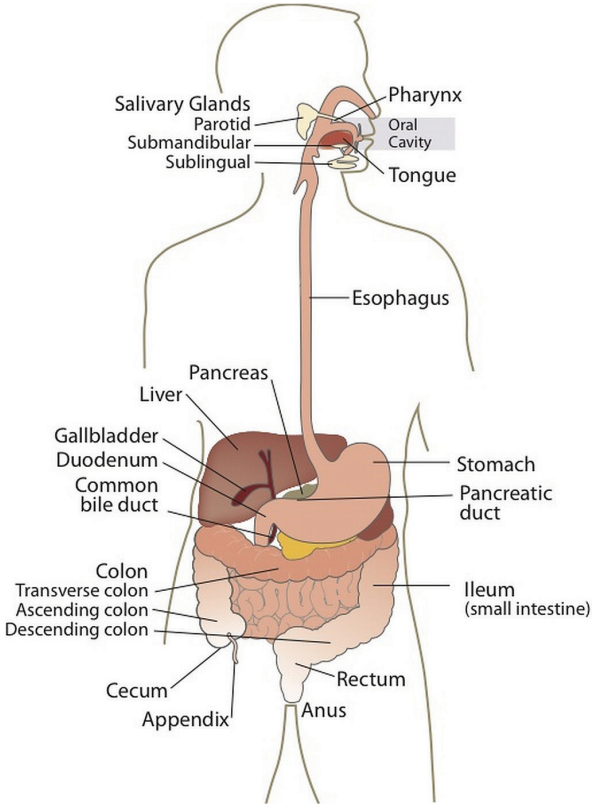
9. The body system responsible for breaking down complex food particles into smaller absorbable components. The entire system is composed of several hollow, tube-shaped organs including the mouth, pharynx, esophagus, stomach, small intestine, large intestine (or colon), rectum, and anus.

Once you have eaten, your **digestive system**[9] (Figure 3.4 "The Human Digestive System") breaks down the food into smaller components. To do this, it functions on two levels, mechanical and chemical. Once the smaller particles have been broken down, they will be absorbed and processed by cells throughout the body for energy or used as building blocks for new cells. The digestive system is one of the eleven organ systems of the human body and it is composed of several hollow tube-shaped organs including the mouth, pharynx, esophagus, stomach, small intestine, large

intestine (or colon), rectum, and anus. It is lined with mucosal tissue that secretes digestive juices (which aid in the breakdown of food) and mucus (which facilitates the propulsion of food through the tract). Smooth muscle tissue surrounds the digestive tract and its contraction produces waves, known as **peristalsis**[10], that propel food down the tract. Nutrients as well as some nonnutrients are absorbed. Substances such as fiber get left behind and are appropriately excreted.

From the Mouth to the Stomach

Figure 3.4 *The Human Digestive System*



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10. Waves of smooth muscle contraction that propel food down the digestive tract.

11. Collection of nutrients into the alimentary canal.

12. The breaking apart of food macromolecules by enzymes secreted by the salivary glands, stomach, pancreas, and small intestine. Additionally, bile emulsifies fats.

There are four steps in the digestion process (Figure 3.4 "The Human Digestive System"). The first step is **ingestion**[11], which is the collection of food into the digestive tract. It may seem a simple process, but ingestion involves smelling food, thinking about food, and the involuntary release of saliva in the mouth to prepare for food entry. In the mouth, where the second step of digestion occurs, the mechanical and chemical breakdown of food begins. The **chemical breakdown**[12] of food involves enzymes, which break apart the components in food. Theses enzymes

are secreted by the salivary glands, stomach, pancreas, and small intestine. **Mechanical breakdown**[13] starts with mastication (chewing) in the mouth. Teeth crush and grind large food particles, while saliva initiates the chemical breakdown of food and enables its movement downward. The slippery mass of partially broken-down food is called bolus, which moves down the digestive tract as you swallow. Swallowing may seem voluntary at first because it requires conscious effort to push the food with the tongue back toward the throat, but after this, swallowing proceeds involuntarily, meaning it cannot be stopped once it begins. As you swallow, the bolus is pushed from the mouth through the pharynx and into a muscular tube called the esophagus. As it travels through the pharynx, a small flap called the epiglottis closes, to prevent choking by keeping food from going into the trachea. Peristaltic contractions in the esophagus propel the food down to the stomach. At the junction between the esophagus and stomach there is a sphincter muscle that remains closed until the food bolus approaches. The pressure of the food bolus stimulates the lower esophageal sphincter to relax and open and food then moves from the esophagus into the stomach. The mechanical breakdown of food is accentuated by the muscular contractions of the stomach and small intestine that mash, mix, slosh, and propel food down the alimentary canal. Solid food takes between four and eight seconds to travel down the esophagus, and liquids take about one second.

From the Stomach to the Small Intestine

When food enters the stomach, a highly muscular organ, powerful peristaltic contractions help mash, pulverize, and churn food into chyme. **Chyme**[14] is a semiliquid mass of partially digested food that also contains gastric juices secreted by cells in the stomach. Cells in the stomach also secrete hydrochloric acid and the enzyme pepsin, that chemically breaks down food into smaller molecules. The stomach has three basic tasks:

1. To store food
2. To mechanically and chemically break down food
3. To empty partially broken-down food into the small intestine

The length of time food spends in the stomach varies by the macronutrient composition of the meal. A high-fat or high-protein meal takes longer to break down than one rich in carbohydrates. It usually takes a few hours after a meal to empty the stomach contents completely.

Video 3.2

Digestion Video

13. Includes mastication (chewing) and the muscular contractions of the stomach and small intestine that mash, mix, slosh, and propel food down the alimentary canal.

14. A semiliquid mass of partially digested food that also contains gastric juices.

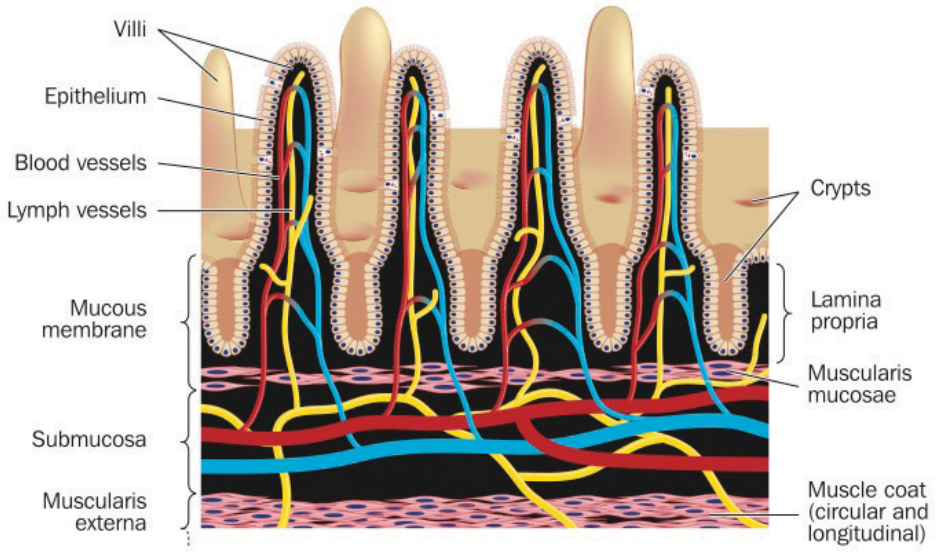
(click to see video)

This video shows the mechanical and chemical breakdown of food into chyme.

The small intestine is divided into three structural parts: the duodenum, the jejunum, and the ileum. Once the chyme enters the duodenum (the first segment of the small intestine), the pancreas and gallbladder are stimulated and release juices that aid in digestion. The pancreas secretes up to 1.5 liters of pancreatic juice through a duct into the duodenum per day. This fluid consists mostly of water, but it also contains bicarbonate ions that neutralize the acidity of the stomach-derived chyme and enzymes that further breakdown proteins, carbohydrates, and lipids. The gallbladder secretes a much smaller amount of bile to help digest fats, also through a duct that leads to the duodenum. Bile is made in the liver and stored in the gall bladder. Bile's components act like detergents by surrounding fats similar to the way dish soap removes grease from a frying pan. This allows for the movement of fats in the watery environment of the small intestine. Two different types of muscular contractions, called peristalsis and segmentation, move and mix the food in various stages of digestion through the small intestine. Similar to what occurs in the esophagus and stomach, peristalsis is circular waves of smooth muscle contraction that propel food forward. Segmentation sloshes food back and forth in both directions promoting further mixing of the chyme. Almost all the components of food are completely broken down to their simplest unit within the first 25 centimeters of the small intestine. Instead of proteins, carbohydrates, and lipids, the chyme now consists of amino acids, monosaccharides, and emulsified fatty acids.

The next step of digestion (nutrient absorption) takes place in the remaining length of the small intestine, or ileum (> 5 meters).

Figure 3.5



The way the small intestine is structured gives it a huge surface area to maximize nutrient absorption. The surface area is increased by folds, villi, and microvilli. Digested nutrients are absorbed into either capillaries or lymphatic vessels contained within each microvilli.

The small intestine is perfectly structured for maximizing nutrient absorption. Its surface area is greater than 200 square meters, which is about the size of a tennis court. The surface area of the small intestine increases by multiple levels of folding. The internal tissue of the small intestine is covered in villi, which are tiny finger-like projections that are covered with even smaller projections, called microvilli (Figure 3.5). The digested nutrients pass through the absorptive cells of the intestine via diffusion or special transport proteins. Amino acids and monosaccharides (sugars) are transported from the intestinal cells into capillaries, but the much larger emulsified fatty acids, fat-soluble vitamins, and other lipids are transported first through lymphatic vessels, which soon meet up with blood vessels.

From the Small Intestine to the Large Intestine

The process of digestion is fairly efficient. Any food that is still incompletely broken down (usually less than ten percent of food consumed) and the food's indigestible fiber content moves from the small intestine to the large intestine (colon) through a connecting valve. The main task of the large intestine is to reabsorb water. Remember, water is present not only in solid foods, but also the stomach releases a few hundred millilters of gastric juice and the pancreas adds approximately another 500 milliliters during the digestion of the meal. For the body to conserve water, it is important that the water be reabsorbed. In the large intestine, no further chemical or mechanical breakdown of food takes place, unless it is accomplished by the bacteria that inhabit this portion of the digestive tract. The number of bacteria residing in the large intestine is estimated to be greater than $10^{(14)}$, which is more than the total number of cells in the human body ($10^{(13)}$). This may seem rather unpleasant, but the great majority of bacteria in the large intestine are harmless and some are even beneficial.

Kefir, a dairy product fermented with probiotic bacteria, can make a pleasant tasting milkshake.

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Tools for Change

There has been significant talk about pre- and probiotic foods in the mainstream media. The World Health Organization defines probiotics as live bacteria that confer beneficial health effects on their host. They are sometimes called "friendly bacteria." The most common bacteria labeled as probiotic is lactic acid bacteria (lactobacilli). They are added as live cultures to certain fermented foods such as yogurt. Prebiotics are indigestible foods, primarily soluble fibers, that stimulate the growth of certain strains of bacteria in the large intestine and provide health benefits to the host. A review article in the June 2008 issue of the *Journal of Nutrition* concludes that there is scientific consensus that probiotics ward off viral-induced diarrhea and reduce the symptoms of lactose intolerance.Farnworth, E. R. "The Evidence to Support Health Claims for Probiotics." *J Nutr* 138, no. 6 (2008): 1250S–4S. http://jn.nutrition.org/content/138/6/1250S.long. Expert nutritionists agree that more health benefits of pre- and probiotics will likely reach scientific consensus. As the fields of pre- and probiotic manufacturing and their clinical study progress, more information on proper dosing and what exact strains of bacteria are potentially "friendly" will become available.

You may be interested in trying some of these foods in your diet. A simple food to try is kefir. Several websites provide good recipes, including http://www.kefir.net/recipes.htm.

From the Large Intestine to the Anus

After a few hours in the stomach, plus three to six hours in the small intestine, and about sixteen hours in the large intestine, the digestion process enters step four, which is the elimination of indigestible food as feces. Feces contain indigestible food and gut bacteria (almost 50 percent of content). It is stored in the rectum until it is expelled through the anus via defecation.

Video 3.3

The Stages of Digestion

(click to see video)

This video reviews the sequence of events during food digestion.

KEY TAKEAWAYS

- The breakdown of complex macromolecules in foods to simple absorbable components is accomplished by the digestive system. These components are processed by cells throughout the body into energy or are used as building blocks.
- The digestive system is composed of the mouth, pharynx, esophagus, stomach, small intestine, large intestine (or colon), rectum, and anus. There are four steps in the digestion process: ingestion, the mechanical and chemical breakdown of food, nutrient absorption, and elimination of indigestible food.
- The mechanical breakdown of food occurs via muscular contractions called peristalsis and segmentation. Enzymes secreted by the salivary glands, stomach, pancreas, and small intestine accomplish the chemical breakdown of food. Additionally, bile emulsifies fats.

DISCUSSION STARTER

1. Decide whether you want to consume pre- and probiotic foods to benefit your health. Visit the websites below to help in your decision-making process. Defend your decision scientifically.

   http://www.health.harvard.edu/fhg/updates/update0905c.shtml

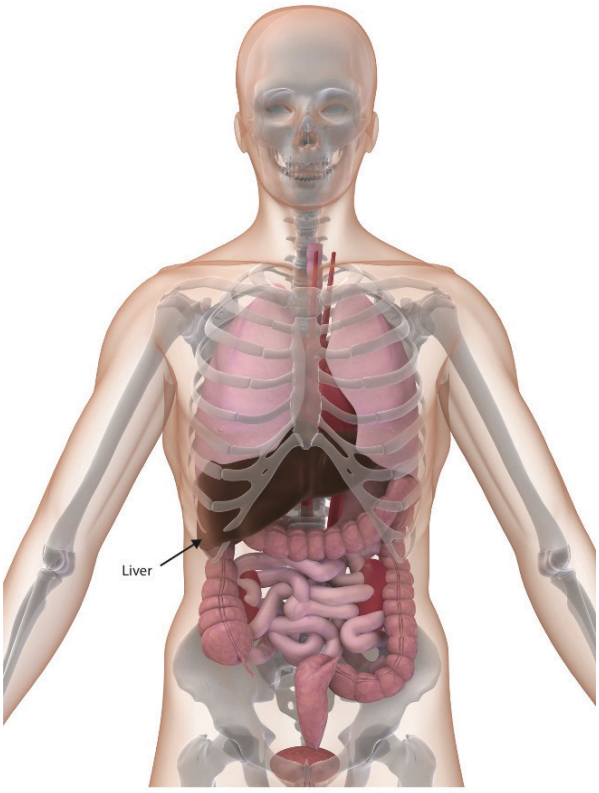
   http://nccam.nih.gov/research/results/spotlight/110508.htm

3.3 Nutrients Are Essential for Organ Function

LEARNING OBJECTIVES

1. Generalize how the body distributes nutrients to the rest of the body.
2. Summarize the importance of adequate nutrition on other organ systems.

When the digestive system has broken down food to its nutrient components the body eagerly awaits delivery. The first stop of most absorbed nutrients is the liver. One of the liver's primary functions is to regulate metabolic homeostasis. **Metabolic homeostasis**[15] may be defined as when the nutrients consumed and absorbed matches the energy required to carry out life's biological processes. Simply put, nutrient energy intake equals energy output. Through the body's network of blood vessels and veins, glucose and amino acids are directly transported from the small intestine to the liver. Lipids are transported to the liver by a more circuitous route involving the lymphatic system, which contains vessels similar to the circulatory system that transport white blood cells called lymph.



15. The nutrients consumed and absorbed matches the energy required to carry out life's biological processes.

The liver is the checkpoint for metabolic activity.

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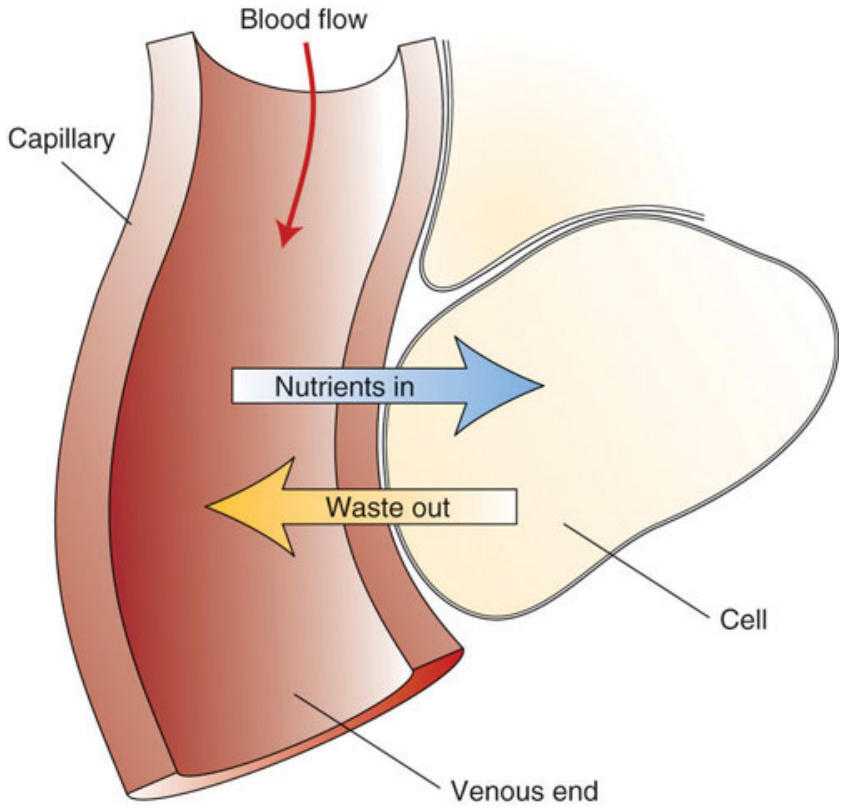
Maintaining the body's energy status quo is crucial because when metabolic homeostasis is disturbed by an eating disorder or disease, bodily function suffers. This will be discussed in more depth in the last section of this chapter. The liver is the only organ in the human body that is capable of exporting nutrients for energy production to other tissues. Therefore, when a person is in between meals (fasted state) the liver exports nutrients and when a person has just eaten (fed state) the liver stores nutrients within itself. Nutrient levels and the hormones that respond to their levels in the blood provide the input so that the liver can distinguish between the fasted and fed states and distribute nutrients appropriately.

All eleven organ systems in the human body require nutrient input to perform their specific biological functions. No energy in means no work output. Overall health and the ability to carry out all of life's basic processes is fueled by nutrients. Without them organ systems would fail, humans would not reproduce, and the race would disappear. In this section, we will discuss some of the critical nutrients that support specific organ system functions.

The Circulatory System

Figure 3.6 *The Circulatory System*



The circulatory system transports nutrients to all cells and carries wastes out.

The **circulatory system**[16] is one of the eleven organ systems of the human body. Its main function is to transport nutrients to cells and wastes from cells (Figure 3.6 "The Circulatory System"). This system consists of the heart, blood, and blood vessels. The heart pumps the blood, and the blood is the transportation fluid. The transportation route to all tissues is a highly intricate blood-vessel network, comprised of arteries, veins, and capillaries. Nutrients absorbed in the small intestine travel mainly to the liver through the hepatic portal vein. From the liver, nutrients travel upward through the inferior vena cava blood vessel to the heart. The heart forcefully pumps the nutrient-rich blood first to the lungs to pick up some oxygen and then to all other cells in the body. Arteries become smaller and smaller on their way to cells, so that by the time blood reaches a cell, the artery's diameter is extremely small and the vessel is now called a capillary. The reduced diameter of the blood vessel substantially slows the speed of blood flow. This

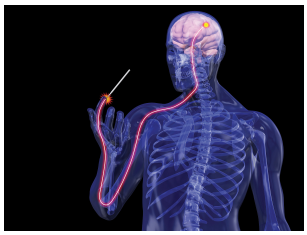
16. Comprised of the heart, blood, and blood vessels. Its main functions are to transport nutrients to all cells and transport wastes from all cells.

dramatic reduction in blood flow gives cells time to harvest the nutrients in blood and exchange metabolic wastes.

The Central Nervous System

The human brain (which weighs only about 3 pounds, or 1,300 kilograms) is estimated to contain over one hundred billion neurons. Neurons form the core of the **central nervous system**[17], which consists of the brain, spinal cord, and other nerve bundles in the body. The main function of the central nervous system is to sense changes in the external environment and create a reaction to them. For instance, if your finger comes into contact with a thorn on a rose bush, a sensory neuron transmits a signal from your finger up through the spinal cord and into the brain. Another neuron in the brain sends a signal that travels back to the muscles in your hand and stimulates muscles to contract and you jerk your finger away. All of this happens within a tenth of a second. All nerve impulses travel by the movement of charged sodium, potassium, calcium, and chloride atoms. These are some of the essential minerals in our diets—essential because they are absolutely required for central nervous system function. Nerves communicate with each other via chemicals built from amino acids called neurotransmitters. Eating adequate protein from a variety of sources will ensure the body gets all of the different amino acids that are so important for central nervous system function.

Every day the brain uses over 20 percent of the energy obtained from nutrients. Its main fuel is glucose and only in extreme starvation will it use anything else. For acute mental alertness and clear thinking, glucose must be systematically delivered to your brain. This does not mean that sucking down a can of sugary soda before your next exam is a good thing. Just as too much glucose is bad for other organs, such as the kidneys and pancreas, it also produces negative effects upon the brain. Excessive glucose levels in the blood can cause a loss of cognitive function and chronically high blood-glucose levels can damage brain cells. The brain's cognitive functions include language processing, learning, perceiving, and thinking. Recent scientific studies demonstrate that having continuously high blood-glucose levels substantially elevates the risk for developing Alzheimer's disease, which is the greatest cause of age-related cognitive decline.



The brain has been compared to a central computer that controls all body functions. It relays messages to and from various body parts at lightning speed within a vast communication network of cells.

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The good news is that much research is directed toward determining the best diets and foods that slow cognitive decline and maximize brain health. A study in the

17. Neurons form the core of the central nervous system, which consists of the brain, spinal cord, and other nerve bundles. The main function of the central nervous system is to sense changes in the external environment and create a reaction to them.

