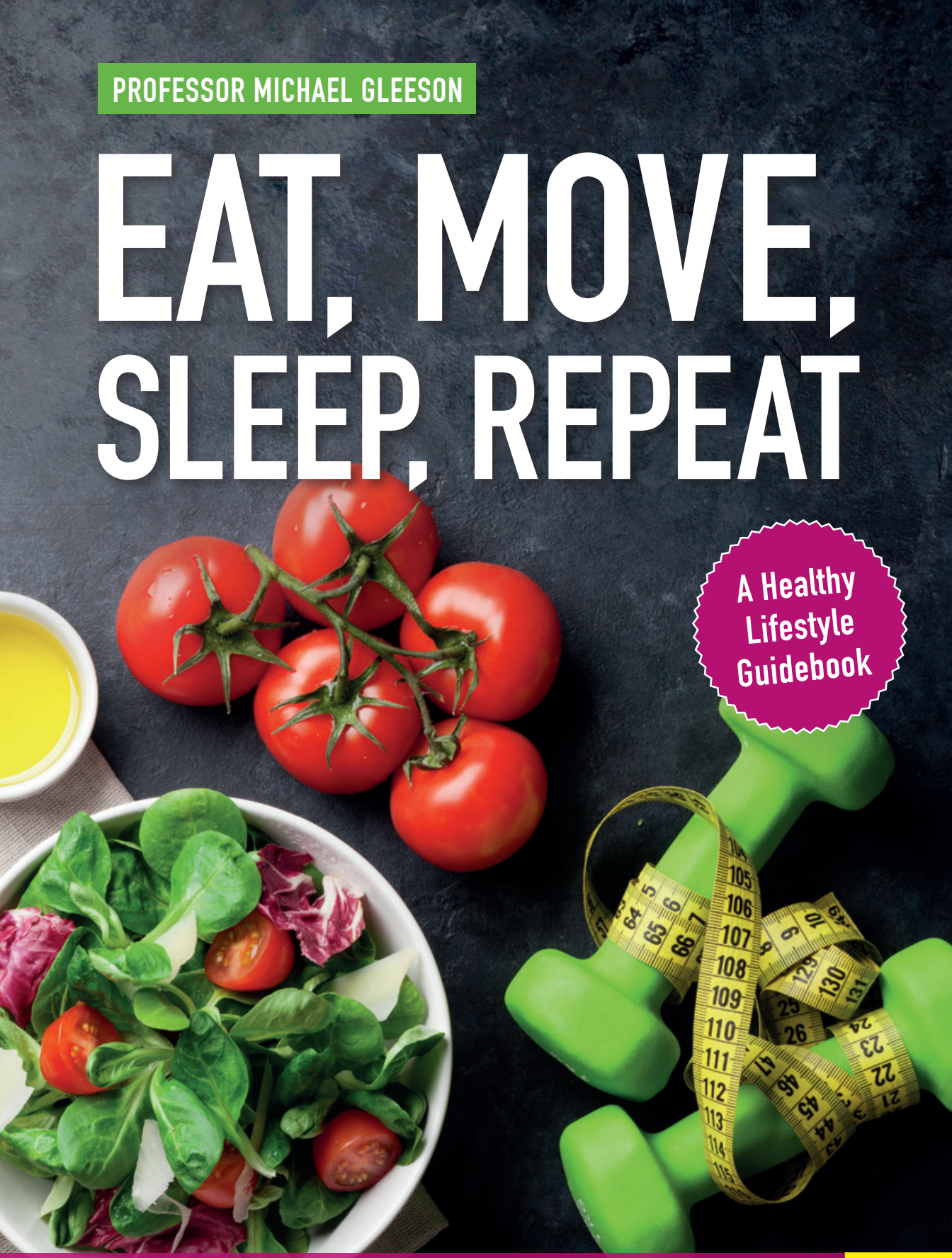
PROFESSOR MICHAEL GLEESON

EAT, MOVE, SLEEP, REPEAT

A Healthy Lifestyle Guidebook



Diet & Fitness for Living Long & Healthy

MEYER & MEYER SPORT

Eat, Move, Sleep, Repeat

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Chapter 1

Optimizing Health, Fitness, and Well-Being Throughout the Lifespan

Objectives

After studying this chapter, you should:

- Understand the scope of this book
- Know something about the author
- Have a basic understanding of how particular aspects of your lifestyle and behavior can have a negative or positive impact on your health
- Appreciate the potential long-term health problems caused by being overweight
- Understand the concept of optimal health
- Appreciate how our genetics influences our susceptibility to gaining or losing body fat in response to dietary energy intake and exercise
- Appreciate the concept of relative risk