June 2010 issue of the *Archives of Neurology* reports that people over age sixty-five who adhered to diets that consisted of higher intakes of nuts, fish, poultry, tomatoes, cruciferous vegetables, fruits, salad dressing, and dark green, and leafy vegetables, as well as a lower intake of high-fat dairy products, red meat, organ meat, and butter, had a much reduced risk for Alzheimer's disease.Gu, Y., PhD et al. "Food Combination and Alzheimer Disease Risk: A Protective Diet." *Arch Neurol* 67, no. 6 (2010): 699–706. doi: 10./1001/archneurol.2010.84. Other scientific studies provide supporting evidence that foods rich in omega-3 fatty acids and/or antioxidants provide the brain with protection against Alzheimer's disease. One potential "brain food" is the blueberry. The protective effects of blueberries upon the brain are linked to their high content of anthocyanins, which are potent antioxidants and reduce inflammation. A small study published in the April 2010 issue of the *Journal of Agricultural and Food Chemistry* found that elderly people who consumed blueberry juice every day for twelve weeks had improved learning and memorization skills in comparison to other subjects given a placebo drink.Krikorian, R. et al. "Blueberry Supplementation Improves Memory in Older Adults." *J Agric Food Chem* 58, no. 7 (2010): 3996–4000. doi: 10.1021/jf9029332. More clinical trials are evaluating the effects of blueberries and other foods that benefit the brain and preserve its function as we age.

The Muscular System

The **muscular system**[18] allows the body to move voluntarily, but it also controls involuntary movements of other organ systems such as heartbeat in the circulatory system and peristaltic waves in the digestive system. It consists of over six hundred skeletal muscles, as well as the heart muscle, the smooth muscles that surround your entire alimentary canal, and all your arterial blood vessels. Muscle contraction relies on energy delivery to the muscle. Each movement uses up cellular energy and without an adequate energy supply muscle function suffers. Muscle, like the liver, can store the energy from glucose in the large polymeric molecule glycogen. But unlike the liver, muscles use up all of their own stored energy and do not export it to other organs in the body. When muscle energy stores are diminished, muscle contraction weakens. However, muscle is not as susceptible to low levels of blood glucose as the brain because it will readily use alternate fuels, such as fatty acids and protein to produce cellular energy.

18. The muscular system allows voluntary movement as well as involuntary movements of other organ systems. It consists of skeletal muscle, the heart muscle, and smooth muscles.

"Hitting the Wall" or "Bonking"

In order to avoid "hitting the wall," athletes consume large amounts of carbohydrates before and during events to ensure enough glucose is available for optimal performance, especially during endurance activities such as cycling.

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If you are familiar with endurance sports, you may have heard of "hitting the wall" or "bonking." These colloquial terms refer to the extreme fatigue that sets in after about 120 minutes of performing an endurance sport, such as marathon running or long-distance cycling. The physiology underlying "hitting the wall" means that muscles have used up all their stored glycogen and are therefore dependent on other nutrients to support their energy needs. Fatty acids are transported from fat-storing cells to the muscle to rectify the nutrient deficit. However, fatty acids take more time to convert to energy than glucose, thus decreasing performance levels. To avoid "hitting the wall" or "bonking," endurance athletes load up on carbohydrates a few days before the event. This will maximize an athlete's amount of glycogen stored in their liver and muscle tissues. It is important not to assume that carbohydrate loading works for everyone. Without accompanied endurance training you will not increase the amount of stored glucose. If you plan on running a five-mile race for fun with your friend and decide to eat a large amount of carbohydrates in the form of a big spaghetti dinner the night before, the excess carbohydrates will be stored fat. Another way for athletes to avoid "hitting the wall" is to consume carbohydrate-containing drinks and foods during an endurance event. In fact, throughout the Tour de France—a twenty-two-day, twenty-four-hundred-mile race—the average cyclist consumes greater than 60 grams of carbohydrates per hour.

The Endocrine System

The functions of the **endocrine system**[19] are intricately connected to the body's nutrition. This organ system is responsible for regulating appetite, nutrient absorption, nutrient storage, and nutrient usage, in addition to other functions, such as reproduction. The glands in the endocrine system are the pituitary, thyroid, parathyroid, adrenals, thymus, pineal, pancreas, ovaries, and testes. The glands secrete **hormones**[20], which are biological molecules that regulate cellular processes in other target tissues, so they require transportation by the circulatory system. Adequate nutrition is critical for the functioning of all the glands in the endocrine system. A protein deficiency impairs gonadal-hormone release, preventing reproduction. Athletic teenage girls with very little body fat often do not menstruate. Children who are malnourished usually do not produce enough growth hormone and fail to reach normal height for their age group. Probably the most popularized connection between nutrition and the functions of the endocrine

19. Organ system that is responsible for regulating nutrient intake, absorption, storage, and usage, in addition to many other things, most notably reproduction. The glands in the endocrine system are the pituitary, thyroid, parathyroid, adrenal, thymus, and pineal gland, as well as the pancreas, ovaries, and testes.

20. Biological molecules transported in the blood that regulate cellular processes in other target tissues.

system is that unhealthy dietary patterns are linked to obesity and the development of Type 2 diabetes. The Centers for Disease Control and Prevention (CDC) estimates that twenty-six million Americans have Type 2 diabetes as of 2011. This is 8.3 percent of the US population. The maps in Note 3.35 "Interactive 3.1" show the percentage of adults who are obese, and those with diagnosed Type 2 diabetes within all American counties. You can see that those counties with the highest incidence of obesity also have the highest incidence of Type 2 diabetes. To see how the rise in obesity in this country is paralleled by the rise in Type 2 diabetes, watch the PowerPoint presentation prepared by the CDC (Note 3.35 "Interactive 3.1").

Video 3.4

Obesity and Type 2 Diabetes

(click to see video)

Watch the National Health video to see the relationship between the rise in obesity and the rise in Type 2 diabetes.

Interactive 3.1

Take a look at the PowerPoint presentation prepared by the CDC that captures the concurrent rises of obesity and Type 2 diabetes in this country. Click on "Maps of Trends in Diabetes and Obesity."

http://www.cdc.gov/diabetes/statistics/diabetes_slides.htm

What is the causal relationship between overnutrition and Type 2 diabetes? The prevailing theory is that the overconsumption of high-fat and high-sugar foods causes changes in muscle, fat, and liver cells that leads to a diminished response from the pancreatic hormone insulin. These cells are called "insulin-resistant." Insulin is released after a meal and instructs the liver and other tissues to take up glucose and fatty acids that are circulating in the blood. When cells are resistant to insulin they do not take up enough glucose and fatty acids and so glucose and fatty acids remain at high concentrations in the blood. The continuously high amounts of glucose and fatty acids in the blood impair the release of insulin from the pancreas, further exacerbating the situation. The chronic elevation of glucose and fatty acids in the blood also causes damage to other tissues over time, so that people who have

Type 2 diabetes are at increased risk for cardiovascular disease, kidney disease, nerve damage, and eye disease.

Tools for Change

Do your part to slow the rising tide of obesity and Type 2 diabetes in this country. On the individual level, improve your own family's diet; at the local community level, support the development of more nutritious school lunch programs; and at the national level, support your nation's nutrition goals. Visit the CDC Diabetes Public Health Resource website at http://www.cdc.gov/diabetes/. It provides information on education resources, projects, and programs, and spotlights news on diabetes and obesity. The CDC also has a new workplace program called CDC's LEAN *Works!* (LEAN: Leading Employees to Activity and Nutrition). The program provides free web-based resources with the mission of designing worksites that prevent obesity. See http://www.cdc.gov/leanworks/ for more details.

The Immune System

The **immune system**[21] is comprised of several types of white blood cells that circulate in the blood and lymph. Their jobs are to seek, recruit, attack, and destroy foreign invaders, such as bacteria and viruses. Other less realized components of the immune system are the skin (which acts as a barricade), mucus (which traps and entangles microorganisms), and even the bacteria in the large intestine (which prevent the colonization of bad bacteria in the gut). Immune system functions are completely dependent on dietary nutrients. In fact, malnutrition is the leading cause of immune-system deficiency worldwide. When immune system functions are inadequate there is a marked increase in the chance of getting an infection. Children in many poor, developing countries have protein- and/or energy-deficient diets that are causative of two different syndromes, kwashiokors and marasmus. These children often die from infections that their bodies could normally have fought off, but because their protein and/or energy intake is so low, the immune system cannot perform its functions.

21. The immune system is made up of several different types of white blood cells and other components that act as barricades to foreign invaders. The functions of the immune system are to barricade, seek, recruit, attack, and destroy foreign invaders, such as bacteria and viruses.

Other nutrients, such as zinc, selenium, copper, folate, and vitamins A, B_6, C, D, and E, all provide benefits to immune system function. Deficiencies in these nutrients can cause an increased risk for infection and death. Zinc deficiency results in suppression of the immune system's barrier functions by damaging skin cells; it is also associated with a decrease in the number of circulating white blood cells. A

review of several studies in the journal *Pediatrics* concluded that zinc supplements administered to children under age five for longer than three months significantly reduces the incidence and severity of diarrhea and respiratory illnesses.Aggarwal R., MD, DM, J. Sentz, MPH and M. A. Miller, MD. "Role of Zinc Administration in Prevention of Childhood Diarrhea and Respiratory Illnesses: A Meta-Analysis." *Pediatrics* 119, no. 6 (2007): 1120–30. doi: 10.1542/peds.2006–3481. Zinc supplementation has also been found to be therapeutically beneficial for the treatment of leprosy, tuberculosis, pneumonia, and the common cold. Equally important to remember is that multiple studies show that it is best to obtain your minerals and vitamins from eating a variety of healthy foods.

Tools for Change

To ensure that your diet includes zinc-friendly foods, try these foods high in zinc and other immune-system friendly nutrients: oysters, poultry, baked beans, chick peas, cashews, sesame seeds, peanuts, whole grains, and zinc-fortified cereals.

These are just some of the foods that are high in zinc.

Just as undernutrition compromises immune system health, so does overnutrition. People who are obese are at increased risk for developing immune system disorders such as asthma, rheumatoid arthritis, and some cancers. Both the quality and quantity of fat affect immune system function. High intakes of saturated and trans fats negatively affect the immune system, whereas increasing your intake of omega-3 fatty acids, found in salmon and other oily fish, decreases inflammatory responses. High intakes of omega-3 fatty acids are linked to a reduction in the risk of developing certain autoimmune disorders, such as rheumatoid arthritis, and are used as part of a comprehensive treatment for rheumatoid arthritis.

KEY TAKEAWAYS

- Metabolic homeostasis occurs when the amount of nutrients consumed matches the energy required to carry out life's biological processes.
- The circulatory system transports nutrients to cells and transports wastes from them.
- The essential minerals sodium, potassium, calcium, and chloride, and the macronutrients protein and carbohydrates, are required for central nervous system function. Fat is also critical for central nervous system function (see the Discussion Starter below).
- Without energy from nutrients, muscles cannot contract.
- Undernutrition and overnutrition compromise endocrine and immune system functions. Type 2 diabetes, increased rates of infection, and inflammatory disorders are symptoms of an imbalance in the diet.

DISCUSSION STARTER

1. Find out how fat supports brain function and protects nerves by visiting the Franklin Institute Resources for Science Learning website.

   http://www.fi.edu/learn/brain/fats.html

   Now look at the websites below to see how too much of the wrong kind of fats may be bad for the brain, while other types of fat are good for the brain.

   http://archneur.ama-assn.org/cgi/content/full/60/2/194

   http://www.sciencedaily.com/releases/2007/12/071210163251.htm

   http://www.webmd.com/alzheimers/news/20070418/omeg-3-fatty-acid-slows-alzheimers

   After viewing all of the videos, discuss the importance of "good fats" in the diet for optimizing brain function and preventing diseases such as Alzheimer's.

3.4 Energy and Calories

LEARNING OBJECTIVE

1. Estimate your total daily caloric /energy needs based upon your physical activity level.

Energy[22] is essential to life. You must eat to have energy. You must go to bed at a decent time, so that when you wake up in the morning, you will not be too tired and you will have sufficient energy for the next day's activities. Energy is also everywhere in our environment: sunlight, wind, water, plants, and animals. All living things use energy every day. Energy can be defined as the quantity of work a particular system can perform, whether it be a growing child's body or a train transporting passengers from one place to another. Energy also helps us perform daily functions and tasks such as breathing, walking up a flight of steps, and studying for a test.

Energy is classified as either potential or kinetic. **Potential energy**[23] is stored energy, or energy waiting to happen. **Kinetic energy**[24] is energy in motion. To illustrate this, think of an Olympic swimmer standing at the pool's edge awaiting the sound of the whistle to begin the race. While he waits for the signal, he has potential energy. When the whistle sounds and he dives into the pool and begins to swim, his energy is kinetic (in motion).

Some basic forms of energy are:

1. **Thermal (heat) energy.** We can say that a cup of hot tea has thermal energy. Thermal energy is defined as the collective, microscopic, kinetic, and potential energy of the molecules within matter. In a cup of tea, the molecules have kinetic energy because they are moving and oscillating, but they also possess potential energy due to their shared attraction to each other.
2. **Chemical energy.** In your body, blood sugar (glucose) possesses **chemical energy**[25]. When glucose reacts chemically with oxgen, energy is released from the glucose. Once the energy is released, your muscles will utilize it to produce mechanical force and heat.
3. **Electrochemical energy.** In the body, electrical impulses travel to and from the brain encoded as nerve impulses. Once the brain receives an electrical impulse it causes the release of a messenger chemical

22. The quantity of work a particular system can perform.
23. Stored energy.
24. Moving energy.
25. Potential energy in chemical bonds.

(glutamate, for example). This in turn facilitates electrical impulses as they move from one neuron to another.

The Calorie Is a Unit of Energy

The amount of energy in nutrients can be quantified into specific units that can be measured. The unit of measurement that defines the energy contained in a energy-yielding nutrient is called a calorie. A **calorie**[26] is the amount of energy in the form of heat that is required to heat one gram of water one degree Celsius. To measure the number of calories in a particular food substance, a certain amount of food is burned in a device called a calorimeter. As the food burns, heat is created. The heat dissipates to the surrounding water while a thermometer detects the change in temperature of the water. You can even perform calorimetry at home with a more basic device. However, it is not likely that you will use this device to measure calorie content in the foods that you eat since mathematical formulas have been developed to estimate caloric content.

Estimating Caloric Content

The energy contained in energy-yielding nutrients differs because the energy-yielding nutrients are composed of different types of chemical bonds. A carbohydrate or a protein yields 4 kilocalories per gram, whereas a lipid yields 9 kilocalories per gram. A **kilocalorie (Calorie)**[27] is the amount of heat generated by a particular macronutrient that raises the temperature of 1 kilogram of water 1 degree Celsius. A kilocalorie of energy performs one thousand times more work than a calorie. On the Nutrition Facts panel, the calories within a particular food are expressed as kilocalories, which is commonly denoted as “Calories” with a capital “C” (1 kcal = 1 Calorie = 1,000 calories).

Calculating the number of Calories in commercially prepared food is made fairly easy since the total number of Calories in a serving of a particular food is listed on the Nutrition Facts panel. If you wanted to know the number of Calories in the breakfast you consumed this morning just add up the number of Calories in each food. For example, if you ate one serving of yogurt that contained 150 Calories, on which you sprinkled one half of a cup of low-fat granola cereal that contained 209 Calories, and drank a glass of orange juice that contained 100 Calories, the total number of Calories you consumed at breakfast is 150 + 209 + 100 = 459 Calories. If you do not have a Nutrition Facts panel for a certain food, such as a half cup of blueberries, and want to find out the amount of Calories it contains, go to MyFood-a-pedia, a website maintained by the USDA (see Note 3.48 "Interactive 3.2").

26. A unit of energy; equivalent to the amount of energy required to heat 1 gram of water 1 degree Celsius.

27. A kilocalorie is the amount of heat generated by a particular macronutrient that raises the temperature of 1 kilogram of water 1 degree Celsius (this is what is denoted on the Nutrition Facts panel).

Interactive 3.2

My Food-a-pedia is a tool that calculates the Calories in foods. It also compares the caloric content between foods.

http://apps.usa.gov/myfood-a-pedia.shtml

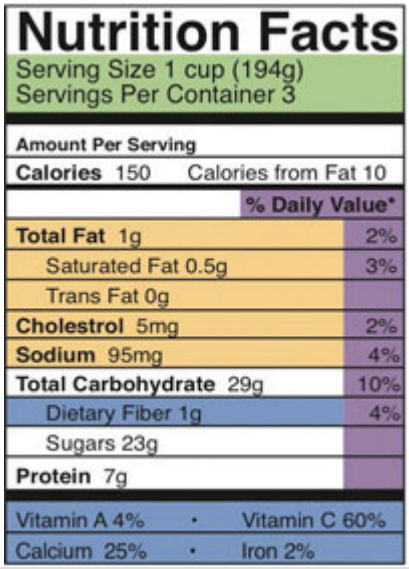
Estimating the Amount of Energy from Each Macronutrient

Also listed on the Nutrition Facts panel are the amounts of total fat, total carbohydrate, and protein in grams. To calculate the contribution of each macronutrient to the total kilocalories in a serving, multiply the number of grams by the number of kilocalories yielded per gram of nutrient. For instance, from the Nutrition Facts panel for yogurt given in Figure 3.7 "A Nutrition Facts Panel for Yogurt", the protein content in one serving is 7 grams. Protein yields 4 kilocalories per gram. The number of kilocalories from protein is calculated by using the following equation:

# of grams of protein × 4 kilocalories/gram of protein

7 grams × 4 kilocalories/gram = 28 kilocalories

Figure 3.7 *A Nutrition Facts Panel for Yogurt*



Because the total number of kilocalories in each serving of yogurt is 150, the percent of energy obtained from protein is calculated by using the following equation:

(# kilocalories from protein ÷ total kilocalories per serving) × 100

(28 ÷ 150) × 100 = 18.7 percent

KEY TAKEAWAYS

- Energy is vital to life and is categorized into two types—kinetic and potential. There are also different forms of energy such as thermal, chemical, and electrochemical.
- Calories are a measurement of a specific quantity of energy contained in foods. The number of calories contained in a commercially prepared food is listed on the Nutrition Facts panel.

DISCUSSION STARTER

1. Estimate the total number of kilocalories that you have eaten so far today. What percentage of the kilocalories you consumed was obtained from carbohydrates? Protein? Fat?

3.5 Disorders That Can Compromise Health

LEARNING OBJECTIVE

1. Interpret why certain disorders and diseases, such as gastroesophageal reflux disease (GERD), celiac disease, and irritable bowel syndrome compromise overall health.

When nutrients and energy are in short supply, cells, tissues, organs, and organ systems do not function properly. Unbalanced diets can cause diseases and, conversely, certain illnesses and diseases can cause an inadequate intake and absorption of nutrients, simulating the health consequences of an unbalanced diet. Overeating high-fat foods and nutrient-poor foods can lead to obesity and exacerbate the symptoms of gastroesophageal reflux disease (GERD) and irritable bowel syndrome (IBS). Many diseases and illnesses, such as celiac disease, interfere with the body getting its nutritional requirements. A host of other conditions and illnesses, such as food allergies, cancer, stomach ulcers, Crohn's disease, and kidney and liver disease, also can impair the process of digestion and/or negatively affect nutrient balance and decrease overall health.

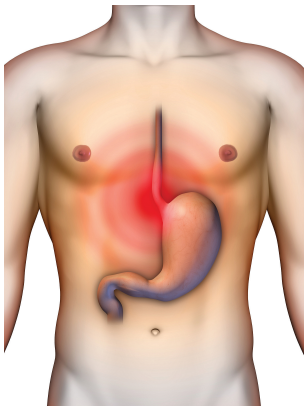
Gastroesophageal Reflux Disease

Gastroesophageal reflux disease (GERD)[28] is a persistent form of acid reflux that occurs more than two times per week. Acid reflux occurs when the acidic contents of the stomach leak backward into the esophagus and cause irritation. It is estimated that GERD affects 25 to 35 percent of the US population. An analysis of several studies published in the August 2005 issue of *Annals of Internal Medicine* concludes that GERD is much more prevalent in people who are obese.Hampel, H. MD, PhD, N. S. Abraham, MD, MSc(Epi) and H. B. El-Serag, MD, MPH. "Meta-Analysis: Obesity and the Risk for Gastroesophageal Reflux Disease and Its Complications." *Ann Intern Med* 143, no. 3 (2005): 199–211. http://www.ncbi.nlm.nih.gov/pubmed/16061918 While the links between obesity and GERD are not completely known, they likely include that excess body fat puts pressure on the stomach, overeating increases pressure in the stomach, and fatty foods are triggers for GERD symptoms. The most common GERD symptom is heartburn, but people with GERD may also experience regurgitation (flow of the stomach's acidic contents into the mouth), frequent coughing, and trouble swallowing. Approximately 35 percent of children born in the United States have GERD. In babies the symptoms are more difficult to distinguish from what babies do normally. The symptoms are spitting up more than

28. A persistant form of acid reflux, in which acidic contents of the stomach leak backward into the esophagus and cause irritation.

normal, incessant crying, refusal to eat, burping, and coughing. Most babies outgrow GERD before their first birthday but a small percentage do not.

Additional Facts about GERD



Heartburn is a burning sensation that radiates throughout the chest.

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There are other causative factors of GERD that may be separate from or intertwined with obesity. The sphincter that separates the stomach's internal contents from the esophagus often does not function properly and acidic gastric contents seep upward. Sometimes the peristaltic contractions of the esophagus are also sluggish and compromise the clearance of acidic contents. In addition to having an unbalanced, high-fat diet, some people with GERD are sensitive to particular foods—chocolate, garlic, spicy foods, fried foods, and tomato-based foods—which worsen symptoms. Drinks containing alcohol or caffeine may also worsen GERD symptoms. GERD is diagnosed most often by a history of the frequency of recurring symptoms. A more proper diagnosis can be made when a doctor inserts a small device into the lower esophagus that measures the acidity of the contents during one's daily activities. Sometimes a doctor may use an endoscope, which is a long tube with a camera at the end, to view the tissue in the esophagus. About 50 percent of people with GERD have inflamed tissues in the esophagus. A condition known as Barrett's esophagus may develop over time in some people who have GERD. Barrett's esophagus refers to a structural difference in the tissue of the esophagus, which is caused by recurrent tissue damage. It occurs in 5 to 15 percent of patients diagnosed with GERD and less than 1 percent of these patients may develop cancer of the esophagus, a highly lethal cancer.

The first approach to GERD treatment is dietary and lifestyle modifications. Suggestions are to reduce weight if you are overweight or obese, avoid foods that worsen GERD symptoms, eat smaller meals, stop smoking, and remain upright for at least three hours after a meal. There is some evidence that sleeping on a bed with the head raised at least six inches helps lessen the symptoms of GERD. People with GERD may not take in the nutrients they need because of the pain and discomfort associated with eating. As a result, GERD can be caused by an unbalanced diet and its symptoms can lead to a worsening of nutrient inadequacy, a viscious cycle that further compromises health. Many medications are available to treat GERD, including antacids, histamine2 (H2) blockers, and proton-pump inhibitors. Some evidence from scientific studies indicates that medications used to treat GERD may accentuate certain nutrient deficiencies, namely zinc and magnesium. When these

treatment approaches do not work surgery is an option. The most common surgery involves reinforcing the sphincter that serves as a barrier between the stomach and esophagus.