INTRODUCTION

Firstly, I want to thank you for buying this book and congratulate you on your decision. The title indicates that this is a guidebook that can direct you to a healthier lifestyle. Well, the aim of any guidebook, in my opinion, should be to explain exactly how to achieve your desired goals, and this is just what my book does. But it doesn't only provide advice and recommendations about appropriate eating, exercising, and sleeping behaviors, it also explains the scientific reasons for this guidance in a way that any reasonably intelligent person can understand. In this book I use my extensive experience of working with elite athletes and games players to help you, the general

public, learn how to safely and effectively lose weight, get fitter, sleep better, avoid illness and live healthily for longer. You can trust the advice I give as it is all based on the latest scientific evidence. I do not promote any fad diets or exercise regimens, just ones that have been proven to be safe and effective. From me you will learn the principles of healthy eating and what you can do to make your health optimal...that is as good as it can be. Essentially, this book describes what you should eat and how you can make informed choices about your food selections based on what is healthy and what your personal preferences are. It explains exactly how you can take control of managing your appetite and how to lose weight (and more importantly body fat) by dieting or doing more exercise. It explains the basis of many different weight loss diets and informs you of the outcomes of scientific studies that have evaluated their efficacy: in other words, whether or not they work and just how effective they actually are.

In this book, I also explore how exercise can be used to achieve weight loss, what the best form of exercise is for fat burning, and the basis for the health benefits of regular exercise that you will have heard about. You will also discover the new evidence that tells us that sleep quantity and quality are also important for our health and how you can improve your own sleep quality. You will also learn about nutrition and lifestyle behavior strategies that will help you avoid common illnesses such as the common cold and tummy upsets as well as practical advice about maintaining healthy senses (eyesight and hearing), tissues and organs (teeth and gums, gut, bones, muscles, skin, heart, lungs, bladder, reproductive system, brain, etc.). Finally, you will be provided with a novel weight loss plan that can be personalized to your own preferences and incorporates multiple weight loss diets (avoiding the boredom of sticking to just one type of diet), combined with some daily moderate exercise that will leave you invigorated rather than exhausted.

Exercise and nutrition programs designed to achieve weight loss and improved health or fitness have continued to receive considerable attention in recent decades, and a large number of books have been published on the subject by authors, including nutritionists, dieticians, medics, sport scientists, personal trainers, and media celebrities. The vast majority of these books focus on the latest fad diet (e.g., Atkins, Intermittent Fast, Sugarbusters, Noncombination, Zone, Paleo, Macrobiotic, Alkaline, Dukan, etc.) usually alone or sometimes in combination with the latest fad exercise regimen (e.g., Aerobics, Stepping, Spinning, High Intensity Interval Exercise) but rarely provide a scientific evidence-based rationale for their use, except in very simplistic terms, nor indicate the range of other options available. People are very different in their goals, physical capabilities, and occupations, and this is often not taken into account; some of these fad diets and exercise regimens are only suitable or effective for a limited number of people. My book is different. It provides both a scientific evidence-based rationale for selecting certain diets and forms of physical activity that can help to achieve effective loss of body fat, explains how to develop a personalized weight loss plan, gives guidelines for a healthy balanced diet, provides advice on how to improve sleep quality, avoid common illnesses, and how much and what type of exercise is needed to see health benefits. As the title suggests, this book aims to provide a set of evidence-based guidelines on how to establish a healthy lifestyle that will promote a better quality of life with reduced risk of chronic disease (e.g., coronary heart disease, type 2 diabetes, cancer, dementia, etc.) throughout the lifespan and extend longevity. In simpler terms, it can help you to live a more satisfying, healthier, and longer life. I hope that by reading this book you will

be motivated and better able to implement the changes to your lifestyle that you need to make to make your life healthier and better. Let me begin by telling you something about myself and what is different about my book.

WHO AM I?

I am a recently retired university professor who has spent the last 40 years of his life teaching and researching in the field of exercise physiology, metabolism, immunology, and health with a particular interest in sport nutrition. My last two academic positions were at the University of Birmingham and Loughborough University, two of the top universities in the world for sport, exercise, and health science. I have coauthored several books on the biochemistry of exercise and training, immune function in sport and exercise, and nutrition for sport, and contributed chapters to more than 30 other books. I have published over 200 research papers in the scientific and medical literature, and much of this has been focused on the well-being of athletes and the factors influencing their performance. Now, as an aging member of the general public, I have turned my attention to the issue of living a healthy lifestyle (in part, to improve my own quality of life and longevity) and have spent the last couple of years formulating the ideas for this new book. Some people have called me "the second most famous professor from Chadderton" (my hometown in the county of Lancashire, England). The most (and far more) famous professor from Chadderton is, of course, the physicist Brian Cox, (who actually grew up on the same street as me) and can so engagingly explain the workings of the universe on television and in his books as well as happening to be an ex-rock star! Well, I can't compete with that, but I do hope you will enjoy reading this book. I have tried to emulate Brian's writing style by attempting to explain the science in a way that the average person can understand, learn from, and enjoy. I suggest that you read this book slowly, just as you would savor a fine meal, take time to digest the information (pardon the pun!), and use it to change the way you live to make you and your loved ones both healthier and happier.

WHAT IS DIFFERENT ABOUT THIS BOOK?

A lot of people equate being healthy with being slim, and as the majority of the population in the Western world is overweight there is much emphasis on how weight loss can be achieved. There are so many books out there on dieting to lose weight, and some of those books also mention exercises that can help with weight loss. Most of these books spend a few pages explaining the scientific basis of some new diet (though often only using selected evidence that favors the new idea and ignoring evidence that does not), and some may briefly cover the health benefits of weight loss, but almost invariably the rest of the book will contain pictures of appetizing dishes and recipes. In fact, the difference between these books and the seemingly ever popular cook books by celebrity chefs is really often rather small.

The books that focus more on exercise may provide a list of health benefits and suggest which type of exercise is best for fitness and weight loss, but again the majority of the pages will mostly be filled with pictures; usually these will illustrate a series of supposedly suitable exercises being performed by a young, slim, attractive person in minimal clothing! That is why I decided to write this book with a very different approach, with more emphasis on the science, and limiting recommendations and guidelines to those that are evidence-based. As my 40-year career has been as an educator of university students, I wanted to apply what I know about exercise and nutrition to the issue of weight loss and explain the science behind a healthy lifestyle. It is my firm belief that if people gain a better understanding of the principles underlying the health consequences of overeating, not exercising, and not getting good, quality sleep, and learn how these poor lifestyle habits can be easily remedied to improve their long-term health, quality of life, and longevity, they are much more likely to decide (and stick with it) to change their behaviors to the benefit of their health and enjoyment of life. It is about understanding the reasons for the expert advice and recommendations and realizing that it is relatively simple to change bad habits to good ones without big changes to daily routines and personal preferences.

So, this book is written with the aim of teaching the average, reasonably intelligent person about the nature of the food we eat (chapter 2), why some foods are essential to our health and some are not (chapter 3), the potentially harmful consequences of eating too much or too little of certain **nutrients**, and the basis of a healthy balanced diet (chapter 4). The concept of **energy balance** (**calories** in versus calories out) is clearly explained in chapter 5, and you will also learn in chapter 6 about the factors that influence **appetite** and **satiety** (i.e., what controls our hunger and what makes us feel full after a good meal). Because many people are overweight (or overfat), chapters are devoted to different diet and exercise strategies to lose body fat. You will also learn about all the benefits of exercise, and the importance of getting sufficient amounts of good quality sleep. For example, did you know that both these aspects of our daily lives have important influences on our risk of developing **chronic diseases** such as cardiovascular disease, **type 2 diabetes**, **dementia**, and **cancer** later in life, and also on our current risk of infections? The reasons are explained in this book, and I have also included a chapter on how to maintain a robust **immune system**, with practical advice on how to avoid common infections. In this paragraph you will have noticed that some words are in **bold** font. Any word that appears in **bold** font in this book is defined in the glossary which you will find at the end of the book. I have tried to identify some of the key words or terms as well as words that may be unfamiliar to some readers and some other words that it is just useful to know the exact meaning of.

Finally, you will learn about an effective weight loss plan I have devised that is achievable for any moderately overweight but mobile adult who is between 18 and 70 years of age. This does not require sticking to the same boring diet for several months. In fact, the plan incorporates multiple diets that can be changed every week and combines this with exercise so that you will lose fat, not lean muscle. With this moderate but effective weight loss plan you can lose on average 100 g (4 oz) of body fat per day which means you can lose about 7 kg (15 lbs.) of fat in just 10 weeks.

WHAT DO YOU NEED TO BE HEALTHY?

When I have asked different people the question "what do you think you need to do to be healthy?", almost all mention "not overeating" and "not smoking" which is entirely correct, but not many will mention "eating well" or "eating healthy foods". Some will include "doing some regular exercise" or "avoiding excess **alcohol**" in their reply. Very few will mention "not being overweight", "not having too much abdominal fat", or "getting sufficient sleep". Yet all of the above are important to health. And by health I not only mean remaining free from illness, but guarding against the risks of **chronic disease**, reduced mobility, and dementia later in life.

Let's think about what our everyday lives involve: At the most basic level we eat, we move, and we sleep. All these actions are needed for basic survival. Without appropriate foods supplying energy and essential nutrients we would waste away, become ill, and die. Without exercise, our immobilized muscles would wither away making us weak and unable to perform basic tasks needed for normal living. With insufficient sleep, we would feel tired, lethargic, and irritable, and life would become a chore. So, we must satisfy the body's needs for nutrition, physical activity, and sleep, but why stop there. Let's rephrase the original question. We should really be asking "what do we need to do to achieve and maintain **optimal health** throughout the lifespan?" because this is what can give us the best quality of life. Optimal health should be considered as a state of complete physical, mental, and social well-being and not merely the absence of illness, disease, or infirmity. The key word here is "optimal"; it is not just what we need to survive, but what we can do to attain the best possible health outcomes and enable us to improve our quality of life, not only in the present but also in the future. You will realize and appreciate the importance of this as you get older, just as I have! By being healthier, fitter, stronger, and more robust, we can lead more fulfilling and enjoyable lives, live independently for longer, and actually live longer.