Irritable Bowel Syndome

Irritable bowel syndrome (IBS)[29] is characterized by muscle spasms in the colon that result in abdominal pain, bloating, constipation, and/or diarrhea. Interestingly, IBS produces no permanent structural damage to the large intestine as often happens to patients who have Crohn's disease or inflammatory bowel disease. It is estimated that one in five Americans displays symptoms of IBS. The disorder is more prevalent in women than men. Two primary factors that contribute to IBS are an unbalanced diet and stress. There is no specific test to diagnose IBS, but other conditions that have similar symptoms (such as celiac disease) must be ruled out. This involves stool tests, blood tests, and having a colonoscopy (which involves the insertion of a flexible tube with a tiny camera on the end through the anus so the doctor can see the colon tissues).

Symptoms of IBS significantly decrease a person's quality of life as they are present for at least twelve consecutive or nonconsecutive weeks in a year. Large meals and foods high in fat and added sugars, or those that contain wheat, rye, barley, peppermint, and chocolate intensify or bring about symptoms of IBS. Additionally, beverages containing caffeine or alcohol may worsen IBS. Stress and depression compound the severity and frequency of IBS symptoms. As with GERD, the first treatment approaches for IBS are diet and lifestyle modifications. People with IBS are often told to keep a daily food journal to help identify and eliminate foods that cause the most problems. Other recommendations are to eat slower, add more fiber to the diet, drink more water, and to exercise. There are some medications (many of which can be purchased over-the-counter) to treat IBS and the resulting diarrhea or constipation. Sometimes antidepressants and drugs to relax the colon are prescribed.

Celiac Disease

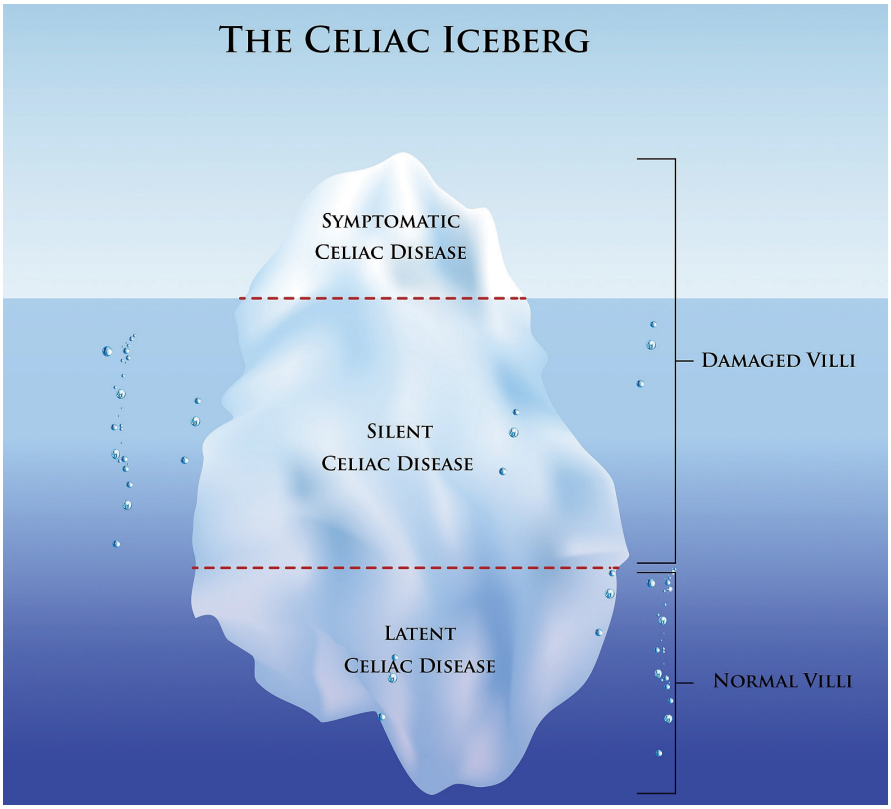
Celiac disease[30] is an autoimmune disorder affecting between 0.5 and 1.0 percent of Americans—that is, one in every one- to two-hundred people. It is caused by an abnormal immune reaction of small intestine cells to a type of protein, called gluten. Gluten forms in the presence of water and is composed of two protein parts, glutenin and gliadin. Glutenin and gliadin are found in grains that are commonly used to make bread, such as wheat, rye, and barley. When bread is made, yeast eats the flour and makes a waste product, carbon dioxide, which forms bubbles in the dough. As the dough is kneaded, gluten forms and stretches. The carbon dioxide gas bubbles infiltrate the stretchy gluten, giving bread its porosity and tenderness. For

29. A disorder characterized by muscle spasms in the colon that result in abdominal pain, bloating, constipation, and/or diarrhea. There is no permanent structural damage to the large intestine.

30. An autoimmune disorder caused by an abnormal reaction of cells in the small intestine to a type of protein, called gluten.

those who are sensitive to gluten, it is good to know that corn, millet, buckwheat, and oats do not contain the proteins that make gluten. However, some people who have celiac disease also may have a response to products containing oats. This is most likely the result of cross-contamination of grains during harvest, storage, packaging, and processing.

Figure 3.8 Celiac



Not everyone with celiac is diagnosed—many have "silent" or "latent" celiac disease.

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Celiac disease is most common in people of European descent and is rare in people of African American, Japanese, and Chinese descent. It is much more prevalent in women and in people with Type 1 diabetes, autoimmune thyroid disease, and Down and Turner syndromes. Symptoms can range from mild to severe and can include pale, fatty, loose stools, gastrointestinal upset, abdominal pain, weight loss and, in children, a failure to grow and thrive. The symptoms can appear in infancy or much later in life, even by age seventy. Celiac disease is not always diagnosed because the

symptoms may be mild. A large number of people have what is referred to as "silent" or "latent" celiac disease (Figure 3.8 "Celiac").

Celiac disease diagnosis requires a blood test and a biopsy of the small intestine. Because celiac disease is an autoimmune disease, antibodies produced by white blood cells circulate in the body and can be detected in the blood. When gluten-containing foods are consumed the antibodies attack cells lining the small intestine leading to a destruction of the small villi projections. This tissue damage can be detected with a biopsy, a procedure that removes a portion of tissue from the damaged organ. Villi destruction is what causes many of the symptoms of celiac disease. The destruction of the absorptive surface of the small intestine also results in the malabsorption of nutrients, so that while people with this disease may eat enough, nutrients do not make it to the bloodstream because absorption is reduced. The effects of nutrient malabsorption are most apparent in children and the elderly as they are especially susceptible to nutrient deficiencies. Over time these nutrient deficiencies can cause health problems. Poor absorption of iron and folic acid can cause anemia, which is a decrease in red blood cells. Anemia impairs oxygen transport to all cells in the body. Calcium and vitamin D deficiences can lead to osteoporosis, a disease in which bones become brittle (we will explore this in detail in Chapter 9 "Nutrients Important for Bone Health").

If you think you or someone close to you may have celiac disease, do not despair; it is a very treatable disease. Once diagnosed, a person follows a gluten-free diet for life. This requires dedication and careful detective work to seek out foods with hidden gluten, but some stores carry gluten-free foods. After eliminating gluten from the diet, the tissues of the small intestine rapidly repair themselves and heal in less than six months.

Food Allergies

Paying attention to the way individuals react to various foods is essential in determining what foods may specifically affect a person adversely. Food allergies are one of the many ways in which different body make-ups affect nutritional concerns. Although an estimated twelve million Americans have food allergies, there are likely many more people who say they have food allergies than actually do. This is because food sensitization is different from a medically-determined food allergy. When someone has a **food allergy**[31], the immune system mistakenly attacks a certain kind of food (usually the protein component of a food), such as peanuts, as if it were a threat and IgE antibodies are produced. Doctors sometimes test for food allergies by using skin-prick tests or blood tests to look for the presence of IgE antibodies. However, these types of tests are not always reliable as they can sometimes yield a false positive result. By far, the most valuable tests for determining a food allergy is the Double Blind Placebo Controlled Food Challenge

31. After eating certain kinds of food, the immune system reacts shortly thereafter producing symptoms such as digestive troubles, swollen airways, hives, or possible death.

(DBPCFC), which involves administering the food orally and then denoting the signs and symptoms of the allergic response.

Food allergy symptoms usually develop within a few minutes to two hours after a person has eaten a food to which they are allergic. These symptoms can range from the annoying to the potentially fatal, and include:

- A tingling mouth
- Swelling tongue and/or throat
- Difficulty breathing
- Hives
- Stomach cramps
- Diarrhea
- Vomiting
- Drop in blood pressure
- Loss of consciousness
- Death

Many people with food allergies experience skin rashes after eating an allergenic food.

© Shutterstock

There are no clear treatments for food allergies. Epinephrine is sometimes used to control severe reactions, and individuals with known and dangerous allergies may get prescriptions for self-injectable devices. The only certain way to avoid allergic reactions to food is to avoid the foods that cause them. Beyond avoidance, this can mean reading food labels carefully, or even calling manufacturers for product information.

Ninety percent of food allergies are caused by these eight foods:

1. Milk
2. Eggs
3. Peanuts
4. Tree nuts
5. Fish
6. Shellfish
7. Wheat
8. Soy

The prevalence of food allergies is a complex and growing problem. In response to this situation, the National Institute of Allergy and Infectious Diseases (NIAID) collaborated with thirty-four professional organizations, federal agencies, and patient-advocacy groups to develop a comprehensive guide to diagnosing and

managing food allergies and treating acute food allergy reactions. The guide defines various food allergies, allergens, and reactions, provides comprehensive information on the prevalence of different food allergies, tracks the history of food allergies, and reviews medical management techniques for people with food allergies.

KEY TAKEAWAYS

- Unbalanced diets can cause diseases and, conversely, certain disorders and diseases can cause an inadequate intake and absorption of nutrients simulating the health consequences of an unbalanced diet.
- Unbalanced, high-fat diets can exacerbate the symptoms of GERD and IBS.
- Celiac disease and anorexia can lead to nutritional deficiencies, which compromise functioning of the organ systems and decrease health.
- Food allergies affect roughly twelve million Americans, with symptoms that range from mild to deadly. Proper diagnosis leads to better management of food allergies and sensitivities.

DISCUSSION STARTER

1. The next time you visit the grocery store, be a "gluten detective" and use the ingredients list to identify all the foods you might normally purchase that contain gluten. Discuss how you can use food labels to avoid products containing gluten.

3.6 End-of-Chapter Exercises

IT'S YOUR TURN

1. Summarize the organization of the human body in a flow chart.
2. Determine how many calories you ate of a particular food yesterday and calculate the percent of calories that came from carbohydrates, protein, and fat.
3. Watch the video on celiac disease at http://visibleproductions.com/index.php?page=asset_detail&asset_id=vpl_0458_001 and summarize how this ailment leads to decreased nutrient absorption.

APPLY IT

1. Draw a flow chart that summarizes the steps of digestion that take place in each organ of the digestive system.
2. Calculate the calories derived from protein, fats, and carbohydrates from five different foods you often eat.

3. After watching the video on GERD, list the potential consequences of GERD.

   Understanding GERD (GERD #1)

   (click to see video)

EXPAND YOUR KNOWLEDGE

1. Find out how fat supports brain function and protects nerves by visiting the following website: http://www.fi.edu/learn/brain/fats.html. Now look at these other websites to see how too much of the wrong kind of fats may be bad for the brain, while other types of fat are good for the brain.

   http://archneur.ama-assn.org/cgi/content/full/60/2/194

   http://www.sciencedaily.com/releases/2007/12/071210163251.htm

   http://www.webmd.com/alzheimers/news/20070418/omeg-3-fatty-acid-slows-alzheimers.

   Discuss how a balanced fat intake that contains "good fats" helps optimize brain function and prevent diseases such as Alzheimer's.
2. Estimate the total number of kilocalories that you have eaten so far today. What percentage of the kilocalories you consumed was obtained from carbohydrates, protein, and fat? Compare the percentage of calories from carbohydrates, protein, and fat that you consumed to their Acceptable Macronutrient Distribution Ranges.
3. On your next trip to the grocery store, pretend you have a child with a peanut allergy and determine which foods you need to avoid purchasing to prevent your child from having an allergic response.

Chapter 4

Carbohydrates

Big Idea

Whole grains are an energy source with nutritional punch.

Video 4.1

The History of Bread

(click to see video)

Watch the History of Bread, part one, from The History Channel. To further satiate your interest go on to watch the other five parts, available on YouTube.

You likely eat grains every day—cereal, a sandwich, pasta, or your favorite rice dish. Whole grains are vital to a healthful diet. In addition to fiber, whole grains offer other slow-releasing carbohydrates, antioxidants, vitamins, and minerals, all of which are needed for good health. Maybe you are on a diet and have been told to limit or restrict your carbohydrate intake. How much is too much and which carbohydrates are better for you? Can you promote a healthy weight with a balanced intake of whole grains? Before we answer these questions, let's examine in brief the history of grain.

In ancient times whole grains were cracked open using quern stones that required hours of hand labor. As technology slowly advanced, the quern stone was modified into the millstone. It wasn't until the advent of water wheels that human labor to produce grains was reduced. About 2,500 years ago the Romans started milling flour by turning one millstone wheel against another that did not move. The turning was done by animals, slaves, and later by waterwheels. The process of milling breaks the hard outer bran coat of the wheat seeds. The bran and germ, which contain the majority of fiber, vitamins, and minerals, are removed by sifting. In the earliest days, the whitest flour was chosen to make bread for the wealthy, and the coarsest was given to the poor. One's economic status was depicted by the color of bread

they ate. Wheat was the grain of choice for many cultures, as it not only produced white flour but also contained gluten which gives wheat bread its elasticity and lightness in texture. The word “flour” comes from a French word meaning “blossom” and is metaphoric for the finest part of the meal. Bakers highly prized their art and it was kept from the masses. In fact the baker’s mark was one of the first trademarks.

The 2010 Dietary Guidelines recommend that half of all grains in your diet come from whole grains. What percentage of your diet is whole grain?

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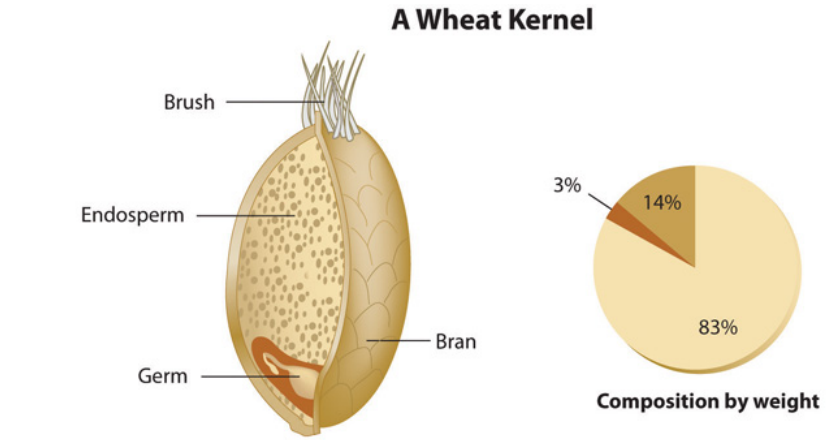
In America, Oliver Evans built the first flour mill, which was powered by a watermill. It used a series of elevators that moved grain through the mill, cleaning it first, then grinding and sifting it. Today, modern milling produces three types of flour; whole meal containing 100 percent of the grain, with nothing added or removed; brown flour, containing 85 percent of the original grain with some bran and germ and white flour, containing 75 percent of the wheat grain with the most bran and germ removed. The vast majority of flour milled and used in foods and cooking in America is white flour. The modern milling process of preparing white flour removes between 50 and 85 percent of B vitamins, vitamin E, calcium, iron, potassium, chromium, phosphorus, zinc, magnesium manganese, and cobalt.



	Carb/g	Protein/g	Fat/g	Fiber/g	Iron (% daily req.)	Others
Bran	63	16	3	43	59	vitamin Bs
Endosperm	79	7	0	4	7	
Germ	52	23	10	14	35	vitamin Bs omega-3/6 lipids

Nutritional value (per 100g)

Wheat kernel anatomy and composition.

In the early nineteenth century several diseases stemming from vitamin and mineral deficiencies, such as pellagra (niacin, B_3), beriberi (thiamine, B_1), and anemia (iron), plagued many inhabitants of the nation. One of the first public health campaigns was to improve the health of Americans by enriching flour, a dietary staple. The B vitamins, niacin, thiamine, riboflavin, and folate were added along with iron to combat dietary deficiencies and proved a successful strategy to improve public health. However, enriched flour contains only 6 percent or less of the recommended daily intake of the vitamins and minerals it "replaces." Overwhelming scientific evidence now shows that diets containing high amounts of whole grains rather than refined white flour decrease weight gain and the risk for many chronic diseases, including certain types of cancer and diabetes. Whole grains contain a whole nutrient package that is not replaced by enriched flour. Consumers are becoming more aware of the many health benefits of whole grains. However, the food industry has created a puzzle for consumers in determining if a product is made from 100 percent whole grains. "Whole wheat" does not always mean the product is made with 100 percent whole grains, and brown breads are not always healthier than white as the color may come from added caramel. The Food and Drug Administration (FDA) has provided the food industry with specifics on how to label whole-grain foods—to label it as made from 100 percent whole grains. The best

method to ensure the product is made from 100 percent whole grains is to check the ingredient list. One-hundred percent whole-grain products list whole grains or whole-wheat flour most often as the first ingredient and do not contain wheat flour, white flour, yellow corn flour, semolina flour, degerminated flour, or durum flour. In America, whole-grain choices are improving, but progress still needs to be made on reducing the added sugar content of many industrially prepared breads, assuring added fiber comes from good sources, eliminating ambiguous labels and claims on packaging, and reducing the costs of whole-grain breads, which still exceed that of white bread.

You Decide

What 100 percent whole-grain products can you include in your diet to improve health, prevent disease, and be tastefully satisfied?

As you read on, you will learn the different types of carbohydrates, their essential roles in the body, the potential health consequences and benefits of diets rich in particular carbohydrates, and the many foods available that are rich in carbohydrates as well as nutritious and satisfying. After reading this chapter, you will be better equipped to decide the best way to get your nutritional punch from various carbohydrates in your diet.

"If thou tastest a crust of bread, thou tastest all the stars and all the heavens."

- Robert Browning, English poet and playwright (May 1812–December 1889)

4.1 A Closer Look at Carbohydrates

LEARNING OBJECTIVES

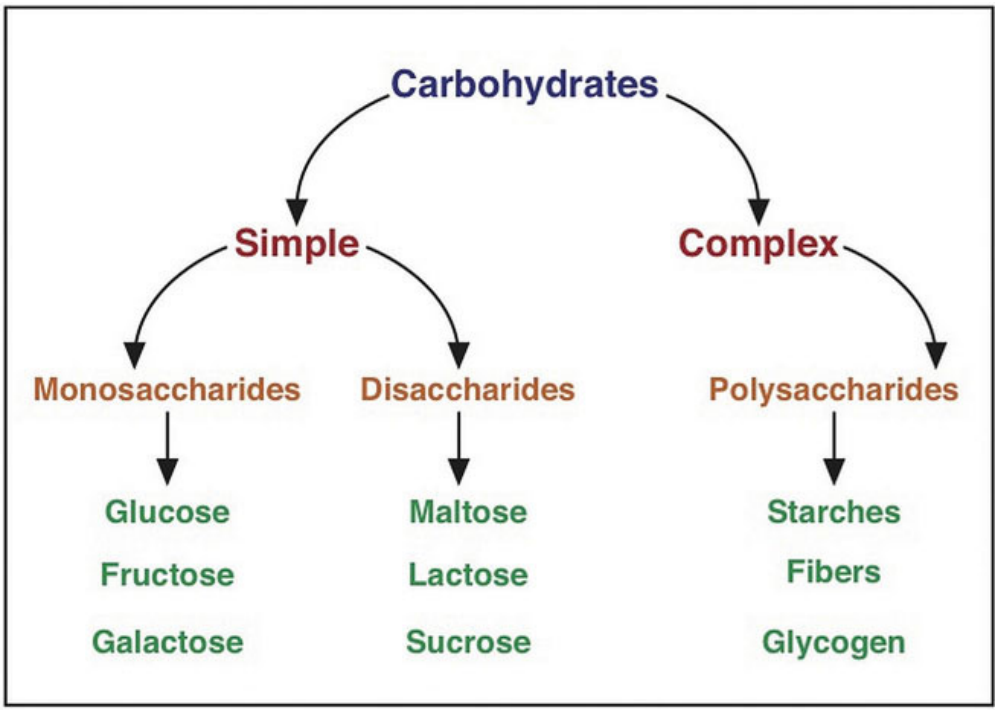
1. Describe some of the distinguishing features of carbohydrates.
2. Describe the differences between fast-releasing and slow-releasing carbohydrates.

What Exactly Are Carbohydrates and How Many Types Are There?

Carbohydrates are the perfect nutrient to meet your body's nutritional needs. They nourish your brain and nervous system, provide energy to all of your cells (and within proper caloric limits), and help keep your body fit and lean. Specifically, digestible carbohydrates provide bulk in foods, vitamins, and minerals, while indigestible carbohydrates provide a good amount of fiber with a host of other health benefits.

Plants synthesize the fast-releasing carbohydrate, glucose, from carbon dioxide in the air and water, and by harnessing the sun's energy. Recall from Chapter 3 "Nutrition and the Human Body" that plants convert the energy in sunlight to chemical energy in the molecule, glucose. Plants use glucose to make other larger, more slow-releasing carbohydrates. When we eat plants we harvest the energy of glucose to support life's processes.

Figure 4.1 Carbohydrate Classification Scheme



Carbohydrates are broken down into the subgroups "fast-releasing" and "slow-releasing" carbohydrates. These subgroups are further categorized into mono-, di-, and polysaccharides.

Carbohydrates are a group of organic compounds containing a ratio of one carbon atom to two hydrogen atoms to one oxygen atom. Basically, they are hydrated carbons. The word "carbo" means carbon and "hydrate" means water. **Glucose**[1], the most abundant carbohydrate in the human body, has six carbon atoms, twelve hydrogen atoms, and six oxygen atoms. The chemical formula for glucose is written as $C_6H_{12}O_6$. Synonymous with the term carbohydrate is the Greek word "saccharide," which means sugar. The simplest unit of a carbohydrate is a **monosaccharide**[2]. Carbohydrates are broadly classified into two subgroups, "fast-releasing" and "slow-releasing." Fast-releasing carbohydrates are further grouped into the monosaccharides and dissacharides. Slow-releasing carbohydrates are long chains of monosaccharides. (Figure 4.1 "Carbohydrate Classification Scheme").

1. The most abundant carbohydrate in the human body. It has six carbon atoms, twelve hydrogen atoms, and six oxygen atoms.
2. The simplest unit of a carbohydrate.