THE OBESITY PROBLEM: IT'S NOT ALL ABOUT GENETICS

One of the major problems in developed countries is the **obesity** epidemic. In the USA, two in three people are now classed as being overweight or obese; in fact, almost 38% of the adult population are classed as obese, a trend that has been growing for the past three decades. The UK has the highest proportion of obese people in Europe at 27%. Being obese or just overweight increases the risk of developing chronic metabolic and cardiovascular diseases and dying at an earlier age. Being overweight is the major cause of type 2 diabetes and is also an important risk factor for coronary heart disease, **peripheral vascular disease**, dementia, and cancer. The **metabolic syndrome** is a term used by clinicians and scientists to describe the co-occurrence of several known cardiovascular disease risk factors, including insulin resistance, obesity, high blood cholesterol, and high blood pressure **(hypertension)**. All these risk factors are more prevalent in people who are carrying too much weight or an excess of fat, particularly around the waist (called **visceral fat**).

What the Science Tells Us About the Genetics of Obesity

To study the influence of genetics on the effects of overfeeding, identical twins were investigated. In one study, identical (monozygotic) twins were submitted to an energy surplus of 1,000 **kcal**/day (4.2 **MJ**/day) six days per week for 100 days. The excess energy intake over the entire period was 84,000 kcal (353 MJ). The average gain in body mass was 8.1 kg, but considerable variation between individuals was evident. The range of weight gain was 4.3 to 13.3 kg, and the variation between 12 different pairs of twins was more than three times greater than the variation within pairs (which averaged 1.8 kg), suggesting an important genetic component (figure 1.1a). The variation between pairs was even greater for changes in visceral fat, indicating that the site of storage is also partly genetically determined.

Similarly, when seven pairs of identical twins completed a weight loss protocol by exercising over a period of 93 days without increasing energy intake, more variation occurred between pairs than within pairs. The energy deficit was estimated to be 58,000 kcal (244 MJ), and the mean body-weight loss was 5.0 kg. The range of weight loss, however, was 1.0 to 8.0 kg whereas the average difference within pairs was only 1.4 kg as illustrated in figure 1.1b.

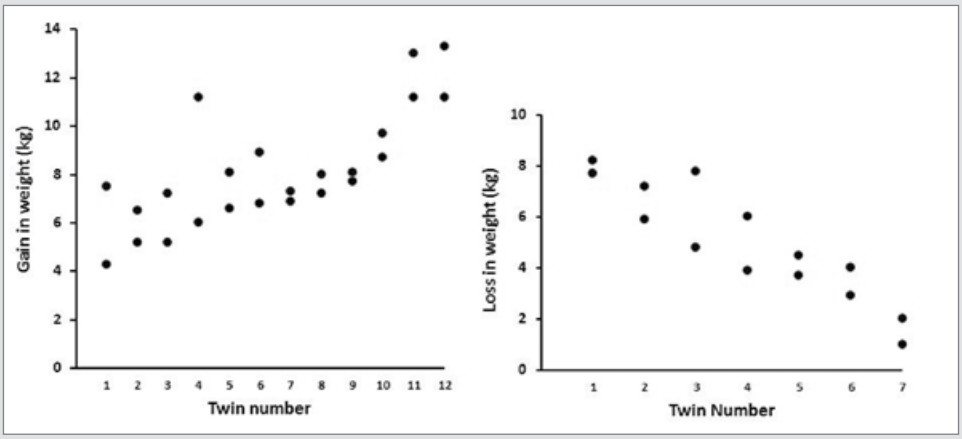

Figure 1.1: Changes in body mass in identical twins (a) after overfeeding and (b) after being subjected to a negative energy balance by exercise. Considerably more variation occurred between pairs than within pairs, strongly suggesting a genetic component in the regulation of body mass. Data from Bouchard et al. (1990) and Bouchard et al. (1994).

Our tendency to put on weight is partly due to our behaviors with regard to eating too much, exercising too little, and not getting good quality sleep, but a significant portion of the variation in body-fat levels between individuals is genetically determined, though not quite as much as you might think. Perhaps 25% to 40% of the fat stored in our body is the result of our genes that influence both our metabolic efficiency and, at least to some degree, our preferred behaviors (e.g.,

whether we enjoy or hate exercise, whether we need relatively little or lots of sleep to function well, and whether we are "night owls" or "morning people"). Genetic factors also determine the susceptibility to gaining or losing body fat in response to dietary energy intake and exercise.

Several classic early studies (see the sidebar) have demonstrated a genetic factor in the development of obesity. This link has been confirmed by large scale studies that have analyzed the contribution of potential genetic and environmental risk factors, identified at the molecular level, to the patterns and causes of obesity in defined populations (known as **molecular epidemiology studies**), and now more than 250 **genes** are believed to have the potential to influence body fatness.

Several of the risk factors known to be associated with weight gain, such as a low **resting metabolic rate**, high reliance on **carbohydrate** metabolism, and a lower level of spontaneous physical activity, almost certainly have a genetic basis. But the relative contribution of genetic versus environmental (lifestyle-related) factors is still a subject of debate. You can't do anything to modify your genes, but you can decide to adopt behaviors that will reduce your risk of becoming overweight. These behaviors include your eating, exercising, and sleeping habits (figure 1.2) as will be explained in detail later in this book.

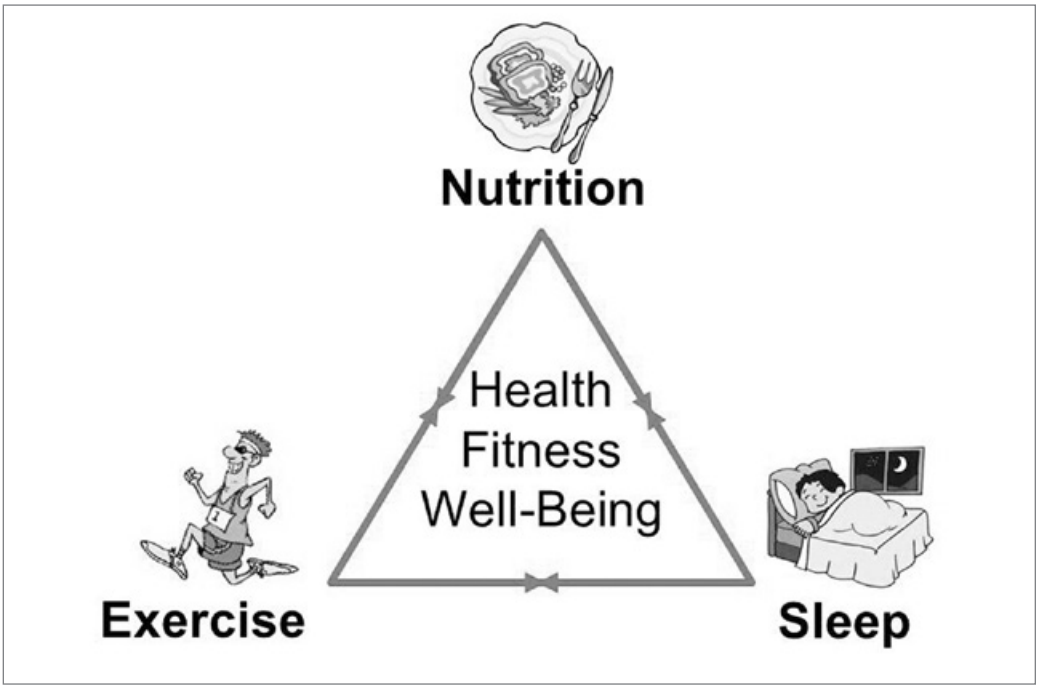

Figure 1.2: Our nutrition, exercise, and sleep behaviors have important influences on our health, well-being, and longevity. Note the bidirectional arrows in the triangle indicating that (a) nutrition and sleep affect our ability to exercise, (b) nutrition and exercise affect how we sleep and (c) exercise and sleep influence our nutrition (appetite and food choices).

TAKING CONTROL

So, we can't control our genetics, but we can control how we live and what we eat. Nourishing our bodies by eating a healthy diet, maintaining an equal balance between energy intake and energy expenditure, not smoking, and doing some form of regular exercise are the most important things you can do to prevent the accumulation of body fat and the development of chronic health conditions like type 2 diabetes, heart disease, cancer, and dementia. Getting sufficient amounts of good quality sleep is also now recognized as having an important influence on our eating habits, our risk of chronic diseases, as well as our mood, and mental health.

Research shows that in order to maintain a healthy weight, eating appropriate amounts of a healthy diet is very important. After all, you can take in calories from food and beverages much faster than you can burn them off with metabolism and exercise! The US Office of Disease Prevention and Health Promotion recommends eating a variety of fruits and vegetables, whole grains, low-fat dairy, and lean sources of protein, while limiting sodium, added sugars, alcohol and fats, particularly saturated and trans fats. This is sound advice, but the devil is in the details; for example, do you know what *trans* fats are, or what the main sources of sodium in the diet are, or what amounts of sugar or alcohol are considered to be too much? After all, in reality we eat foods, not nutrients. Knowing what you are eating and understanding the consequences of consuming excess amounts of certain nutrients or food groups can empower you in selecting foods from the myriad of options displayed on the supermarket shelves. These important issues are covered in the next three chapters.

Regular physical activity can also help with weight control and allow us to enjoy eating well without going over the calorie limit, which would lead to putting on body fat and body weight. Exercise itself brings health benefits that will enhance your quality of life and reduce the risk of many health problems and potential disabilities that can develop as we get older. Another problem with aging is that we tend to lose muscle mass (the medics call this **sarcopenia**), which means that we become weaker and at some point may be no longer able to function independently (for example, you need a certain amount of leg strength just to get up from an armchair or the toilet!). Regular exercise, and in particular **resistance exercise**, together with appropriate ingestion of dietary protein, can help to maintain muscle mass across the lifespan. Chapter 9 describes how your body adapts to doing regular moderate exercise, and the various health benefits that ensue. In short, some regular moderate exercise in combination with good nutrition can help you stay healthy, live longer, and be happier. Knowing what types of exercise are best, and understanding how your body adapts to exercise, how much is needed for health benefits, and just how many calories you are burning in different activities will allow you to decide what is best for you and what is easiest to fit into your normal daily routine.