Fast-Releasing Carbohydrates

Fast-releasing carbohydrates are also known more simply as "sugars." Fast-releasing carbohydrates are grouped as either monosaccharides or dissacharides.

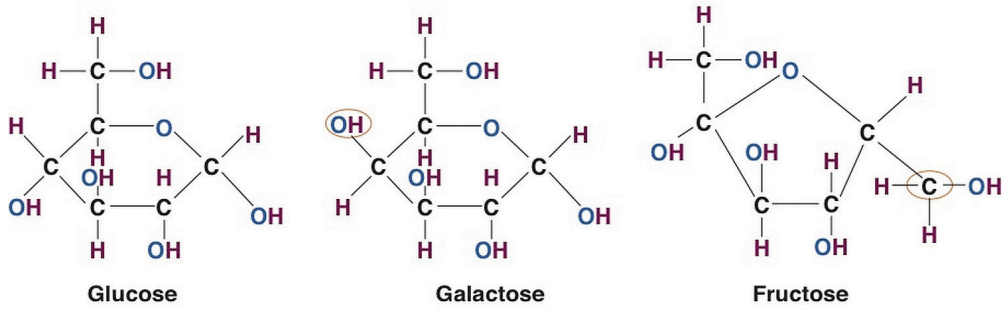
Monosaccharides include glucose, fructose, and galactose, and the dissacharides include, lactose, maltose, and sucrose.

Monosaccharides

For all organisms from bacteria to plants to animals, glucose is the preferred fuel source. The brain is completely dependent on glucose as its energy source (except during extreme starvation conditions). The monosaccharide galactose differs from glucose only in that a hydroxyl (-OH) group faces in a different direction on the number four carbon (Figure 4.2 "Structures of the Three Most Common Monosaccharides: Glucose, Galactose, and Fructose"). This small structural alteration causes galactose to be less stable than glucose. As a result, the liver rapidly converts it to glucose. Most absorbed galactose is utilized for energy production in cells after its conversion to glucose. (Galactose is one of two simple sugars that are bound together to make up the sugar found in milk. It is later freed during the digestion process.)

Fructose also has the same chemical formula as glucose but differs in its chemical structure, as the ring structure contains only five carbons and not six (Figure 4.2 "Structures of the Three Most Common Monosaccharides: Glucose, Galactose, and Fructose"). Fructose, in contrast to glucose, is not an energy source for other cells in the body. Mostly found in fruits, honey, and sugarcane, fructose is one of the most common monosaccharides in nature. It is also found in soft drinks, cereals, and other products sweetened with high fructose corn syrup.

Figure 4.2 *Structures of the Three Most Common Monosaccharides: Glucose, Galactose, and Fructose*



Red circles indicate the structural differences between the three.

Less common monosaccharides are the pentoses, which have only five carbons and not six. The pentoses are abundant in the nucleic acids RNA and DNA, and also as components of fiber.

Lastly, there are the sugar alcohols, which are industrially synthesized derivatives of monosaccharides. Some examples of sugar alcohols are sorbitol, xylitol, and glycerol. (Xylitol is similar in sweetness as table sugar.) Sugar alcohols are often used in place of table sugar to sweeten foods as they are incompletely digested and absorbed, and therefore less caloric. The bacteria in your mouth opposes them, hence sugar alcohols do not cause tooth decay. Interestingly, the sensation of "coolness" that occurs when chewing gum that contains sugar alcohols comes from them dissolving in the mouth, a chemical reaction that requires heat from the inside of the mouth.

Disaccharides

Disaccharides[3] are composed of pairs of two monosaccharides linked together. Disaccharides include sucrose, lactose, and maltose. All of the disaccharides contain at least one glucose molecule.

Sucrose, which contains both glucose and fructose molecules, is otherwise known as table sugar. Sucrose is also found in many fruits and vegetables, and at high concentrations in sugar beets and sugar cane, which are used to make table sugar. Lactose, which is commonly known as milk sugar, is composed of one glucose unit and one galactose unit. Lactose is prevalent in dairy products such as milk, yogurt, and cheese. Maltose consists of two glucose molecules bonded together. It is a common breakdown product of plant starches and is rarely found in foods as a disaccharide.

Slow-Releasing Carbohydrates

Slow-releasing carbohydrates are **polysaccharides**[4], long chains of monosaccharides that may be branched or not branched. There are two main groups of polysaccharides: starches and fibers.

Starches

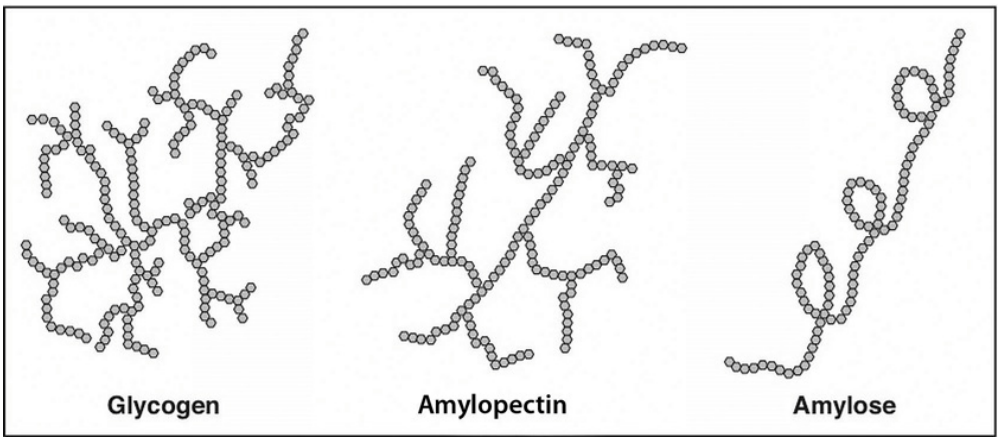
Starch molecules are found in abundance in grains, legumes, and root vegetables, such as potatoes. Amylose, a plant starch, is a linear chain containing hundreds of glucose units. Amylopectin, another plant starch, is a branched chain containing thousands of glucose units. These large starch molecules form crystals and are the energy-storing molecules of plants. These two starch molecules (amylose and

3. Two monosaccharides joined together.

4. A long chain of monosaccharides that may be branched or not branched.

amylopectine) are contained together in foods, but the smaller one, amylose, is more abundant. Eating raw foods containing starches provides very little energy as the digestive system has a hard time breaking them down. Cooking breaks down the crystal structure of starches, making them much easier to break down in the human body. The starches that remain intact throughout digestion are called resistant starches. Bacteria in the gut can break some of these down and may benefit gastrointestinal health. Isolated and modified starches are used widely in the food industry and during cooking as food thickeners.

Figure 4.3 *Structures of the Plant Starches and Glycogen*



Humans and animals store glucose energy from starches in the form of the very large molecule, **glycogen**[5]. It has many branches that allow it to break down quickly when energy is needed by cells in the body. It is predominantly found in liver and muscle tissue in animals.

Dietary Fibers

Dietary fibers[6] are polysaccharides that are highly branched and cross-linked. Some dietary fibers are pectin, gums, cellulose, and lignin. Humans do not produce the enzymes that can break down dietary fiber; however, bacteria in the large intestine (colon) do. Dietary fibers are very beneficial to our health. The Dietary Guidelines Advisory Committee states that there is enough scientific evidence to support that diets high in fiber reduce the risk for obesity and diabetes, which are primary risk factors for cardiovascular disease.US Department of Agriculture. "Part D. Section 5: Carbohydrates." In *Report of the DGAC on the* Dietary Guidelines for Americans, 2010. Accessed September 30, 2011. http://www.cnpp.usda.gov/Publications/DietaryGuidelines/2010/DGAC/Report/D-5-Carbohydrates.pdf. Dietary

5. A highly branched macromolecule consisting of thousands of glucose monomers held together by chemical bonds.

6. Polysaccharides that are highly branched and cross-linked and only found in plant-based foods, with the exception of chitin (which forms the exoskeletons of some animals).

fiber is categorized as either water-soluble or insoluble. Some examples of soluble fibers are inulin, pectin, and guar gum and they are found in peas, beans, oats, barley, and rye. Cellulose and lignin are insoluble fibers and a few dietary sources of them are whole-grain foods, flax, cauliflower, and avocados. Cellulose is the most abundant fiber in plants, making up the cell walls and providing structure. Soluble fibers are more easily accessible to bacterial enzymes in the large intestine so they can be broken down to a greater extent than insoluble fibers, but even some breakdown of cellulose and other insoluble fibers occurs.

The last class of fiber is functional fiber. Functional fibers have been added to foods and have been shown to provide health benefits to humans. Functional fibers may be extracted from plants and purified or synthetically made. An example of a functional fiber is psyllium-seed husk. Scientific studies show that consuming psyllium-seed husk reduces blood-cholesterol levels and this health claim has been approved by the FDA. Total dietary fiber intake is the sum of dietary fiber and functional fiber consumed.

KEY TAKEAWAYS

- Carbohydrates are a group of organic compounds containing a ratio of one carbon atom to two hydrogen atoms to one oxygen atom. Carbohydrates are broadly classified into two subgroups, fast-releasing and slow-releasing carbohydrates.
- Fast-releasing carbohydrates are sugars and they include the monosaccharides and disaccharides. Slow-releasing carbohydrates include the polysaccharides, amylose, amylopectin, glycogen, dietary fiber, and functional fiber.
- Glucose is the most important monosaccharide in human nutrition. Many other monosaccharides and disaccharides become glucose in the body.
- Fiber-rich foods are scientifically proven to reduce the risk of obesity and diabetes. Functional fibers are added to foods because they are proven to have added health benefits.

DISCUSSION STARTERS

1. What do you eat most of: fast-releasing carbohydrates, starches, or fiber?

2. Bring in the packages for the breads you eat and compare the different ingredients lists with your classmates. Are they labeled well? Do they contain any health claims? Are they made from 100 percent whole grain? Do they contain added sugars? For more help on defining products made with whole grains, visit the website of the Whole Grains Council.

   http://www.wholegrainscouncil.org/whole-grains-101/definition-of-whole-grains

4.2 Digestion and Absorption of Carbohydrates

LEARNING OBJECTIVE

1. Discuss how carbohydrates are digested and absorbed in the human body.

Whole grains provide satisfaction from the beginning to the end of the digestion process.

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Sweetness is one of the five basic taste sensations of foods and beverages and is sensed by protein receptors in cells of the taste buds. Fast-releasing carbohydrates stimulate the sweetness taste sensation, which is the most sensitive of all taste sensations. Even extremely low concentrations of sugars in foods will stimulate the sweetness taste sensation. Sweetness varies between the different carbohydrate types—some are much sweeter than others. Fructose is the top naturally occurring sugar in sweetness value. See Table 4.1 "Sweetness Comparison of Carbohydrates" for sweetness comparisons among different naturally-occurring carbohydrates. Sweetness is a pleasurable sensation and some people enjoy the taste more than others. In a colloquial sense we identify such people as having a "sweet tooth." This does not mean that the less-sweet whole grains containing more starches and fiber are less satisfying. Whole grains take longer to chew and get sweeter the more you chew them. Additionally, once in the stomach, whole-grain foods take longer to digest, and keep you full longer. Remember too that they contain fiber which makes elimination much smoother. Whole-grain foods satisfy the body the entire way through the digestive tract and provide the nutrients that also better satisfy the body's functional needs.

Table 4.1 Sweetness Comparison of Carbohydrates

Carbohydrate	Sweetness (percentage of sucrose)
Sucrose	100
Glucose	74
Galactose	33

Carbohydrate	Sweetness (percentage of sucrose)
Fructose	173
Maltose	33
Lactose	16
Starch	0
Fiber	0

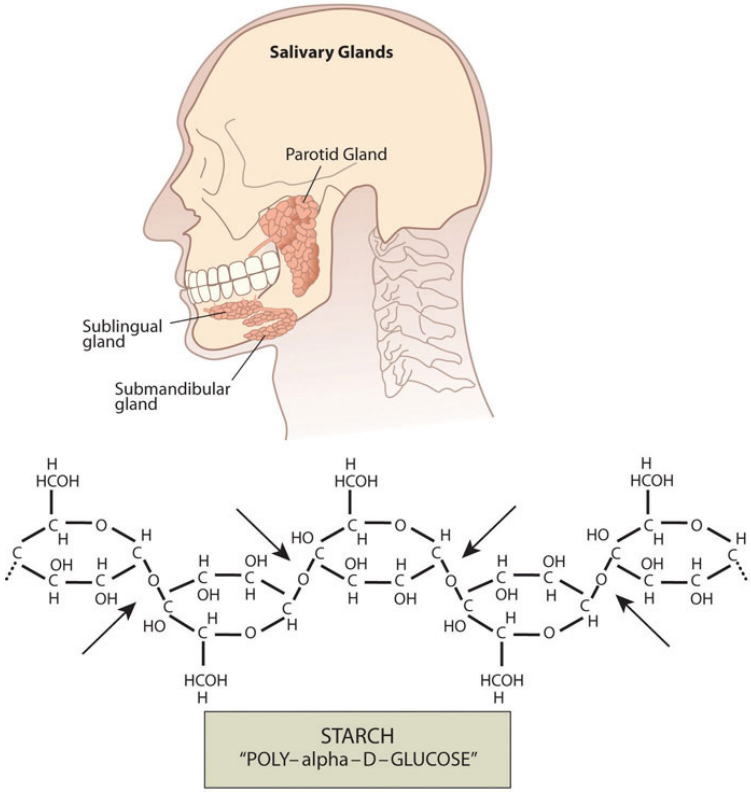
Source: Carter, J. Stein. "Carbohydrates." © 1996 by J. Stein Carter. All rights reserved. http://www.biology.clc.uc.edu/courses/bio104/carbohydrates.htm.

From the Mouth to the Stomach

The mechanical and chemical digestion of carbohydrates begins in the mouth. Chewing, also known as mastication, crumbles the carbohydrate foods into smaller and smaller pieces. The salivary glands in the oral cavity secrete saliva that coats the food particles. Saliva contains the enzyme, **salivary amylase**[7]. This enzyme breaks the bonds between the monomeric sugar units of disaccharides, **oligosaccharides**[8], and starches. The salivary amylase breaks down amylose and amylopectin into smaller chains of glucose, called dextrins and maltose. The increased concentration of maltose in the mouth that results from the mechanical and chemical breakdown of starches in whole grains is what enhances their sweetness. Only about five percent of starches are broken down in the mouth. (This is a good thing as more glucose in the mouth would lead to more tooth decay.) When carbohydrates reach the stomach no further chemical breakdown occurs because the amylase enzyme does not function in the acidic conditions of the stomach. But mechanical breakdown is ongoing—the strong peristaltic contractions of the stomach mix the carbohydrates into the more uniform mixture of chyme.

7. Enzyme secreted by the salivary glands in the mouth that breaks down carbohydrates by breaking the glycosidic bonds between monomers.

8. A carbohydrate that is a chain of a few (between three and ten) monosaccharides.



Salivary glands secrete salivary amylase, which begins the chemical breakdown of carbohydrates by breaking the bonds between monomeric sugar units.

From the Stomach to the Small Intestine

The chyme is gradually expelled into the upper part of the small intestine. Upon entry of the chyme into the small intestine, the pancreas releases pancreatic juice through a duct. This pancreatic juice contains the enzyme, **pancreatic amylase**[9], which starts again the breakdown of dextrins into shorter and shorter carbohydrate chains. Additionally, enzymes are secreted by the intestinal cells that line the villi. These enzymes, known collectively as disaccharides, are sucrase, maltase, and lactase. Sucrase breaks sucrose into glucose and fructose molecules. Maltase breaks the bond between the two glucose units of maltose, and lactase breaks the bond between galactose and glucose. Once carbohydrates are chemically broken down into single sugar units they are then transported into the inside of intestinal cells.

When people do not have enough of the enzyme lactase, lactose is not sufficiently broken down resulting in a condition called **lactose intolerance**[10]. The undigested lactose moves to the large intestine where bacteria are able to digest it. The

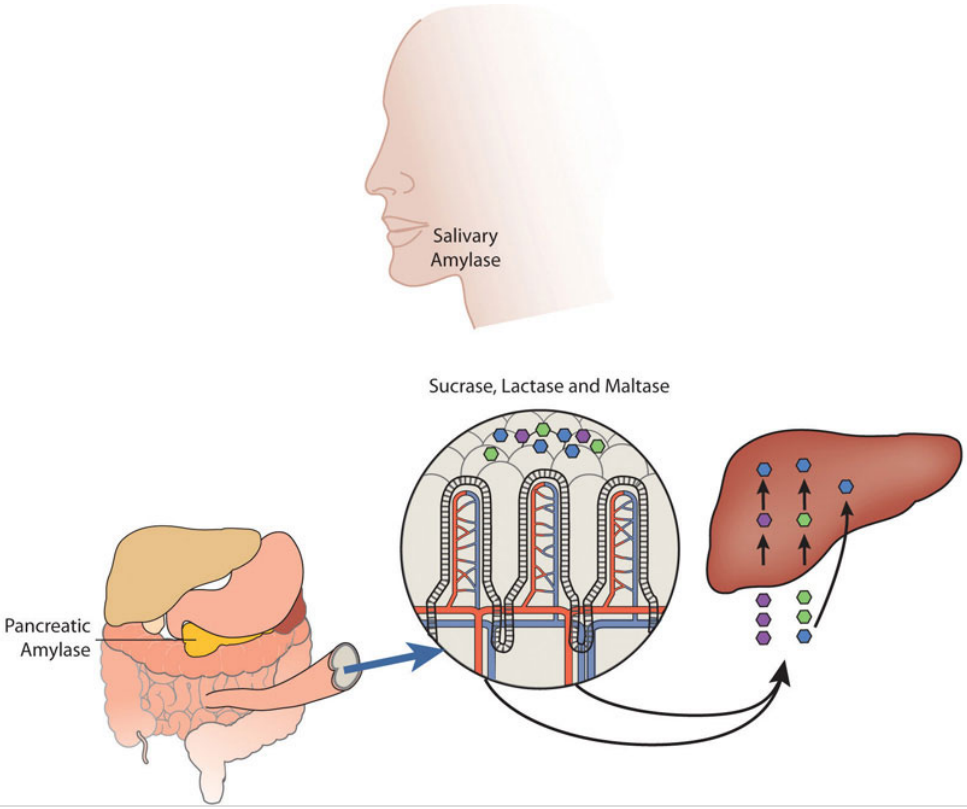
9. Enzyme secreted by the pancreas that breaks down carbohydrates in the small intestine by breaking the glycosidic bonds between monomers.

10. A condition in which there is incomplete digestion of lactose. It is caused by a deficiency in the enzyme, lactase. Symptoms include diarrhea, bloating, and abdominal cramps.

bacterial digestion of lactose produces gases leading to symptoms of diarrhea, bloating, and abdominal cramps. Lactose intolerance usually occurs in adults and is associated with race. The National Digestive Diseases Information Clearing House states that African Americans, Hispanic Americans, American Indians, and Asian Americans have much higher incidences of lactose intolerance while those of northern European descent have the least.National Digestive Diseases Information Clearing House. "Lactose Intolerance." Last updated April 23, 2012. http://digestive.niddk.nih.gov/ddiseases/pubs/lactoseintolerance/. Most people with lactose intolerance can tolerate some amount of dairy products in their diet. The severity of the symptoms depends on how much lactose is consumed and the degree of lactase deficiency.

Absorption: Going to the Blood Stream

The cells in the small intestine have membranes that contain many transport proteins in order to get the monosaccharides and other nutrients into the blood where they can be distributed to the rest of the body. The first organ to receive glucose, fructose, and galactose is the liver. The liver takes them up and converts galactose to glucose, breaks fructose into even smaller carbon-containing units, and either stores glucose as glycogen or exports it back to the blood. How much glucose the liver exports to the blood is under hormonal control and you will soon discover that even the glucose itself regulates its concentrations in the blood.



Carbohydrate digestion begins in the mouth and is most extensive in the small intestine. The resultant monosaccharides are absorbed into the bloodstream and transported to the liver.

Maintaining Blood Glucose Levels: The Pancreas and Liver

Glucose levels in the blood are tightly controlled, as having either too much or too little glucose in the blood can have health consequences. Glucose regulates its levels in the blood via a process called negative feedback. An everyday example of negative feedback is in your oven because it contains a thermostat. When you set the temperature to cook a delicious homemade noodle casserole at 375°F the thermostat senses the temperature and sends an electrical signal to turn the elements on and heat up the oven. When the temperature reaches 375°F the thermostat senses the temperature and sends a signal to turn the element off. Similarly, your body senses blood glucose levels and maintains the glucose "temperature" in the target range. The glucose thermostat is located within the cells of the pancreas. After eating a meal containing carbohydrates glucose levels rise in the blood.

Insulin-secreting cells in the pancreas sense the increase in blood glucose and release the hormonal message, insulin, into the blood. Insulin sends a signal to the body's cells to remove glucose from the blood by transporting to the insides of cells and to use it to make energy or for building macromolecules. In the case of muscle tissue and the liver, insulin sends the biological message to store glucose away as glycogen. The presence of insulin in the blood signifies to the body that it has just been fed and to use the fuel. Insulin has an opposing hormone called glucagon. As the time after a meal increases, glucose levels decrease in the blood. Glucagon-secreting cells in the pancreas sense the drop in glucose and, in response, release glucagon into the blood. Glucagon communicates to the cells in the body to stop using all the glucose. More specifically, it signals the liver to break down glycogen and release the stored glucose into the blood, so that glucose levels stay within the target range and all cells get the needed fuel to function properly.

Leftover Carbohydrates: The Large Intestine

Almost all of the carbohydrates, except for dietary fiber and resistant starches, are efficiently digested and absorbed into the body. Some of the remaining indigestible carbohydrates are broken down by enzymes released by bacteria in the large intestine. The products of bacterial digestion of these slow-releasing carbohydrates are short-chain fatty acids and some gases. The short-chain fatty acids are either used by the bacteria to make energy and grow, are eliminated in the feces, or are

absorbed into cells of the colon, with a small amount being transported to the liver. Colonic cells use the short-chain fatty acids to support some of their functions. The liver can also metabolize the short-chain fatty acids into cellular energy. The yield of energy from dietary fiber is about 2 kilocalories per gram for humans, but is highly dependent upon the fiber type, with soluble fibers and resistant starches yielding more energy than insoluble fibers. Since dietary fiber is digested much less in the gastrointestinal tract than other carbohydrate types (simple sugars, many starches) the rise in blood glucose after eating them is less, and slower. These physiological attributes of high-fiber foods (i.e. whole grains) are linked to a decrease in weight gain and reduced risk of chronic diseases, such as Type 2 diabetes and cardiovascular disease.