Poor sleep quality (e.g., regular awakenings during the night, sleeping lightly or sleeping for less than seven hours per night) can be detrimental to both your short-term and long-term health. Poor sleep quality will make you feel tired during the day time, will negatively affect your mood, and contribute to the development of mental health problems. But don't despair; there are several things you can do to help you sleep better, and these are explained in chapter 10.

Another very important aspect of a healthy lifestyle is having good mental well-being. This is sometimes taken to mean that you are simply free from depression or mental illness, but again, just like with health in general, we should be aiming to have optimal mental well-being (i.e., feeling as good as we can be) as part of our overall aim to have optimal health. Having good mental well-being can be said to underpin all aspects of living healthily and not just managing and recovering from illness or coping with living with long-term illness conditions. Mental well-being encompasses our emotional, psychological, and social well-being, and it affects how we think, feel, and act. It also influences how we react to stress and cope with problems, how we communicate with others, and the decisions and choices that we make in our daily lives. Nurturing our brains through things that stimulate us to think, understand, solve problems, and promote our enjoyment of life (e.g., listening to music, watching a theater show or movie, reading a book, or playing a favorite sport) can also help us combat or prevent depression and other mental health problems that are sometimes associated with a chronic physical illness and aging. In some cases, good mental well-being can even prevent the onset or relapse of a physical or mental illness. For example, it is known that being able to cope well with stress can have a positive impact on delaying coronary heart disease and stroke. Being happy provides a great boost to mental well-being. For many people, happiness comes from knowing you are loved, valued, respected, or cared for by others and the enjoyment that comes from doing things we like such as being outdoors in good weather, going on holidays, playing with children or pets. Just being nice to others can make us feel good, too. More information about keeping our brains active and healthy can be found in chapter 12. Figure 1.3 summarizes the various components of a healthy lifestyle, and much of the content of this book is devoted to explaining how we can ensure that we include them in our lives to get as close as we can to the ideal of optimal health.

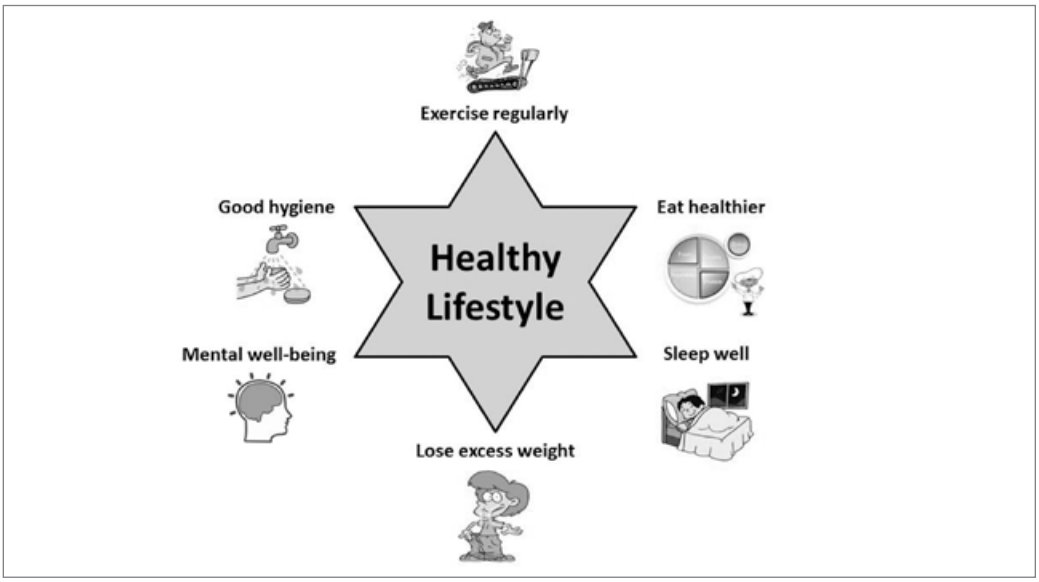

Figure 1.3: Components of a healthy lifestyle that can reduce our risk of disease and extend our longevity. If any of these components is missing, it is unlikely that we will attain optimal health (i.e., as good as it can be). This is not a comprehensive list. For example, avoiding drinking excess alcohol, practicing safe sex, and keeping well hydrated by drinking plenty of water could also be included.

Reading this book will help you to understand the science that underpins the advice and recommendations about a healthy lifestyle. Many people are at least slightly overweight and want to know how to lose weight effectively but with as little disruption to their normal lifestyle as possible. This book can help you with that too. Chapters 7 and 8 discuss the various ways in which you can lose body fat by dieting and exercising, respectively. Chapter 13 provides all the information you need to develop your own personalized weight loss plan involving a combination of multiple diets with a selection of suitable exercises that should see you lose about 7 kg (15 lbs.) of body fat in just 10 weeks. Example meal plans for the different weight loss diets are provided in chapter 14. Chapter 11 explains how to minimize your risk of picking up infections, and chapter 12 provides useful tips on how to maintain the health of your senses, tissues, and organs throughout your lifespan.

Each of the chapters that follow begins with a list of objectives that explain what you should learn from the chapter. These objectives can be used to preview the chapter and to check whether you have achieved the objectives after reading the chapter. As mentioned previously, key terms (in **bold**) are defined in the text, and these, as well as many other terms that may not be familiar to readers without a science background, are defined in the glossary. Chapters are organized to promote learning of concepts and ideas rather than simple memorization of facts and figures. The illustrations and tables used in each chapter help accomplish this goal, as do occasional sidebars, which provide more detailed, in-depth coverage of selected topics, or summarize some important guidelines. At the end of every chapter, a list of the key points reemphasizes the important messages that you should take away from each chapter. In-text citations (i.e., references to the published scientific literature) are not included so as not to interrupt the flow of the writing, but at the end of the book there is a list of selected reference sources that I have used to compile this book and for the reader who wants to delve into more detail. The appendices provide at-a-glance information on the **recommended dietary allowances** (RDAs) or their equivalents for adults in North America, the UK, Australia and New Zealand.

A NOTE ABOUT RELATIVE RISK

In this book you will read about many scientific studies that report the relative health risks of certain lifestyle behaviors, such as being sedentary, eating too much sugar and fat, smoking, drinking alcohol, etc. It is important to realize that the comparisons of risk are made relative to the average person who, for example does some exercise, consumes an average amount of sugar or fat, does not smoke or does not drink alcohol. It is not to say that the risk of health problems in these people with healthy habits is zero. Everyone has a certain degree of risk for a particular health problem like heart disease, type 2 diabetes, or cancer, but the risk of some diseases can be increased above the average by unhealthy lifestyle behaviors. Let's take alcohol as an example. A massive global study published in the Lancet in 2018 concluded that there is no safe level of alcohol consumption. In other words, drinking even one glass of wine or beer per day increases the risk of health problems such as cancer, injuries, and infectious diseases (see chapter 4 for an in-depth discussion of this topic). But the increased risk to health of having just one alcoholic beverage per day is only 0.5% and this would probably not dissuade people from having a daily

glass of wine with their meal. Indeed, Prof David Spiegelhalter, Winton Professor for the Public Understanding of Risk at the University of Cambridge, UK, has sounded a note of caution about such findings. He has said, "Given the pleasure presumably associated with moderate drinking, claiming there is no safe level *(of drinking)* does not seem an argument for abstention." He added, "There is no safe level of driving, but the government does not recommend that people avoid driving." He finished with the comment, "Come to think of it, there is no safe level of living, but nobody would recommend abstention." Bear his comments in mind when you read about relative risk in this book. Of course, this does not apply to all potentially unhealthy lifestyle behaviors. Take smoking for example. Having just one cigarette per day has been reported to increase the risk of **coronary heart disease (CHD)** by over 50%, and that should be interpreted as a very good reason for not smoking at all. Some risks are bigger than others, and what decisions you make about changes to your current lifestyle should be well-informed ones that take into account the magnitude of any relative risk.

Key Points

- By being healthier, fitter, and stronger we can lead more fulfilling and enjoyable lives, live independently for longer, and actually live longer.
- Being obese or just overweight increases the risk of developing chronic metabolic and cardiovascular diseases and dying at an earlier age.
- Optimal health is a state of complete physical, mental, and social well-being and not merely the absence of illness, disease, or infirmity. Optimal health is not just what we need to survive but what we can do to attain the best possible health outcomes that will enable us to improve our quality of life, not only in the present, but also in the future.
- Our tendency to put on weight is partly due to our behaviors with regard to eating, exercising, and sleeping, but a significant portion of the variation in body-fat levels between individuals is genetically determined. We can't control our genetics, but we can control how we live and what we eat.
- Nourishing our bodies by eating a healthy diet, maintaining an equal balance between energy intake and energy expenditure, not smoking, and doing some form of regular exercise are the most important things you can do to reduce your risk of accumulating body fat, and developing chronic health conditions like type 2 diabetes, heart disease, cancer, and dementia.
- Exercise brings a variety of health benefits that will enhance your quality of life as you get older and reduce the risk of many health problems and potential disabilities. It may well help you live independently and healthily for longer.
- Getting sufficient amounts of good quality sleep also has an important influence on your eating habits and risk of chronic diseases as well as your mood and mental health.
- In addition to regular exercise, a healthy diet, good sleep quality, and other lifestyle behaviors can be employed to help maintain the health of your senses, tissues, and organ systems throughout the lifespan.

Chapter 2

Know What You Eat

Objectives

After reading this chapter, you should:

- Know the main components of a normal Western diet
- Know the main classes of nutrients
- Understand the different types of carbohydrates (monosaccharides, disaccharides, polysaccharides, and dietary fiber) and their main functions in the body
- Understand the functions of fats (lipids), the differences between saturated and unsaturated fatty acids, and the differences between ***cis*** and ***trans*** **fatty acids**
- Know the functions of protein in the body
- Understand the general role of water in the human body
- Know the different classes and the general role of micronutrients in the human body

If you want to have a healthy diet and before you even think about restricting dietary energy intake to lose weight, it helps to know something about the nature of the food you eat. This will help you to decide which type of diet is best for you. It will also help to ensure that you choose healthy options and understand why you should never cut out any major food group or major nutrient from your diet whether trying to lose weight or simply maintain your current weight. It should also help you understand why "a healthy diet" is not just about the number of calories you eat, and that other aspects of the diet, such as the amount and quality of protein, the amount and type of fat you consume, and vitamin and mineral needs must also be considered in order to eat healthily.