A Carbohydrate Feast

It's Thanksgiving and you have just consumed turkey with mashed potatoes, stuffing smothered in gravy, green beans topped with crispy fried onions, a hot roll dripping with butter, and cranberry sauce. Less than an hour later you top it all off with a slice of pumpkin pie and then lie down on the couch to watch the football game. What happens in your body after digesting and absorbing the whopping amount of nutrients in this Thanksgiving feast? The "hormone of plenty," insulin, answers the nutrient call. Insulin sends out the physiological message that glucose and everything else is in abundant supply in the blood, so cells absorb and then use or store it. The result of this hormone message is maximization of glycogen stores and all the excess glucose, protein, and lipids are stored as fat.

Thanksgiving dinner: A feast of high-carbohydrate foods.

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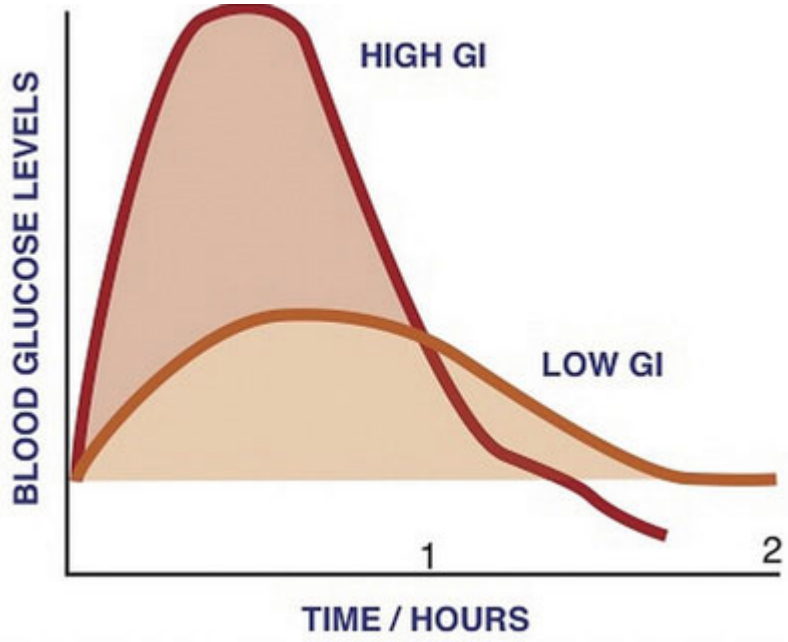
Figure 4.4



The glycemic index measures the effects of foods on blood-glucose levels.

A typical American Thanksgiving meal contains many foods that are dense in carbohydrates, with the majority of those being simple sugars and starches. These types of carbohydrate foods are rapidly digested and absorbed. Blood glucose levels rise quickly causing a spike in insulin levels. Contrastingly, foods containing high amounts of fiber are like time-release capsules of sugar. A measurement of the effects of a carbohydrate-containing food on blood-glucose levels is called the glycemic response (Figure 4.4).

Glycemic Index

The glycemic responses of various foods have been measured and then ranked in comparison to a reference food, usually a slice of white bread or just straight glucose, to create a numeric value called the **glycemic index (GI)**[11]. Foods that have a low GI do not raise blood-glucose levels neither as much nor as fast as foods that have a higher GI. A diet of low-GI foods has been shown in epidemiological and clinical trial studies to increase weight loss and reduce the risk of obesity, Type 2 diabetes, and cardiovascular disease.Brand-Miller, J., PhD, et al. "Dietary Glycemic Index: Health Implications." *J Am Coll Nutr* 28, no. 4, supplement (2009): 446S–49S. http://www.jacn.org/content/28/4_Supplement_1/446S.long.

11. A measurement of the effects of carbohydrate-containing foods on blood-glucose levels.

Table 4.2 The Glycemic Index: Foods in Comparison to Glucose

Foods	GI Value
Low GI Foods (< 55)	
Apple	44
Pear	38
Banana (under-ripe)	51
Grapefruit	25
Barley	25
Navy beans	38
Green peas	48
Oat bran (Quaker Oats)	50
Spaghetti (whole wheat)	37
Mashed sweet potatoes	54
Baked beans	48
Butter beans	44
Banana bread	47
Bread (sourdough)	52
Soy milk	31
Skim milk	32
Whole milk	27
Yogurt (sweetened)	33
Yogurt (plain, artificial sweetener)	14
Medium GI Foods (56–69)	
Apricots	57
Cantaloupe	65
Mashed potatoes	70
Whole-wheat pita bread	57
Whole-wheat bread	69
Couscous	65

Foods	GI Value
Brown rice	55
Cheese pizza	60
Rye bread	65
Hamburger bun	61
Black bean soup	64
Macaroni and cheese	64
Coca-Cola	63
High GI Foods (70 and higher)	
Dates	103
Banana (over-ripe)	82
Parsnips	97
Corn chips	72
Pretzels	83
White bread	70
White rice	72
Spaghetti (durum flour)	78
White rice (instant)	87
French baguette	95
Bagel	72
Bread stuffing	74
Cheerios	74
Cream of wheat	71
Raisin Bran	73
Fruit roll-up	99
Gatorade	78

Source: University of Sydney. Glycemic Index Database. © 2011 The University of Sydney, all rights reserved. http://www.glycemicindex.com/.

The carbohydrate type within a food affects the GI, but so does its fat and fiber content (which reduce the GI). Increased fat and fiber in foods increases the time required for digestion and delays the rate of gastric emptying into the small intestine. Processing and cooking additionally affect a food's GI by increasing their digestibility. Advancements in the technologies of food processing and the high consumer demand for convenient, precooked foods in the United States have created foods that are digested and absorbed more rapidly, independent of the fiber content. Modern breakfast cereals, breads, pastas, and many prepared foods have a high GI. In contrast, most raw foods have a lower GI. (However, the more ripened a fruit or vegetable is, the higher its GI.) Table 4.2 "The Glycemic Index: Foods in Comparison to Glucose" provides the GI for various foods. The GI can be used as a guide for choosing healthier carbohydrate choices but has some limitations. One is that the GI does not take into account the *amount* of carbohydrates in a portion of food, only the *type* of carbohydrate. Another is that combining low- and high-GI foods changes the GI for the meal. Also, some nutrient-dense foods have higher GIs than less nutritious food. (For instance, oatmeal has a higher GI than chocolate because the fat content of chocolate is higher.) Lastly, meats and fats do not have a GI since they do not contain carbohydrates.

Interactive 4.1

Visit this online database of glycemic indices of foods.

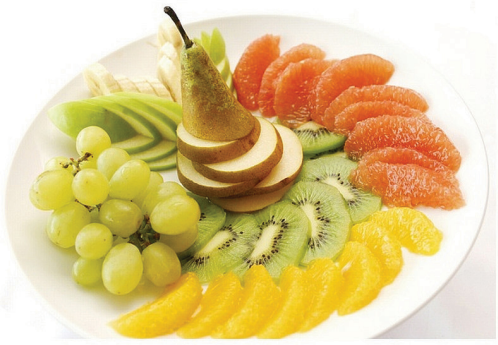
http://www.gilisting.com/

Balancing the Thanksgiving Feast

To balance the high-GI foods on the Thanksgiving table with low-GI foods, follow some of these suggestions:

- Serve a winter fruit salad.
- Leave the skins on the potatoes. The skin contains fiber and adds texture to mashed potatoes. Do not use instant potatoes.
- Instead of canned green beans with cream of mushroom soup and fried onions for a side dish, combine butter beans and green peas for a colorful, low-GI food.
- Make your stuffing with whole-grain bread and add mushrooms and extra celery and onions.

- Try a new low-sugar pumpkin pie recipe and make the crust from whole-grain flour.
- Offer homemade banana bread for dessert.



Balance the high-GI foods at the Thanksgiving table with low-GI foods.

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KEY TAKEAWAYS

- Carbohydrate digestion begins in the mouth with the mechanical action of chewing and the chemical action of salivary amylase. Carbohydrates are not chemically broken down in the stomach, but rather in the small intestine. Pancreatic amylase and the disaccharidases finish the chemical breakdown of digestible carbohydrates.
- The monosaccharides are absorbed into the bloodstream and delivered to the liver.
- Some of the indigestible carbohydrates are digested by bacteria in the large intestine.
- Glucose itself participates in regulating its levels in the blood. Not all carbohydrates have the same effect on blood-glucose levels. The glycemic response is a measurement of the effects of a carbohydrate-containing food on blood-glucose levels.

DISCUSSION STARTERS

1. Experience the taste sensations of different carbohydrates. What are some foods that satisfy your sweetness sensation?
2. Even though fiber contains calories, albeit less than half of other carbohydrates, why do we generally discount its caloric contribution from our diets?
3. How long a person feels full after eating a carbohydrate-rich meal depends on the type of carbohydrate consumed and what other nutrients are in the meal. Conduct an experiment and determine how long you feel full after eating a candy bar; after eating a slice of whole-grain bread; after eating an apple; and after eating a potato. Compare your results with your classmates and discuss why some of these carbohydrate foods make you feel full longer than others.

4.3 The Functions of Carbohydrates in the Body

LEARNING OBJECTIVE

1. List four primary functions of carbohydrates in the human body.

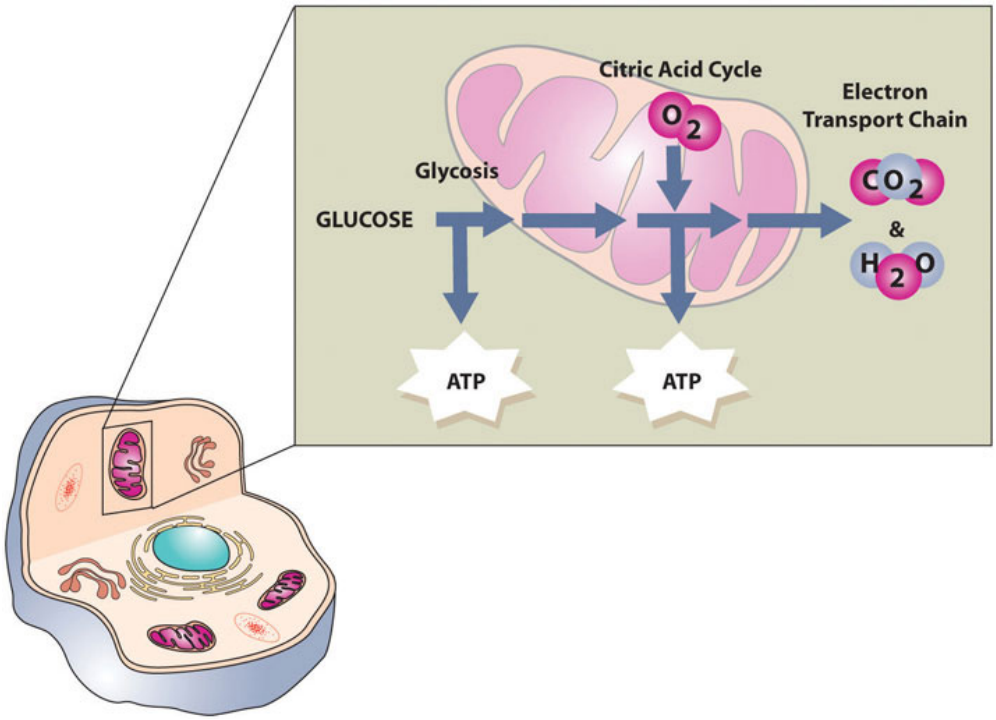
There are five primary functions of carbohydrates in the human body. They are energy production, energy storage, building macromolecules, sparing protein, and assisting in lipid metabolism.

Energy Production

The primary role of carbohydrates is to supply energy to all cells in the body. Many cells prefer glucose as a source of energy versus other compounds like fatty acids. Some cells, such as red blood cells, are only able to produce cellular energy from glucose. The brain is also highly sensitive to low blood-glucose levels because it uses *only* glucose to produce energy and function (unless under extreme starvation conditions). About 70 percent of the glucose entering the body from digestion is redistributed (by the liver) back into the blood for use by other tissues. Cells that require energy remove the glucose from the blood with a transport protein in their membranes. The energy from glucose comes from the chemical bonds between the carbon atoms. Sunlight energy was required to produce these high-energy bonds in the process of photosynthesis. Cells in our bodies break these bonds and capture the energy to perform cellular respiration. Cellular respiration is basically a controlled burning of glucose versus an uncontrolled burning. A cell uses many chemical reactions in multiple enzymatic steps to slow the release of energy (no explosion) and more efficiently capture the energy held within the chemical bonds in glucose.

The first stage in the breakdown of glucose is called glycolysis. **Glycolysis**[12], or the splitting of glucose, occurs in an intricate series of ten enzymatic-reaction steps. The second stage of glucose breakdown occurs in the energy factory organelles, called mitochondria. One carbon atom and two oxygen atoms are removed, yielding more energy. The energy from these carbon bonds is carried to another area of the mitochondria, making the cellular energy available in a form cells can use.

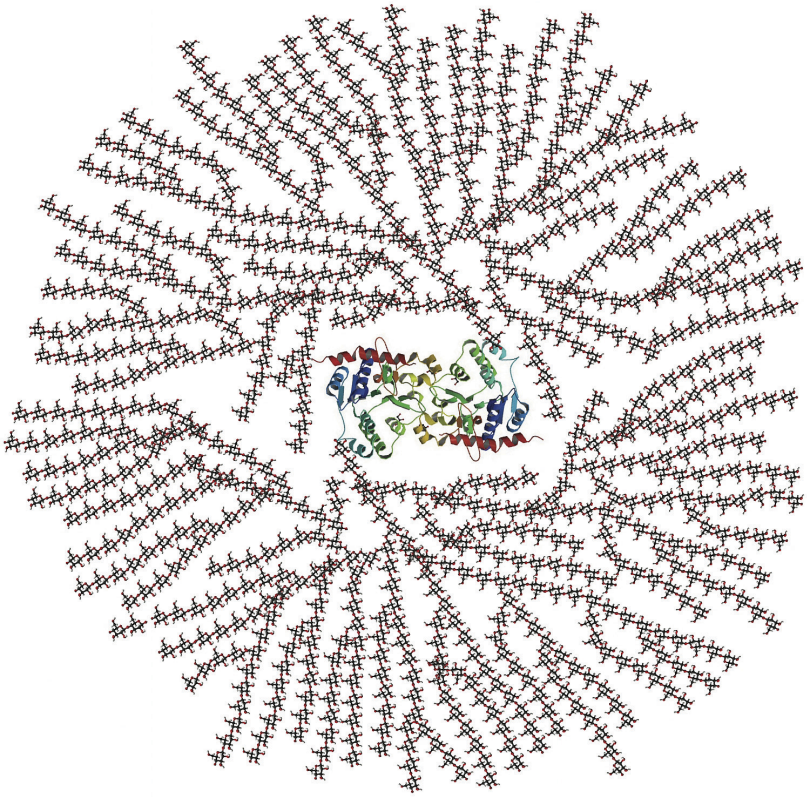
12. The first stage of glucose breakdown; a ten-step enzymatic process that splits glucose into two three-carbon molecules and yields two molecules of ATP.



Cellular respiration is the process by which energy is captured from glucose.

Energy Storage

Figure 4.5



The structure of glycogen enables its rapid mobilization into free glucose to power cells.

If the body already has enough energy to support its functions, the excess glucose is stored as glycogen (the majority of which is stored in the muscle and liver). A molecule of glycogen may contain in excess of fifty thousand single glucose units and is highly branched, allowing for the rapid dissemination of glucose when it is needed to make cellular energy (Figure 4.5).

The amount of glycogen in the body at any one time is equivalent to about 4,000 kilocalories—3,000 in muscle tissue and 1,000 in the liver. Prolonged muscle use (such as exercise for longer than a few hours) can deplete the glycogen energy reserve. Remember also from Chapter 3 "Nutrition and the Human Body" that this is referred to as “hitting the wall” or “bonking” and is characterized by fatigue and a decrease in exercise performance. The weakening of muscles sets in because it takes longer to transform the chemical energy in fatty acids and proteins to usable energy than glucose. After prolonged exercise, glycogen is gone and muscles must

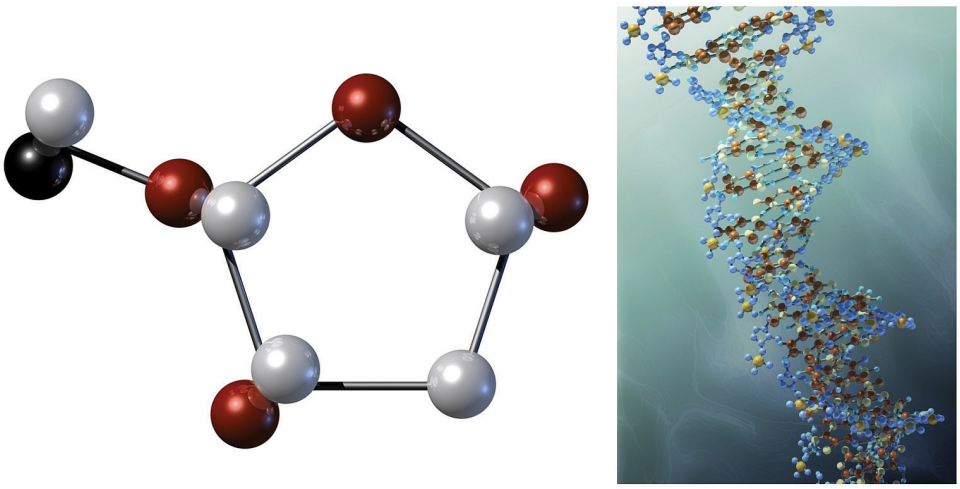
rely more on lipids and proteins as an energy source. Athletes can increase their glycogen reserve modestly by reducing training intensity and increasing their carbohydrate intake to between 60 and 70 percent of total calories three to five days prior to an event. People who are not hardcore training and choose to run a 5-kilometer race for fun do not need to consume a big plate of pasta prior to a race since without long-term intense training the adaptation of increased muscle glycogen will not happen.

The liver, like muscle, can store glucose energy as a glycogen, but in contrast to muscle tissue it will sacrifice its stored glucose energy to other tissues in the body when blood glucose is low. Approximately one-quarter of total body glycogen content is in the liver (which is equivalent to about a four-hour supply of glucose) but this is highly dependent on activity level. The liver uses this glycogen reserve as a way to keep blood-glucose levels within a narrow range between meal times. When the liver's glycogen supply is exhausted, glucose is made from amino acids obtained from the destruction of proteins in order to maintain metabolic homeostasis.

Building Macromolecules

Although most absorbed glucose is used to make energy, some glucose is converted to ribose and deoxyribose, which are essential building blocks of important macromolecules, such as RNA, DNA, and ATP (Figure 4.6). Glucose is additionally utilized to make the molecule NADPH, which is important for protection against oxidative stress and is used in many other chemical reactions in the body. If all of the energy, glycogen-storing capacity, and building needs of the body are met, excess glucose can be used to make fat. This is why a diet too high in carbohydrates and calories can add on the fat pounds—a topic that will be discussed shortly.

Figure 4.6



The sugar molecule deoxyribose is used to build the backbone of DNA.

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Sparing Protein

In a situation where there is not enough glucose to meet the body's needs, glucose is synthesized from amino acids. Because there is no storage molecule of amino acids, this process requires the destruction of proteins, primarily from muscle tissue. The presence of adequate glucose basically spares the breakdown of proteins from being used to make glucose needed by the body.

Lipid Metabolism

As blood-glucose levels rise, the use of lipids as an energy source is inhibited. Thus, glucose additionally has a "fat-sparing" effect. This is because an increase in blood glucose stimulates release of the hormone insulin, which tells cells to use glucose (instead of lipids) to make energy. Adequate glucose levels in the blood also prevent the development of ketosis. Ketosis is a metabolic condition resulting from an elevation of ketone bodies in the blood. Ketone bodies are an alternative energy source that cells can use when glucose supply is insufficient, such as during fasting. Ketone bodies are acidic and high elevations in the blood can cause it to become too acidic. This is rare in healthy adults, but can occur in alcoholics, people who are malnourished, and in individuals who have Type 1 diabetes. The minimum amount of carbohydrate in the diet required to inhibit ketosis in adults is 50 grams per day.

Carbohydrates are critical to support life's most basic function—the production of energy. Without energy none of the other life processes are performed. Although our bodies can synthesize glucose it comes at the cost of protein destruction. As with all nutrients though, carbohydrates are to be consumed in moderation as having too much or too little in the diet may lead to health problems.

KEY TAKEAWAYS

- The four primary functions of carbohydrates in the body are to provide energy, store energy, build macromolecules, and spare protein and fat for other uses.
- Glucose energy is stored as glycogen, with the majority of it in the muscle and liver. The liver uses its glycogen reserve as a way to keep blood-glucose levels within a narrow range between meal times. Some glucose is also used as building blocks of important macromolecules, such as RNA, DNA, and ATP.
- The presence of adequate glucose in the body spares the breakdown of proteins from being used to make glucose needed by the body.

DISCUSSION STARTERS

1. Discuss two reasons it is essential to include carbohydrates in your diet.
2. Why is it necessary for the body to spare protein?

4.4 Looking Closely at Diabetes

LEARNING OBJECTIVE

1. Summarize the long-term health implications and the dietary approaches to living with Type 1 and Type 2 diabetes.

What Is Diabetes?

Diabetes is one of the top three diseases in America. It affects millions of people and causes tens of thousands of deaths each year. Diabetes is a metabolic disease of insulin deficiency and glucose over-sufficiency. Like other diseases, genetics, nutrition, environment, and lifestyle are all involved in determining a person's risk for developing diabetes. One sure way to decrease your chances of getting diabetes is to maintain an optimal body weight by adhering to a diet that is balanced in carbohydrate, fat, and protein intake. There are three different types of diabetes: Type 1 diabetes, Type 2 diabetes, and gestational diabetes.

Type 1 Diabetes

Type 1 diabetes[13] is a metabolic disease in which insulin-secreting cells in the pancreas are killed by an abnormal response of the immune system, causing a lack of insulin in the body. Its onset typically occurs before the age of thirty. The only way to prevent the deadly symptoms of this disease is to inject insulin under the skin. Before this treatment was discovered, people with Type 1 diabetes died rapidly after disease onset. Death was the result of extremely high blood-glucose levels affecting brain function and leading to coma and death. Up until 1921, patients with Type 1 diabetes, the majority of them children, spent their last days in a ward where they lapsed into a coma awaiting death. One of the most inspiring acts in medical history is that of the scientists who discovered, isolated, and purified insulin and then went on to find out that it relieved the symptoms of Type 1 diabetes, first in dogs and then in humans. Frederick Banting, Charles Best, and James Collip went into a hospital ward in Toronto, Canada and injected comatose children with insulin. Before they completed their rounds children were already awakening to the cheers of their families.

13. A metabolic disease in which cells in the pancreas are killed by an abnormal response of the immune system, causing a lack of insulin in the body.

A person with Type 1 diabetes usually has a rapid onset of symptoms that include hunger, excessive thirst and urination, and rapid weight loss. Because the main function of glucose is to provide energy for the body, when insulin is no longer

present there is no message sent to cells to take up glucose from the blood. Instead, cells use fat and proteins to make energy, resulting in weight loss. If Type 1 diabetes goes untreated individuals with the disease will develop a life-threatening condition called ketoacidosis. This condition occurs when the body uses fats and not glucose to make energy, resulting in a build-up of ketone bodies in the blood. It is a severe form of ketosis with symptoms of vomiting, dehydration, rapid breathing, and confusion and eventually coma and death. Upon insulin injection these severe symptoms are treated and death is avoided. Unfortunately, while insulin injection prevents death, it is not considered a cure. People who have this disease must adhere to a strict diet to prevent the development of serious complications. Type 1 diabetics are advised to consume a diet low in the types of carbohydrates that rapidly spike glucose levels (high-GI foods), to count the carbohydrates they eat, to consume healthy-carbohydrate foods, and to eat small meals frequently. These guidelines are aimed at preventing large fluctuations in blood glucose. Frequent exercise also helps manage blood-glucose levels. Type 1 diabetes accounts for between 5 and 10 percent of diabetes cases.

Type 2 Diabetes

The other 90 to 95 percent of diabetes cases are Type 2 diabetes. **Type 2 diabetes**[14] is defined as a metabolic disease of insulin insufficiency, but it is also caused by muscle, liver, and fat cells no longer responding to the insulin in the body (Figure 4.7). In brief, cells in the body have become resistant to insulin and no longer receive the full physiological message of insulin to take up glucose from the blood. Thus, similar to patients with Type 1 diabetes, those with Type 2 diabetes also have high blood-glucose levels.

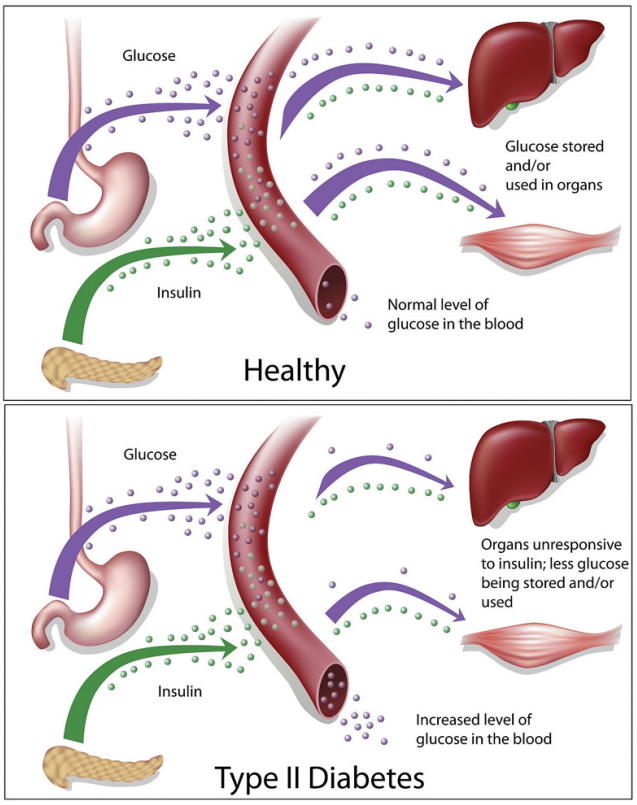
For Type 2 diabetics, the onset of symptoms is more gradual and less noticeable than for Type 1 diabetics. The symptoms are increased thirst and urination, unexplained weight loss, and hunger. The first stage of Type 2 diabetes is characterized by high glucose and insulin levels. This is because the insulin-secreting cells in the pancreas attempt to compensate for insulin resistance by making more insulin. In the second stage of Type 2 diabetes, the insulin-secreting cells in the pancreas become exhausted and die. At this point, Type 2 diabetics also have to be treated with insulin injections. Healthcare providers is to prevent the second stage from happening. As with Type 1 diabetes, chronically high-glucose levels cause big detriments to health over time, so another goal for patients with Type 2 diabetes is to properly manage their blood-glucose levels. The front-line approach for treating Type 2 diabetes includes eating a healthy diet and increasing physical activity.

14. A metabolic disease of insulin insufficiency; also caused by muscle, liver, and fat cells no longer responding to the insulin in the body.

The Centers for Disease Control Prevention (CDC) estimates that as of 2010, 25.8 million Americans have diabetes, which is 8.3 percent of the population.Centers for

Disease Control and Prevention. “Diabetes Research and Statistics.” Accessed September 30, 2011. http://www.cdc.gov/diabetes/consumer/research.htm. In 2007 the cost of diabetes to the United States was estimated at $174 billion.Centers for Disease Control and Prevention. “CDC Statements on Diabetes Issues.” Accessed September 30, 2011. http://www.cdc.gov/diabetes/news/docs/dpp.htm. The incidence of Type 2 diabetes has more than doubled in America in the past thirty years and the rise is partly attributed to the increase in obesity in this country. Genetics, environment, nutrition, and lifestyle all play a role in determining a person’s risk for Type 2 diabetes. We learned in Chapter 1 "Nutrition and You" that we have the power to change some of the determinants of disease but not others. The Diabetes Prevention Trial that studied lifestyle and drug interventions in more than three thousand participants who were at high risk for Type 2 diabetes found that intensive lifestyle intervention reduced the chances of getting Type 2 diabetes by 58 percent.Knowler, W. C. et al. “Reduction in the Incidence of Type 2 Diabetes with Lifestyle Intervention or Metformin.” N Engl J Med 346, no. 6 (2002): 393–403. http://www.nejm.org/doi/full/10.1056/NEJMoa012512.

Figure 4.7



Type 2 diabetes is a metabolic disease characterized by high blood-glucose levels.

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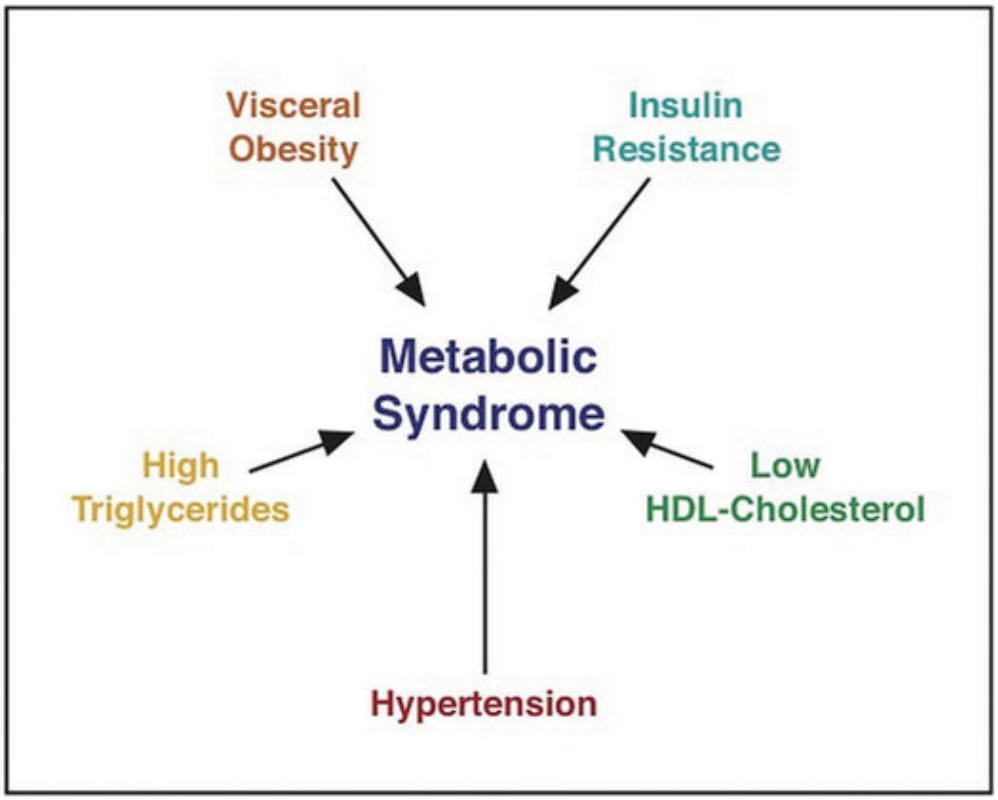
Video 4.2

Do You Have High Blood Sugar?

(click to see video)

A more in-depth view of blood sugar and your health.

Figure 4.8 *Metabolic Syndrome: A Combination of Risk Factors Increasing the Chances for Chronic Disease*



Having more than one risk factor for Type 2 diabetes substantially increases a person's chances for developing the disease. **Metabolic syndrome**[15] refers to a medical condition in which people have three or more risk factors for Type 2 diabetes and cardiovascular disease (Figure 4.8 "Metabolic Syndrome: A Combination of Risk Factors Increasing the Chances for Chronic Disease"). According to the International Diabetes Federation (IDF) people are diagnosed with

15. A medical condition in which people have three or more risk factors for Type 2 diabetes and cardiovascular disease.

this syndrome if they have central (abdominal) obesity and any two of the following health parameters: triglycerides greater than 150 mg/dL; high density lipoproteins (HDL) lower than 40 mg/dL; systolic blood pressure above 100 mmHg, or diastolic above 85 mmHg; fasting blood-glucose levels greater than 100 mg/dL.International Diabetes Federation. "The IDF Consensus Worldwide Definition of the Metabolic Syndrome." Accessed September 30, 2011. http://www.idf.org/webdata/docs/IDF_Meta_def_final.pdf. The IDF estimates that between 20 and 25 percent of adults worldwide have metabolic syndrome. Studies vary, but people with metabolic syndrome have between a 9 and 30 times greater chance for developing Type 2 diabetes than those who do not have the syndrome.International Diabetes Federation. "The IDF Consensus Worldwide Definition of the Metabolic Syndrome." Accessed September 30, 2011. http://www.idf.org/webdata/docs/IDF_Meta_def_final.pdf.

Gestational Diabetes

During pregnancy some women develop **gestational diabetes**[16]. Gestational diabetes is characterized by high blood-glucose levels and insulin resistance. The exact cause is not known but does involve the effects of pregnancy hormones on how cells respond to insulin. Gestational diabetes can cause pregnancy complications and it is common practice for healthcare practitioners to screen pregnant women for this metabolic disorder. The disorder normally ceases when the pregnancy is over, but the National Diabetes Information Clearing House notes that women who had gestational diabetes have between a 40 and 60 percent likelihood of developing Type 2 diabetes within the next ten years.National Diabetes Information Clearing House. "Diabetes Overview." Accessed September 30, 2011. http://diabetes.niddk.nih.gov/dm/pubs/overview/. Gestational diabetes not only affects the health of a pregnant woman but also is associated with an increased risk of obesity and Type 2 diabetes in her child.

Prediabetes

As the term infers, **prediabetes**[17] is a metabolic condition in which people have moderately high glucose levels, but do not meet the criteria for diagnosis as a diabetic. Over seventy-nine million Americans are prediabetic and at increased risk for Type 2 diabetes and cardiovascular disease.National Diabetes Information Clearing House. "Diabetes Overview." Accessed September 30, 2011. http://diabetes.niddk.nih.gov/dm/pubs/overview/. The National Diabetes Information Clearing House reports that 35 percent of adults aged twenty and older, and 50 percent of those over the age of sixty-five have prediabetes.National Diabetes Information Clearing House. "Diabetes Overview." Accessed September 30, 2011. http://diabetes.niddk.nih.gov/dm/pubs/overview/.

16. A metabolic condition similar to Type 2 diabetes that occurs in some pregnant women.

17. A metabolic condition in which people have moderately high glucose levels, but do not meet the criteria for diagnosis as a diabetic.

Long-Term Health Consequences of Diabetes

The long-term health consequences of diabetes are severe. They are the result of chronically high glucose concentrations in the blood accompanied by other metabolic abnormalities such as high blood-lipid levels. People with diabetes are between two and four times more likely to die from cardiovascular disease. Diabetes is the number one cause of new cases of blindness, lower-limb amputations, and kidney failure. Many people with diabetes develop peripheral neuropathy, characterized by muscle weakness, loss of feeling and pain in the lower extremities. More recently, there is scientific evidence to suggest people with diabetes are also at increased risk for Alzheimer's disease.

Video 4.3

Diabetes and Associated Complications

(click to see video)

Watch this video to learn more about the whole-body complications associated with diabetes.

Diabetes Treatment

Keeping blood-glucose levels in the target range (70–130 mg/dL before a meal) requires careful monitoring of blood-glucose levels with a blood-glucose meter, strict adherence to a healthy diet, and increased physical activity. Type 1 diabetics begin insulin injections as soon as they are diagnosed. Type 2 diabetics may require oral medications and insulin injections to maintain blood-glucose levels in the target range. The symptoms of high blood glucose, also called hyperglycemia, are difficult to recognize, diminish in the course of diabetes, and are mostly not apparent until levels become very high. The symptoms are increased thirst and frequent urination. Having too low blood glucose levels, known as hypoglycemia, is also detrimental to health. Hypoglycemia is more common in Type 1 diabetics and is most often caused by injecting too much insulin or injecting it at the wrong time. The symptoms of hypoglycemia are more acute including shakiness, sweating, nausea, hunger, clamminess, fatigue, confusion, irritability, stupor, seizures, and coma. Hypoglycemia can be rapidly and simply treated by eating foods containing about ten to twenty grams of fast-releasing carbohydrates. If symptoms are severe a person is either treated by emergency care providers with an intravenous solution of glucose or given an injection of glucagon, which mobilizes glucose from glycogen in the liver. Some people who are not diabetic may experience reactive hypoglycemia. This is a condition in which people are sensitive to the intake of sugars, refined starches, and high GI foods. Inviduals with reactive hypoglycemia have some symptoms of hypoglycemia. Symptoms are caused by a higher than

normal increase in blood-insulin levels. This rapidly decreases blood-glucose levels to a level below what is required for proper brain function.

The major determinants of Type 2 diabetes that can be changed are overnutrition and a sedentary lifestyle. Therefore, reversing or improving these factors by lifestyle interventions markedly improve the overall health of Type 2 diabetics and lower blood-glucose levels. In fact it has been shown that when people are overweight, losing as little as nine pounds (four kilograms) decreases blood-glucose levels in Type 2 diabetics. The Diabetes Prevention Trial demonstrated that by adhering to a diet containing between 1,200 and 1,800 kilocalories per day with a dietary fat intake goal of less than 25 percent and increasing physical activity to at least 150 minutes per week, people at high risk for Type 2 diabetes achieved a weight loss of 7 percent and significantly decreased their chances of developing Type 2 diabetes.Knowler, W. C. et al. “Reduction in the Incidence of Type 2 Diabetes with Lifestyle Intervention or Metformin.” N Engl J Med 346, no. 6 (2002): 393–403. http://www.nejm.org/doi/full/10.1056/NEJMoa012512.

The American Diabetes Association (ADA) has a website that provides information and tips for helping diabetics answer the question, “What Can I Eat” (see Note 4.34 "Interactive 4.2"). In regard to carbohydrates the ADA recommends diabetics keep track of the carbohydrates they eat and set a limit. These dietary practices will help keep blood-glucose levels in the target range.

Interactive 4.2

The ADA has a website containing great information and tips on how to eat a healthy diet that helps keep blood-glucose levels in the target range. Visit it to learn more on how to prevent serious complications of this disease.

http://www.diabetes.org/food-and-fitness/food/what-can-i-eat/?utm_source=WWW&utm_medium=DropDownFF&utm_content=WhatCanIEat&utm_campaign=CON

An unfortunate problem is that most diabetics do not adhere to the lifestyle interventions long-term. This is partly because of individual disinclination, but is also because health insurance companies do not provide continued financial support for dietary guidance and because primary care physicians do not prescribe dietary guidance from a dietitian. This shifts the way diabetes is treated away from

lifestyle intervention toward medications, as the goal still remains to manage blood-glucose levels. Numerous oral medications are available on the market and are often prescribed to Type 2 diabetics in combination.

KEY TAKEAWAYS

- Diabetes is a disease of insulin deficiency and glucose oversufficiency. Like other diseases, genetics, nutrition, environment, and lifestyle are all involved in determining a person's risk for developing diabetes.
- Type 1 diabetes was once a death sentence, but now can be treated with insulin injections. However, insulin injections do not cure the disease, and diabetics can suffer many disease complications. Diabetes complications can be relieved by strictly managing blood-glucose levels, adhering to a healthy diet, and increasing physical activity.
- The incidence of Type 2 diabetes has more than doubled in America in the past thirty years and the rise is partly attributed to the increase in obesity. The front-line approach for treating Type 2 diabetes includes eating a healthy diet and increasing physical activity.
- The long-term health consequences of diabetes are severe. They are the result of chronically high glucose concentrations in the blood and other metabolic abnormalities such as high blood-lipid levels.

DISCUSSION STARTERS

1. If you owned a grocery store what are some practices you could introduce to combat the epidemic of Type 2 diabetes in this country?
2. What are some options for you to intervene in your lifestyle and decrease your risk for Type 2 diabetes?

4.5 Health Consequences and Benefits of High-Carbohydrate Diets

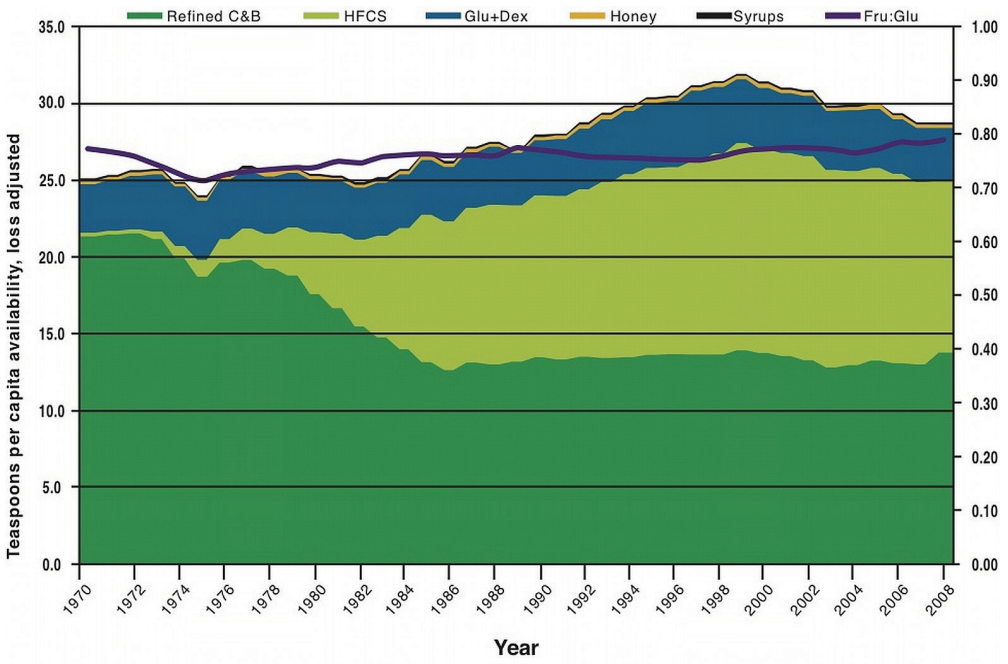
LEARNING OBJECTIVE

1. Identify the health benefits of eating a diet rich in whole grains.

Can America blame its obesity epidemic on the higher consumption of added sugars and refined grains? This is a hotly debated topic by both the scientific community and the general public. In this section, we will give a brief overview of the scientific evidence.

Added Sugars

Figure 4.9 *Sugar Consumption (in Teaspoons) from Various Sources*



The Food and Nutrition Board of the Institute of Medicine (IOM) defines **added sugars**[18] as "sugars and syrups that are added to foods during processing or preparation." The IOM goes on to state, "Major sources of added sugars include soft drinks, sports drinks, cakes, cookies, pies, fruitades, fruit punch, dairy desserts, and

18. Sugars and syrups that are added to foods during processing or preparation.

candy." Processed foods, even microwaveable dinners, also contain added sugars. Added sugars do not include sugars that occur naturally in whole foods (such as an apple), but do include natural sugars such as brown sugar, corn syrup, dextrose, fructose, fruit juice concentrates, maple syrup, sucrose, and raw sugar that are then added to create other foods (such as cookies). Currently, nutrition labels do not distinguish between added and naturally occurring sugars and give only the total sugar content, making it difficult for consumers to determine their consumption of added sugars. Results from a survey of forty-two thousand Americans reports that in 2008 the average intake of added sugars is 15 percent of total calories, a drop from 18 percent of total calories in 2000.Welsh J. A. et al. "Consumption of Added Sugars Is Decreasing in the United States." *Am J Clin Nutr* 94, no. 3 (2011): 726–34. http://www.ncbi.nlm.nih.gov/pubmed/21753067. This is still above the recommended intake of less than 10 percent of total calories. The US Department of Agriculture (USDA) reports that sugar consumption in the American diet in 2008 was, on average, 28 teaspoons per day (Figure 4.9 "Sugar Consumption (in Teaspoons) from Various Sources").

Obesity, Diabetes, and Heart Disease and Their Hypothesized Link to Excessive Sugar and Refined Carbohydrate Consumption

To understand the magnitude of the health problem in the United States consider this—in the United States approximately 130 million adults are overweight, and 30 percent of them are considered obese. The obesity epidemic has reached young adults and children and will markedly affect the prevalence of serious health consequences in adulthood. Health consequences linked to being overweight or obese include Type 2 diabetes, cardiovascular disease, arthritis, depression, and some cancers. An infatuation with sugary foods and refined grains likely contributes to the epidemic proportion of people who are overweight or obese in this country, but so do the consumption of high-calorie foods that contain too much saturated fat and the sedentary lifestyle of most Americans. There is much disagreement over whether high-carbohydrate diets increase weight-gain and disease risk, especially when calories are not significantly higher between compared diets. Many scientific studies demonstrate positive correlations between diets high in added sugars with weight gain and disease risk, but some others do not show a significant relationship. In regard to refined grains, there are no studies that show consumption of refined grains increases weight gain or disease risk. What is clear, however, is that getting more of your carbohydrates from dietary sources containing whole grains instead of refined grains stimulates weight loss and reduces disease risk.

A major source of added sugars in the American diet is soft drinks. There is consistent scientific evidence that consuming sugary soft drinks increases weight gain and disease risk. An analysis of over thirty studies in the *American Journal of*

Clinical Nutrition concluded that there is much evidence to indicate higher consumption of sugar-sweetened beverages is linked with weight gain and obesity.Malik, V. S., M. B. Schulze, and F. B. Hu. "Intake of Sugar-Sweetened Beverages and Weight Gain: A Systematic Review." *Am J Clin Nutr* 84, no. 2 (2006): 274–88. http://www.ajcn.org/content/84/2/274.long. A study at the Harvard School of Public Health linked the consumption of sugary soft drinks to an increased risk for heart disease.Harvard School of Public Health. "Public HealthTakes Aim at Sugar and Salt." Accessed September 30, 2011. http://www.hsph.harvard.edu/news/hphr/fall-2009/sugar-and-salt.html. While the sugar and refined grains and weight debate rages on, the results of all of these studies has led some public health organizations like the American Heart Association (AHA) to recommend even a lower intake of sugar per day (fewer than 9 teaspoons per day for men and fewer than 6 teaspoons for women) than what used to be deemed acceptable. After its 2010 scientific conference on added sugars, the AHA made the following related dietary recommendations:

- First, know the number of total calories you should eat each day.
- Consume an overall healthy diet and get the most nutrients for the calories, using foods high in added sugars as discretionary calories (those left over after getting all recommended nutrients subtracted from the calories used).
- Lower sugar intake, especially when the sugars in foods are not tied to positive nutrients such as in sugary drinks, candies, cakes, and cookies.
- Focus on calories in certain food categories such as beverages and confections, and encourage consumption of positive nutrients and foods such as cereals and low-fat or fat-free dairy products.Van Horn, L. et al. "Added Sugars and Health." Research reviewed at the AHA Added Sugars Conference, 2010. *Circulation* 122 (2010): 2470–90. doi: 10.1161/CIR.0b013e3181ffdcb0.

The Most Notorious Sugar

Before high-fructose corn syrup (HCFS) was marketed as the best food and beverage sweetener, sucrose (table sugar) was the number-one sweetener in America. (Recall that sucrose, or table sugar, is a disaccharide consisting of one glucose unit and one fructose unit.) HFCS also contains the simple sugars fructose and glucose, but with fructose at a slightly higher concentration. In the production of HFCS, corn starch is broken down to glucose and fructose, and some of the glucose is then converted to fructose. Fructose is sweeter than glucose; hence many food manufacturers choose to sweeten foods with HFCS. HFCS is used as a sweetener for carbonated beverages, condiments, cereals, and a great variety of other processed foods.

Some scientists, public health personnel, and healthcare providers believe that fructose is the cause of the obesity epidemic and its associated health consequences. The majority of their evidence stems from the observation that since the early 1970s the number of overweight or obese Americans has dramatically increased and so has the consumption of foods containing HFCS. However, as discussed, so has the consumption of added sugars in general. Animal studies that fuel the fructose opponents show fructose is not used to produce energy in the body; instead it is mostly converted to fat in the liver—potentially contributing to insulin resistance and the development of Type 2 diabetes. Additionally, fructose does not stimulate the release of certain appetite-suppressing hormones, like insulin, as glucose does. Thus, a diet high in fructose could potentially stimulate fat deposition and weight gain.

In human studies, excessive fructose intake has sometimes been associated with weight gain, but results are inconsistent. Moderate fructose intake is not associated with weight gain at all. Moreover, other studies show that some fructose in the diet actually improves glucose metabolism especially in people with Type 2 diabetes.Elliott, S. S. et al. "Fructose, Weight Gain, and the Insulin Resistance Syndrome." *Am J Clin Nutr* 76, no. 5 (2002): 911–22. http://www.ajcn.org/content/76/5/911.full. In fact, people with diabetes were once advised to use fructose as an alternative sweetener to table sugar. Overall, there is no good evidence that moderate fructose consumption contributes to weight gain and chronic disease. At this time conclusive evidence is not available on whether fructose is any worse than any other added sugar in increasing the risk for obesity, Type 2 diabetes, and cardiovascular disease.

Interactive 4.3

The USDA is in the process of developing a database on the added sugars in many different foods and has made the information accessible. You might be frightened by what you discover when perusing it. For instance, one 6-ounce container (170 grams) of flavored yogurt contains 20 grams (5 teaspoons) of added sugars.

http://www.ars.usda.gov/SP2UserFiles/Place/12354500/Data/Add_Sug/addsug01.pdf

Oral Disease

Oral health refers not only to healthy teeth and gums, but also to the health of all the supporting tissues in the mouth such as ligaments, nerves, jawbone, chewing muscles, and salivary glands. Over ten years ago the Surgeon General produced its first report dedicated to oral health, stating that oral health and health in general are not separate entities.Surgeon General. "National Call to Action to Promote Oral Health." Accessed September 30, 2011. http://www.surgeongeneral.gov/library/calls/oralhealth/nationalcalltoaction.html. Instead, oral health is an integral part of overall health and well-being. Soft drinks, sports drinks, candies, desserts, and fruit juices are the main sources of "**fermentable sugars**[19]" in the American diet. (Fermentable sugars are those that are easily metabolized by bacteria in a process known as fermentation. Glucose, fructose, and maltose are three examples.) Bacteria that inhabit the mouth metabolize fermentable sugars and starches in refined grains to acids that erode tooth enamel and deeper bone tissues. The acid creates holes (cavities) in the teeth that can be extremely painful (Figure 4.10 "Gingivitis"). Gums are also damaged by bacteria produced by acids, leading to gingivitis (characterized by inflamed and bleeding gums). Saliva is actually a natural mouthwash that neutralizes the acids and aids in building up teeth that have been damaged.

According to Healthy People 2010, 23 percent of US children have cavities by the age of four, and by second grade, one-half of all children in this country have at least one cavity.Continuing MCH Education in Oral Health. "Oral Health and Health Care." Accessed September 30, 2011. http://ccnmtl.columbia.edu/projects/otm/index.html. Cavities are an epidemic health problem in the United States and are associated with poor diet, but other contributors include poor dental hygiene and the inaccessibility to regular oral health care. A review in *Academic Pediatrics* reports that "frequent consumption of fast-releasing carbohydrates, primarily in the form of dietary sugars, is significantly associated with increased dental caries risk."Mobley C., PhD, et al. "The Contribution of Dietary Factors to Dental Caries and Disparities in Caries." Acad Pediatr 9, no. 6 (2009): 410–14. doi: 10.1016/j.acap.2009.09.008. In regards to sugary soft drinks, the American Dental Association says that drinking sugary soft drinks increases the risk of decay formation.American Dental Association. "Diet and Oral Health." Accessed September 30, 2011. http://www.ada.org/2984.aspx#eatoothdecay.

Figure 4.10 Gingivitis

One way to prevent gingivitis and subsequent tooth decay is to lower consumption of sugary drinks.

© Shutterstock

19. Sugars such as glucose, fructose, and maltose that are easily metabolized by bacteria in a process known as fermentation.

Interactive 4.4

The Harvard School of Public Health *Nutrition Source* has developed a guide called "How Sweet Is It?" that notes the calories and sugar contents of many popular beverages. Visit the site to determine drinks that are better for your oral and overall health.

http://www.hsph.harvard.edu/nutritionsource/files/how-sweet-is-it-color.pdf

Tools for Change

Save your teeth and gums and choose to drink a beverage that does not contain excess added sugars. An idea: brew some raspberry tea, add some sparkling mineral water, a raspberry or two, some ice, and a mint leaf. Then sit back and refresh.

Do Low-Carbohydrate Diets Affect Health?

Since the early 1990s, marketers of low-carbohydrate diets have bombarded us with the idea that eating fewer carbohydrates promotes weight loss and that these diets are superior to others in their effects on weight loss and overall health. The most famous of these low-carbohydrate diets is the Atkin's diet. Others include the "South Beach" diet, the "Zone" diet, and the "Earth" diet. Despite the claims these diets make, there is little scientific evidence to support that low-carbohydrate diets are significantly better than other diets in promoting long-term weight loss. A study in *The Nutritional Journal* concluded that all diets, (independent of carbohydrate, fat, and protein content) that incorporated an exercise regimen significantly decreased weight and waist circumference in obese women.Kerksick, C. M. et al. "Changes in Weight Loss, Body Composition, and Cardiovascular Disease Risk after Altering Macronutrient Distributions During a Regular Exercise Program in Obese Women." *J Nutr* 9, no. 59 (2010). doi: 10.1186/1475-2891-9-59. Some studies do provide evidence that in comparison to other diets, low-carbohydrate diets improve insulin levels and other risk factors for Type 2 diabetes and cardiovascular disease. The overall scientific consensus is that consuming fewer calories in a balanced diet will promote health and stimulate weight loss, with significantly better results achieved when combined with regular exercise.

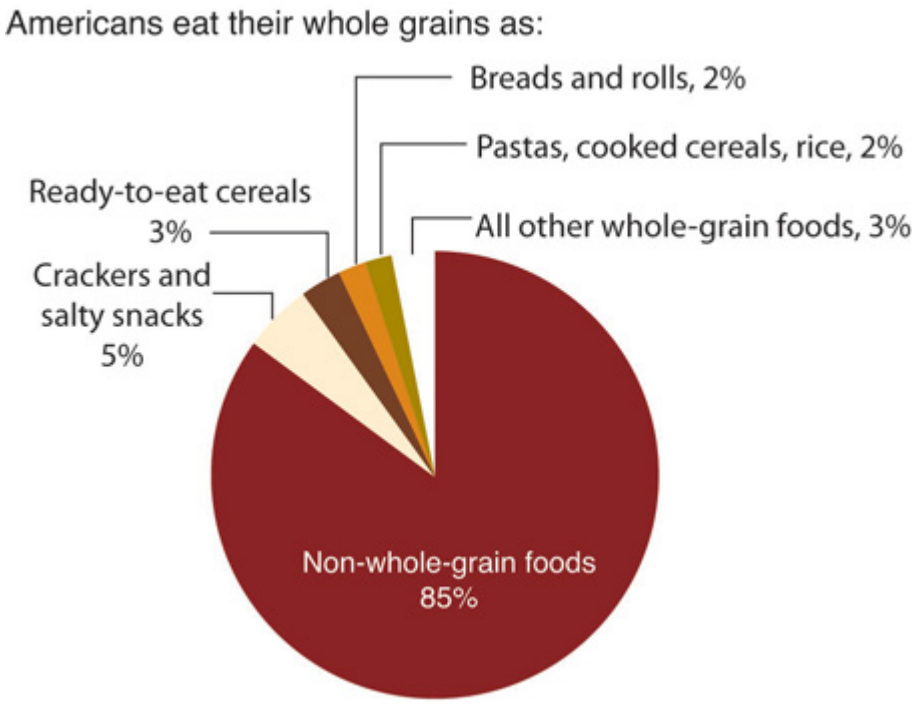
Health Benefits of Whole Grains in the Diet

While excessive consumption of fast-releasing carbohydrates is potentially bad for your health, consuming more slow-releasing carbohydrates is extremely beneficial to health. There is a wealth of scientific evidence supporting that replacing refined grains with whole grains decreases the risk for obesity, Type 2 diabetes, and cardiovascular disease. Whole grains are great dietary sources of fiber, vitamins, minerals, healthy fats, and a vast amount of beneficial plant chemicals, all of which contribute to the effects of whole grains on health. Americans typically do not consume the recommended amount of whole grains, which is 50 percent or more of grains from whole grains (Figure 4.11 "Grain Consumption Statistics in America").

Diets high in whole grains have repeatedly been shown to decrease weight. A large group of studies all support that consuming more than two servings of whole grains per day reduces one's chances of getting Type 2 diabetes by 21 percent.de Munter, J. S. L. et al. "Whole Grain, Bran, and Germ Intake and Risk of Type 2 Diabetes: A Prospective Cohort Study and Systematic Review." PLoS Medicine, no. 8 (2007): e261. doi: 10.1371/journal.med.0040261. The Nurses' Health Study found that women who consumed two to three servings of whole grain products daily were 30 percent less likely to have a heart attack.Liu, S. et al. "Whole-Grain Consumption and Risk of Coronary Heart Disease: Results from the Nurses' Health Study." *Am J Clin Nutr* 70, no. 3 (1999): 412–19. http://www.ajcn.org/content/70/3/412.long. The AHA makes the following statements on whole grains:

- "Dietary fiber from whole grains, as part of an overall healthy diet, helps reduce blood cholesterol levels and may lower risk of heart disease."
- "Fiber-containing foods, such as whole grains, help provide a feeling of fullness with fewer calories and may help with weight management."American Heart Association. "Whole Grains and Fiber." Accessed September 30, 2011. http://www.heart.org/HEARTORG/GettingHealthy/NutritionCenter/HealthyDietGoals/Whole-Grains-and-Fiber_UCM_303249_Article.jsp.

Figure 4.11 *Grain Consumption Statistics in America*



Source: Economic Research Service. http://www.ers.usda.gov/data-products/commodity-consumption-by-population-characteristics/documentation.aspx.

Colon Health

A substantial health benefit of whole grain foods is that fiber actively supports digestion and optimizes colon health. (This can be more specifically attributed to the insoluble fiber content of whole grains.) There is good evidence supporting that insoluble fiber prevents the irritating problem of constipation and the development of diverticulosis and diverticulitis. **Diverticulosis**[20] is a benign condition characterized by out-pocketings of the colon. **Diverticulitis**[21] occurs when the out-pocketings in the lining of the colon become inflamed. Interestingly, diverticulitis did not make its medical debut until the early 1900s, and in 1971 was defined as a deficiency of whole-grain fiber. According to the National Digestive Diseases Information Clearinghouse, 10 percent of Americans over the age of forty have diverticulosis, and 50 percent of people over the age of sixty have the disorder.National Digestive Diseases Information Clearinghouse, a service of National Institute of Diabetes and Digestive and Kidney Diseases, National Institute of Health. "Diverticulosis and Diverticulitis." *NIH Publication No. 08-1163* (July 2008). http://digestive.niddk.nih.gov/ddiseases/pubs/diverticulosis/. Ten to 25 percent of people who have diverticulosis go on to develop diverticulitis.National Digestive

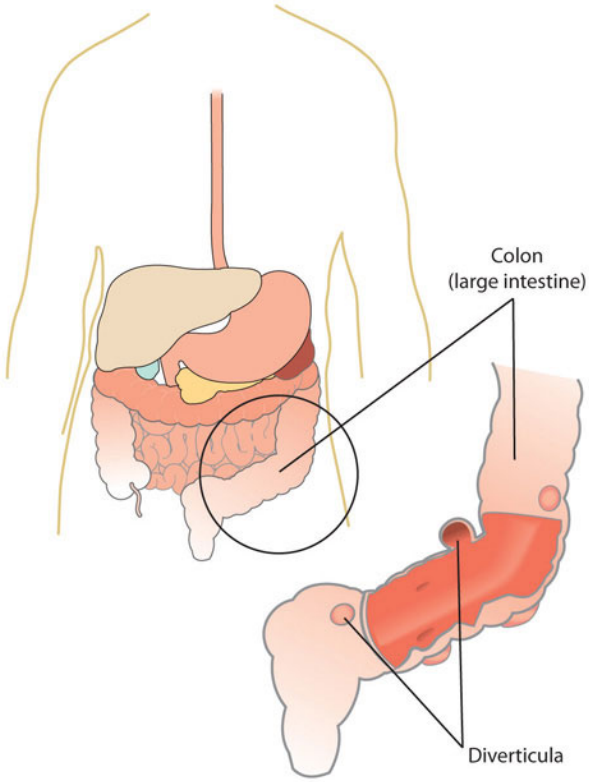
20. A benign condition characterized by out-pocketings of the colon.

21. A condition that occurs when the out-pocketings in the lining of the colon become inflamed. Symptoms include lower abdominal pain, nausea, and alternating between constipation and diarrhea.

Diseases Information Clearinghouse, a service of National Institute of Diabetes and Digestive and Kidney Diseases, National Institute of Health. "Diverticulosis and Diverticulitis." *NIH Publication No. 08-1163* (July 2008). Symptoms include lower abdominal pain, nausea, and alternating between constipation and diarrhea.

The chances of developing diverticulosis can be reduced with fiber intake because of what the breakdown products of the fiber do for the colon. The bacterial breakdown of fiber in the large intestine releases short-chain fatty acids. These molecules have been found to nourish colonic cells, inhibit colonic inflammation, and stimulate the immune system (thereby providing protection of the colon from harmful substances). Additionally, the bacterial indigestible fiber, mostly insoluble, increases stool bulk and softness increasing transit time in the large intestine and facilitating feces elimination. One phenomenon of consuming foods high in fiber is increased gas, since the byproducts of bacterial digestion of fiber are gases.

Figure 4.12 *Diverticulitis: A Disease of Fiber Deficiency*



Some studies have found a link between high dietary-fiber intake and a decreased risk for colon cancer. However an analysis of several studies, published in the

Journal of the American Medical Association in 2005, did not find that dietary-fiber intake was associated with a reduction in colon cancer risk.Park, Y. et al. "Dietary Fiber Intake and Risk of Colorectal Cancer." *JAMA* 294, no. 22 (2005): 2849–57. doi: 10.1001/jama.294.22.2849. There is some evidence that specific fiber types (such as inulin) may protect against colon cancer, but more studies are needed to conclusively determine how certain fiber types (and at what dose) inhibit colon cancer development.

KEY TAKEAWAYS

- Whole grain dietary sources stimulate weight loss and reduce disease risk. Excessive high fructose consumption has been shown to cause weight gain. A primary source of added sugars in the American diet is sugary soft drinks.
- While excessive consumption of some fast-releasing carbohydrates and refined grains is potentially bad for your health, consuming whole grains made up of nutrient-dense slow-releasing carbohydrates is extremely beneficial to health.

DISCUSSION STARTERS

1. Have a debate in your classroom on the USDA restriction on the sale of carbonated beverages in schools. Find out more information on this topic by reading "Soft Drinks and School-Age Children: Trends, Effects, Solutions," developed by the North Carolina School Nutrition Action Committee.

   http://nepc.colorado.edu/files/CERU-0203-41-OWI.pdf

2. Learn about the "Australian Paradox:" How decreased sugar consumption paralleled increased rates of overweight and obese people. Read the study and have a classroom debate over the weight of evidence that supports that diets high in added sugars actually increase weight gain.

   http://www.mdpi.com/2072-6643/3/4/491/pdf

4.6 Carbohydrates and Personal Diet Choices

LEARNING OBJECTIVES

1. Define the Acceptable Macronutrient Distribution Range for carbohydrates, the Adequate Intake for fiber, and recommended intake of added sugars.
2. List five foods that are good sources of slow-releasing carbohydrates.
3. Identify three to five foods high in fiber and carbohydrates from whole, unrefined sources.

In this chapter, you learned what carbohydrates are, the different types of carbohydrates in your diet, and that excess consumption of some types of carbohydrates cause disease while others decrease disease risk. Now that we know the benefits of eating the right carbohydrate, we will examine exactly how much should be eaten to promote health and prevent disease.

How Many Carbohydrates Does a Person Need?

The Food and Nutrition Board of IOM has set the Recommended Dietary Allowance (RDA) of carbohydrates for children and adults at 130 grams per day. This is the average minimum amount the brain requires to function properly. The Acceptable Macronutrient Distribution Range (AMDR) for carbohydrates is between 45 and 65 percent. This means that on a 2,000 kilocalorie diet, a person should consume between 225 and 325 grams of carbohydrate each day. According to the IOM not more than 25 percent of total calories consumed should come from added sugars. The World Health Organization and the AHA recommend much lower intakes of added sugars—10 percent or less of total calories consumed. The IOM has also set Adequate Intakes for dietary fiber, which are 38 and 25 grams for men and women, respectively. The recommendations for dietary fiber are based upon the intake levels known to prevent against heart disease.

Table 4.3 Dietary Reference Intakes for Carbohydrates and Fiber

Carbohydrate Type	RDA (g/day)	AMDR (% calories)
Total Carbohydrates	130	45–65
*** denotes Adequate Intake**		

Carbohydrate Type	RDA (g/day)	AMDR (% calories)
Added Sugars		< 25
Fiber	38 (men),* 25 (women)*	
*** denotes Adequate Intake**		

Dietary Sources of Carbohydrates

Carbohydrates are contained in all five food groups: grains, fruits, vegetables, meats, and beans (only in some processed meats and beans), and dairy products. Fast-releasing carbohydrates are more prevalent in fruits, fruit juices, and dairy products, while slow-releasing carbohydrates are more plentiful in starchy vegetables, beans, and whole grains. Fast-releasing carbohydrates are also found in large amounts in processed foods, soft drinks, and sweets. On average, a serving of fruits, whole grains, or starches contains 15 grams of carbohydrates. A serving of dairy contains about 12 grams of carbohydrates, and a serving of vegetables contains about 5 grams of carbohydrates. Table 4.4 "Carbohydrates in Foods (grams/serving)" gives the specific amounts of carbohydrates, fiber, and added sugar of various foods.

Table 4.4 Carbohydrates in Foods (grams/serving)

Foods	Total Carbohydrates	Sugars	Fiber	Added Sugars
Apple	19 (1 medium)	19.00	4.4	0
Banana	27 (1 medium)	14.40	3.1	0
Lentils	40 (1 c.)	3.50	16.0	0
Snap beans	8.7 (1 c.)	1.60	4.0	0
Green pepper	5.5 (1 medium)	2.90	2.0	0
Corn tortilla	10.7 (1)	0.20	1.5	0
Bread, wheat bran	17.2 (1 slice)	3.50	1.4	3.4
Bread, rye	15.5 (1 slice)	1.20	1.9	1.0
Bagel (plain)	53 (1 medium)	5.30	2.3	4.8
Brownie	36 (1 square)	20.50	1.2	20.0
Oatmeal cookie	22.3 (1 oz.)	12.00	2.0	7.7
Cornflakes	23 (1 c.)	1.50	0.3	1.5
Pretzels	47 (10 twists)	1.30	1.7	0

Foods	Total Carbohydrates	Sugars	Fiber	Added Sugars
Popcorn (homemade)	58 (100 g)	0.50	10.0	0
Skim milk	12 (1 c.)	12.00	0	0
Cream (half and half)	0.65 (1 Tbs.)	0.02	0	0
Cream substitute	1.0 (1 tsp.)	1.00	0	1.0
Cheddar cheese	1.3 (1 slice)	0.50	0	0
Yogurt (with fruit)	32.3 (6 oz.)	32.30	0	19.4
Caesar dressing	2.8 (1 Tbs.)	2.80	0	2.4

Sources: US Department of Agriculture. National Nutrient Database for Standard Reference. Last modified December 7, 2011. http://www.nal.usda.gov/fnic/foodcomp/search/, and US Department of Agriculture. "Database for the Added Sugars Content of Selected Foods." February 2006. http://www.nal.usda.gov/fnic/foodcomp/search/.

It's the Whole Nutrient Package

In choosing dietary sources of carbohydrates the best ones are those that are nutrient dense, meaning they contain more essential nutrients per calorie of energy. In general, nutrient-dense carbohydrates are minimally processed and include whole-grain breads and cereals, low-fat dairy products, fruits, vegetables, and beans. In contrast, empty-calorie carbohydrate foods are highly processed and often contain added sugars and fats. Soft drinks, cakes, cookies, and candy are examples of empty-calorie carbohydrates. They are sometimes referred to as 'bad carbohydrates,' as they are known to cause health problems when consumed in excess.

Interactive 4.5

This interactive USDA tool allows you to enter the foods and serving size of what you're eating and find out the whole nutrient package.

http://www.ars.usda.gov/Services/docs.htm?docid=17032

Understanding Carbohydrates from Product Information

While nutrition facts labels aid in determining the amount of carbohydrates you eat, they do not help in determining whether a food is refined or not. The ingredients list provides some help in this regard. It identifies all of the food's ingredients in order of concentration, with the most concentrated ingredient first. When choosing between two breads, pick the one that lists whole wheat (not wheat flour) as the first ingredient, and avoid those with other flour ingredients, such as white flour or corn flour. (Enriched wheat flour refers to white flour with added vitamins.) Eat less of products that list HFCS and other sugars such as sucrose, honey, dextrose, and cane sugar in the first five ingredients. If you want to eat less processed foods then, in general, stay away from products with long ingredient lists. On the front of food and beverages the manufacturers may include claims such as "sugar-free," "reduced sugar," "high fiber," etc.. The Nutrition and Labeling Act of 1990 has defined for the food industry and consumers what these labels mean (Table 4.5 "Food Labels Pertaining to Carbohydrates").

Table 4.5 Food Labels Pertaining to Carbohydrates

Label	Meaning
Sugar-free	Contains less than 0.5 grams of sugar per serving
Reduced sugar	Contains 25 percent less sugar than similar product
Less sugar	Contains 25 percent less sugar than similar product, and was not altered by processing to become so
No sugars added	No sugars added during processing
High fiber	Contains at least 20 percent of daily value of fiber in each serving
A good source of fiber	Contains between 10 and 19 percent of the daily value of fiber per serving
More fiber	Contains 10 percent or more of the daily value of fiber per serving

Source: US Food and Drug Administration. "Appendix A: Definitions of Nutrient Claims." *Guidance for Industry: A Food Labeling Guide*. September 1994. Last revised October 2009. http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/FoodLabelingNutrition/FoodLabelingGuide/ucm064911.htm.

In addition, the FDA permits foods that contain whole oats (which contain soluble fiber) to make the health claim on the package that the food reduces the risk of coronary heart disease. The FDA no longer permits Cheerios to make the claim that by eating their cereal "you can lower your cholesterol four percent in six weeks."

One serving of Cheerios contains 12 percent of the Daily Value of fiber.

© Shutterstock

The Bottom Line

Read the labels and ingredient lists of foods to determine your carbohydrate intake and know the types of carbohydrate you consume.

Personal Choices

Carbohydrates are in most foods so you have a great variety of choices with which to meet the carbohydrates recommendations for a healthy diet. The *2010 Dietary Guidelines* recommends eating more unrefined carbohydrates and more fiber, and reducing consumption of foods that are high in added sugars. To accomplish these recommendations use some or all of the following suggestions:

- Get more daily carbohydrate servings from whole grains by eating a whole-grain cereal for breakfast, using whole-grain bread to make a sandwich for lunch, and eating a serving of beans and/or nuts with dinner.
- Make sure to get at least three servings (or more) of all the grains you eat as whole grains every day. A serving of whole grains is equal to one

slice of whole-wheat bread, one ounce of whole-grain cereal, and one-half cup of cooked cereal, brown rice, or whole-wheat pasta.
- Food products made with cornmeal use the whole grain so choose tortillas, corn cereals, and corn breads with cornmeal listed as the first ingredient.
- When baking, substitute whole-wheat flour or other whole-grain flour for some of the refined white flour.
- If you like bread at dinner, choose a whole-grain muffin over a Kaiser roll or baguette.
- Add beans, nuts, or seeds to salad—they add texture and taste.
- Choose whole-grain pastas and brown rice, cook al dente, and add some beans and vegetables in equal portions.
- Change it up a bit and experience the taste and satisfaction of other whole grains such as barley, quinoa, and bulgur.
- Eat snacks high in fiber, such as almonds, pistachios, raisins, and air-popped popcorn.
- Add an artichoke and green peas to your dinner plate more often.
- Calm your "sweet tooth" by eating fruits, such as berries or an apple.
- Replace sugary soft drinks with seltzer water, tea, or a small amount of 100 percent fruit juice added to water or soda water.

KEY TAKEAWAYS

- The IOM has set the Recommended Dietary Allowance of carbohydrates for children and adults at 130 grams per day. This is the average minimum amount the brain requires to function properly. The Acceptable Macronutrient Distribution Range for total carbohydrates is 45 to 65 percent.
- Carbohydrates are contained in all five food groups: grains, fruits, vegetables, meats and beans (only in some processed meats and beans), and dairy products.
- The *2010 Dietary Guidelines* recommends eating more slow-releasing carbohydrates and more fiber, and reducing consumption of foods that are high in added sugars. This involves choosing carbohydrate sources that are nutrient-dense, with more essential nutrients per calorie of energy.

DISCUSSION STARTERS

1. Are you getting the recommended amount of dietary fiber in your diet?

2. Visit the USDA "Database for the Added Sugars Content of Selected Foods" and find the added sugar contents of foods common in your diet. Discuss some of the "surprises" that you discover with your classmates.

   http://www.nal.usda.gov/fnic/foodcomp/Data/add_sug/addsug01.pdf

4.7 The Food Industry: Functional Attributes of Carbohydrates and the Use of Sugar Substitutes

LEARNING OBJECTIVE

1. Discuss the usefulness (or lack thereof) of consuming foods containing sugar substitutes.

In the food industry, both fast-releasing and slow-releasing carbohydrates are utilized to give foods a wide spectrum of functional attributes, including increased sweetness, viscosity, bulk, coating ability, solubility, consistency, texture, body, and browning capacity. The differences in chemical structure between the different carbohydrates confer their varied functional uses in foods. Starches, gums, and pectins are used as thickening agents in making jam, cakes, cookies, noodles, canned products, imitation cheeses, and a variety of other foods. Molecular gastronomists use slow-releasing carbohydrates, such as alginate, to give shape and texture to their fascinating food creations (see Note 4.53 "Video 4.4"). Adding fiber to foods increases bulk. Simple sugars are used not only for adding sweetness, but also to add texture, consistency, and browning. In ice cream, the combination of sucrose and corn syrup imparts sweetness as well as a glossy appearance and smooth texture. Added sugars include white, brown, and raw sugar, corn syrup, HFCS, malt and maple syrups, liquid fructose, honey, molasses, agave nectar, and crystal dextrose.

Video 4.4

Ferran Adrian Demonstrates Alginates

(click to see video)

Watch this video to see how molecular gastronomist Ferran Adrian uses the polysaccharide alginate to give shape and texture to olive puree.

Pectin (a carbohydrate) is added to jam to give it its consistency.

© Shutterstock

Due to the potential health consequences of consuming too many added sugars, sugar substitutes have replaced them in many foods and beverages. **Sugar substitutes**[22] may be from natural sources or artificially made. Those that are artificially made are called **artificial sweeteners**[23] and must be approved by the FDA for use in foods and beverages. The artificial sweeteners approved by the FDA are saccharin, aspartame, acesulfame potassium, neotame, and sucralose. Stevia is an example of a naturally derived sugar substitute. It comes from a plant commonly known as sugarleaf and does not require FDA approval. **Sugar alcohols**[24], such as xylitol, sorbitol, erythritol, and mannitol, are carbohydrates that occur naturally in some fruits and vegetables. However, they are industrially synthesized with yeast and other microbes for use as food additives. The FDA requires that foods disclose the fact that they contain sugar alcohols, but does not require scientific testing of it. (Though many of them have undergone studies anyway.) In comparison to sucrose, artificial sweeteners are significantly sweeter (in fact, by several hundred times), but sugar alcohols are more often less sweet than sucrose (see Table 4.6 "Sweetness Comparison of Sugar Substitutes"). Artificial sweeteners and Stevia are not digested or absorbed in significant amounts and therefore are not a significant source of calories in the diet. Sugar alcohols are somewhat digested and absorbed and, on average, contribute about half of the calories as sucrose (4 kilocalories/gram). These attributes make sugar substitutes attractive for many people—especially those who want to lose weight and/or better manage their blood-glucose levels.

Table 4.6 Sweetness Comparison of Sugar Substitutes

Sweetener	Trade Names	Times that of Sucrose
Saccharine	“Sweet-N-Lo”	600.0
Aspartame	“NutraSweet,” “Equal”	180.0–220.0
Acesulfame-K	“Sunette”	200.0
Neotame		7,000.0–13,000.0
Sucralose	“Splenda”	600.0
Stevia		250.0–300.0
Xylitol		0.8
Mannitol		0.5

22. Sugar replacements, including artificial sweeteners, sugar alcohols, and natural sources such as sugarleaf.
23. Sugar substitutes that are chemically synthesized and must be approved by the FDA prior to their use in the food and beverage industry.
24. Carbohydrates that occur naturally in some fruits and vegetables; however they are industrially synthesized by yeast and other microbes for use as food additives.

Sweetener	Trade Names	Times that of Sucrose
Sorbitol		0.6
Erythritol		1.0

Sources: University of North Texas. "Sugar Substitutes." Accessed November 6, 2012. http://dining.unt.edu/nutrition/nutrition_brochures/Sugar%20Substitutes.pdf, and Yale-New Haven Hospital. "Eat Any Sugar Alcohol Lately?" Accessed November 6, 2012. http://www.ynhh.org/about-us/sugar_alcohol.aspx.

Benefits of Sugar Substitutes

Consuming foods and beverages containing sugar substitutes may benefit health by reducing the consumption of simple sugars, which are higher in calories, cause tooth decay, and are potentially linked to chronic disease. Artificial sweeteners are basically nonnutrients though not all are completely calorie-free. However, because they are so intense in sweetness they are added in very small amounts to foods and beverages. Artificial sweeteners and sugar alcohols are not "fermentable sugars" and therefore they do not cause tooth decay. Chewing gum with artificial sweeteners is the only proven way that artificial sweeteners promote oral health. The American Dental Association (ADA) allows manufacturers of chewing gum to label packages with an ADA seal if they have convincing scientific evidence demonstrating their product either reduces plaque acids, cavities, or gum disease, or promotes tooth remineralization.

There is limited scientific evidence that consuming products with artificial sweeteners decreases weight. In fact, some studies suggest the intense sweetness of these products increases appetite for sweet foods and may lead to increased weight gain. Also, there is very limited evidence that suggests artificial sweeteners lower blood-glucose levels. Additionally, many foods and beverages containing artificial sweeteners and sugar alcohols are still empty-calorie foods (i.e. chewing sugarless gum or drinking diet soda pop) are not going to better your blood-glucose levels or your health.

Health Concerns

The most common side effect of consuming products containing sugar substitutes is gastrointestinal upset, a result of their incomplete digestion. Since the introduction of sugar substitutes to the food and beverage markets, the public has expressed concern about their safety. The health concerns of sugar substitutes originally

stemmed from scientific studies, which were misinterpreted by both scientists and the public.

In the early 1970s scientific studies were published that demonstrated that high doses of saccharine caused bladder tumors in rats. This information fueled the still-ongoing debate of the health consequences of all artificial sweeteners. In actuality, the results from the early studies were completely irrelevant to humans. The large doses (2.5 percent of diet) of saccharine caused a pellet to form in the rat's bladder. That pellet chronically irritated the bladder wall, eventually resulting in tumor development. Since this study, scientific investigation in rats, monkeys, and humans have not found any relationship between saccharine consumption and bladder cancer. In 2000, saccharin was removed from the US National Toxicology Program's list of potential carcinogens.National Cancer Institute. "Artificial Sweeteners and Cancer." Accessed September 30, 2011. http://www.cancer.gov/cancertopics/factsheet/Risk/artificial-sweeteners.

There have been health concerns over other artificial sweeteners, most notably aspartame (sold under the trade names of NutraSweet and Equal). The first misconception regarding aspartame was that it was linked with an increase in the incidence of brain tumors in the United States. It was subsequently discovered that the increase in brain tumors started eight years prior to the introduction of aspartame to the market. Today, aspartame is accused of causing brain damage, autism, emotional disorders, and a myriad of other disorders and diseases. Some even believe aspartame is part of a governmental conspiracy to make people dumber. The reality is there is no good scientific evidence backing any of these accusations, and that aspartame has been the most scientifically tested food additive. It is approved for use as an artificial sweetener in over ninety countries.

Aspartame is made by joining aspartic acid and phenylalanine to amino acids. When digested, it is broken down to aspartic acid, phenylalanine, and methanol. People who have the rare genetic disorder phenylketonuria (PKU) have to avoid products containing aspartame. Individuals who have PKU do not have a functional enzyme that converts phenylalanine to the amino acid tyrosine. This causes a build-up of phenylalanine and its metabolic products in the body. If PKU is not treated, the build-up of phenylalanine causes progressive brain damage and seizures. The FDA requires products that contain aspartame to state on the product label, "Phenylketonurics: Contains Phenylalanine."

For more details on sugar substitutes please refer to Table 4.7 "Sweeteners".

Table 4.7 Sweeteners

Sweeteners with Trade Name	Calories	Source/Origin	Consumer Recommendations	Controversial Iss
Aspartame • NutraSweet • Equal	4 kcal/g	Composed of two amino acids (phenylalanine + aspartic acid) + methanol. Two hundred times sweeter than sucrose.	FDA set maximum Acceptable Daily Intakes (ADI): 50 mg/kg body weight = 16 12 oz. diet soft drinks for adults. ***Cannot be used in products requiring cooking.** People with PKU should not consume aspartame.	Children have potential to reach if consuming many beverages, dessert frozen desserts, ar gums containing aspartame routine
Saccharin • Sweet 'n' Low	0 kcal/g	Discovered in 1878. The basic substance is benzoic sulfinide. Three hundred times sweeter than sucrose.	ADI: 5 mg/kg body weight. ***Can be used in cooking.**	1970s, high doses saccharin associat with bladder canc laboratory animal 1977, FDA propose banning saccharin from use in food • prote launc by consu

Sweeteners with Trade Name	Calories	Source/Origin	Consumer Recommendations	Controversial Iss
				& inte group • warni label listed produ about sacch and cance risk i anima until when studie concl that i not ca cance huma
Acesulfame K • Sunnette • Sweet One	0 kcal/g	Discovered in 1967. Composed of an organic salt, potassium (K). Structure is very similar to saccharin's. It passes through the body unchanged which means it does not	ADI: 15 mg/kg body weight. Body cannot digest it. ***Can be used in cooking.**	

Sweeteners with Trade Name	Calories	Source/Origin	Consumer Recommendations	Controversial Iss
		provide energy. Two hundred times sweeter than sucrose.		
Cyclamates • Sugar Twin (Canada only)	0 kcal/g	Thirty times sweeter than sucrose. Discovered in 1937.	No ADI available.	1949, cyclamate approved by FDA f use. Cyclamate wa classified as GRAS (Generally Recogn As Safe) until 1970 when it was remov from GRAS status banned from use i food and beverage products within th United States on t basis of one study indicated it caused bladder cancer in Approval still pend for use in the Unit States since the ba Canada and other countries use this of sweetener.
Sucralose • Splenda	1 Splenda packet contains 3.31	First discovered in 1976. Approved for use in 1998 in	ADI: 5 mg/kg body weight.	

Sweeteners with Trade Name	Calories	Source/Origin	Consumer Recommendations	Controversial Iss
	calories = 1g	the United States and in 1991 in Canada. Derived from sucrose in which three of its hydroxyl (OH) groups are replaced by chlorine (Cl–). Six hundred times sweeter than sugar.	***Can be used in cooking.**	
Stevioside • Stevia • Sweet Leaf	N/A	Derived from stevia plant found in South America. *Stevia rebaudianan* leaves.	Classified as GRAS. Considered to be a dietary supplement and approved not as an additive, but as a dietary supplement.	Used sparingly, ste may do little harm but FDA could not approve extensive of this sweetener c to concerns regard its effect on reproduction, can development, and energy metabolism
Sucrose • Sugar	~4 kcal/ g	Extracted from either sugar beets or sugar cane, which is then	It is illegal to sell true raw sugar in the United States because when raw it contains	Over-consumption been linked to sev health effects such tooth decay or den caries and contrib

Sweeteners with Trade Name	Calories	Source/Origin	Consumer Recommendations	Controversial Iss
		purified and crystallized.	dirt and insect parts, as well as other byproducts. Raw sugar products sold in the United States have actually gone through more than half of the same steps in the refining process as table sugar.	to increased risk f chronic diseases.
Honey	3 kcal/g	Made from sucrose. Contains nectar of flowering plants. Made by bees. Sucrose is fructose + glucose; however, honey contains more calories than sucrose because honey is denser.	*Considered safe for baking and cooking. Infants under twelve months old should not be given honey because their digestive tracts cannot handle the bacteria found in honey. Older children and adults are immune to these effects. Honey contains some harmful bacteria that can cause fatal food	

Sweeteners with Trade Name	Calories	Source/Origin	Consumer Recommendations	Controversial Iss
			poisoning in infants.	
HFCS • high fructose corn syrup	Dry form: 4 kcal/g; Liquid form: 3 kcal/g	Corn is milled to produce corn starch, then the corn starch is further processed to yield corn syrup.		Controversial beca it is found ubiquitously in processed food products, which co lead to over-consumption. Stuc results are varied regarding its role i chronic disease.
Sugar Alcohols • Sorbital • Xylitol • Mannitol	2–4 kcal/g. Not calorie free	Sugar alcohols. Sorbitol is derived from glucose.	Less likely to cause tooth decay than sucrose. Sugar alcohols have a laxative effect.	May cause diarrhe and gastrointestin distress if consum large amounts.

Regulation

Prior to introducing any new artificial sweetener into foods it is rigorously tested and must be legally approved by the FDA. The FDA regulates artificial sweeteners along with other food additives, which number in the thousands. The FDA is responsible for determining whether a food additive presents "a reasonable certainty of no harm" to consumers when used as proposed. The FDA uses the best scientific evidence available to make the statement of no harm, but it does declare

that science has its limits and that the "FDA can never be *absolutely* certain of the absence of any risk from the use of any substance."US Food and Drug Administration. "Food Ingredients and Colors." Accessed September 30, 2011. http://www.fda.gov/food/foodingredientspackaging/ucm094211.htm. The FDA additionally has established ADIs for artificial sweeteners. The ADIs are the maximum amount in milligrams per kilogram of body weight considered safe to consume daily (mg/kg bw/day) and incorporates a large safety factor. The following list contains the artificial sweeteners approved for use in foods and beverages in the United States, and their ADIs:

- **Acesulfame potassium (Sunett, Sweet One).** ADI = 15 mg/kg bw/day
- **Aspartame (Equal, NutraSweet).** ADI = 50 mg/kg bw/day
- **Neotame.** ADI = 18 mg/kg bw/day
- **Saccharin (SugarTwin, Sweet'N Low).** ADI = 5 mg/kg bw/day
- **Sucralose (Splenda).** ADI = 5 mg/kg bw/day

Carbohydrates in a Kernel

Referring back to the wheat kernel mentioned at the opening of this chapter, recall that all components of the wheat kernel are required in order to build an optimal healthy diet. The endosperm provides the carbohydrates, and the bran and germ contain the majority of protein, vitamins, minerals, and fiber. Eating foods made with whole grains provides a better nutritional punch for your health. Once whole grains are processed and refined, enrichment in only a few of these removed nutrients does not offset the gain from consuming whole-grain products. Other dietary sources of carbohydrates that maximize nutrient uptake are vegetables, fruits, beans, and low-fat dairy products. To avoid compromising your health, do not consume excessive amounts of carbohydrate foods that contain added sugars, or that are high in sodium and saturated fat. Processed foods contain all of these ingredients in an unwelcome nutrient package that negatively impacts health. Sugar substitutes provide one avenue of decreasing the intake of fast-releasing carbohydrates, but there are others. Know that consumer demand for healthy carbohydrate choices is on the rise, so in the future you can expect decreased prices, more variety of whole-grain products, and less added sugars.

The Bottom Line

Choose more slow-releasing carbohydrates, eat more fiber, and reduce consumption of foods high in added sugars.

KEY TAKEAWAYS

- In the food industry both fast-releasing and slow-releasing carbohydrates are utilized to give foods a wide spectrum of functional attributes. The differences in chemical structure between the different carbohydrates confer their many different functional uses in foods.
- Due to the health consequences of consuming too many added sugars, sugar substitutes are widely used in many foods and beverages.
- Consuming foods and beverages containing sugar substitutes may benefit health by reducing the consumption of simple sugars, which are higher in calories, cause tooth decay, and are potentially linked to chronic disease. However, the most common side effect of consuming products containing sugar substitutes is gastrointestinal upset, a result of their incomplete digestion.
- Prior to introducing any new artificial sweetener into foods it is rigorously tested and must be legally approved by the FDA.

DISCUSSION STARTERS

1. Conduct a taste test of sugar and its substitutes. What do your taste buds tell you? Do you prefer foods with sugar substitutes or the real thing?

2. Have a class discussion on the safety of aspartame. To fuel the debate, read the FDA's report and watch the reactionary video, "Aspartame, Brain Cancer, and the FDA Approval Process."

   http://www.fda.gov/Food/FoodIngredientsPackaging/FoodAdditives/ucm208580.htm

   Aspartame, Brain Cancer, and the FDA Approval Process

   (click to see video)

4.8 End-of-Chapter Exercises

IT'S YOUR TURN

1. List four functions of carbohydrates in the body.
2. Count the carbohydrates you consume in a day by following the steps for carbohydrate counting. Is your intake within the recommended range?
3. Determine your daily fiber intake and whether your diet supplies the amount of fiber recommended to promote health and prevent disease.

APPLY IT

1. Conduct a dietary assessment of the GI of foods in three of your dinners. To aid in this process peruse the website, http://www.gilisting.com/. Plan a dinner menu that balances the GI of the entire meal.

2. Learn more on glycolysis and cellular respiration by watching this video on YouTube, and describe in a short paragraph what happens in the body as it uses the process of glycolysis to fuel short bursts of activity.

   Glycolysis Cellular Respiration Overview

   (click to see video)
3. Conduct an experiment in the classroom that evaluates the sweetness and tastefulness of sugar substitutes. Try them in pure form by putting a small amount on your finger. Record the results from you and your classmates and make a sweetness and taste comparison chart.

EXPAND YOUR KNOWLEDGE

1. Design a Thanksgiving feast with at least ten items that help balance the GI of the meal.
2. Draw a flow chart that incorporates the concept of negative feedback in the regulation of blood glucose levels.
3. Visit the website of the CDC (http://apps.nccd.cdc.gov/DDTSTRS/default.aspx) and record the estimates of obesity, physical inactivity, and Type 2 diabetes in the county you live in. Make a list of five ways to curb the trends of obesity, physical inactivity, and Type 2 diabetes in your county.