WHAT ARE NUTRIENTS?

The food that we eat contains **nutrients** and is part of our **nutrition**. Nutrition is often defined as the total of the processes of ingestion (eating and drinking), **digestion** (breaking down), **absorption** (moving nutrients from the gut into the blood), and metabolism (processing) of food, and the subsequent assimilation of nutrient materials into the **tissues** and organs. A **nutrient** is a substance found in food that performs one or more specific functions in the body.

The body requires substantial amounts of certain nutrients every day, whereas other nutrients may be ingested only in small amounts. Nutrients for which the daily intake is more than a few grams are usually referred to as **macronutrients**. Macronutrients are carbohydrates, fats, proteins, and water. Nutrients that are needed in only small amounts (less than 1 g/day) are referred to as **micronutrients**. Most nutrients are micronutrients, and they consist of **vitamins**, **minerals**, and **trace elements**. Many micronutrients (including all of the vitamins) are essential for our health, and deficiencies result in disease states (e.g., **scurvy** when vitamin C intake is inadequate, and **anemia** when iron intake is inadequate). There are also some plant-derived micronutrients that are called **phytonutrients**, and although not considered **essential nutrients**, many may be needed for optimal health. The latter is a term that is referred to repeatedly in this book and for good reason. Everyone's aim should be to have the best health that is achievable, and this is more than just aiming to avoid diseases caused by inadequate or excessive intake of certain nutrients.

This chapter discusses the properties and functions of various components of the diet – including the macronutrients, micronutrients and phytonutrients – and the subsequent chapter explains why we have **recommended daily intakes** of various nutrients and what these are.

FUNCTIONS OF NUTRIENTS

Food provides nutrients that have one or more physiological or biochemical functions in the body. Nutrients are usually divided into six different categories: carbohydrates, fats, proteins, water, vitamins, and minerals.

The functions of nutrients are often divided into three main categories:

- *Promotion of growth and development.* This function is mainly performed by **proteins**. Muscle, soft tissues, and organs consist largely of protein, and protein is required for any tissue growth or repair (e.g., following injury or illness). In addition, calcium and phosphorus are important building blocks for the bones and teeth.
- *Provision of **energy***. This function is predominantly performed by **carbohydrates** and **fats**. Although protein can also function as a fuel, its contribution to energy expenditure is usually small, and energy provision is not a primary function of protein.
- *Regulation of metabolism.* Nutrients used in this function are vitamins, minerals, trace elements, and proteins. **Enzymes** are proteins that play an important role as **catalysts**,

allowing metabolic reactions to proceed at much faster rates than they would spontaneously. An example of an enzyme is lipase, which breaks down the storage form of fat (known as **triglyceride**) in white **adipose tissue** and muscles. Another important protein, though not an enzyme, is **hemoglobin**, which is found in **erythrocytes** (red blood **cells**). Erythrocytes are essential for the transport of oxygen from the lungs to the tissues, and the hemoglobin **molecule** acts as an oxygen carrier. The hemoglobin molecule is a complex of protein (**polypeptide** chains) and nonprotein groups (in this case porphyrin rings) that hold iron (to which oxygen molecules can be bound). For the synthesis of this complex, other enzymes, minerals and vitamins are required. Thus, the interaction between vitamins, minerals, and proteins in the regulation of metabolism can be quite complicated.

Categories of Nutrients

Macronutrients are present in relatively large amounts in the human diet, whereas micronutrients are present in minuscule amounts.

The macronutrients are:

- Carbohydrate
- Fat
- Protein
- Water

The micronutrients are:

- Vitamins
- Minerals (including the trace elements)

CARBOHYDRATE

The name carbohydrate indicates molecules built of carbon (carbo, C) and hydrogen (hydrate; water, H_2O). The general formula of a carbohydrate molecule is CH_2O. In other words, the ratio of carbon, hydrogen, and oxygen is 1:2:1 in all carbohydrates. A carbohydrate can be one or a combination of many of these CH_2O units, and this is often written as $(CH_2O)n$, where n is the number of CH_2O units. For example, in **glucose** (which is the sugar in our blood), n = 6; indicating that a molecule of glucose contains 6 carbon **atoms**, 12 hydrogen atoms, and 6 oxygen atoms and has the chemical formula $C_6H_{12}O_6$. Sugars like glucose, **fructose** (fruit sugar) and **sucrose** (cane sugar) are collectively known as **saccharides** meaning "sugar" or "sweet". The chemical

structure of glucose is depicted in figure 2.1. Glucose is formed during photosynthesis in plants, and we obtain almost all our carbohydrates from plants. Carbohydrates, however, can be found in all living cells and are an important source of energy. In plants, the main storage form of carbohydrate is a glucose polymer called starch, whereas in animals its equivalent is called **glycogen** (both are illustrated in figure 2.1). These large molecules which may contain thousands of linked glucose molecules are called **polysaccharides**.

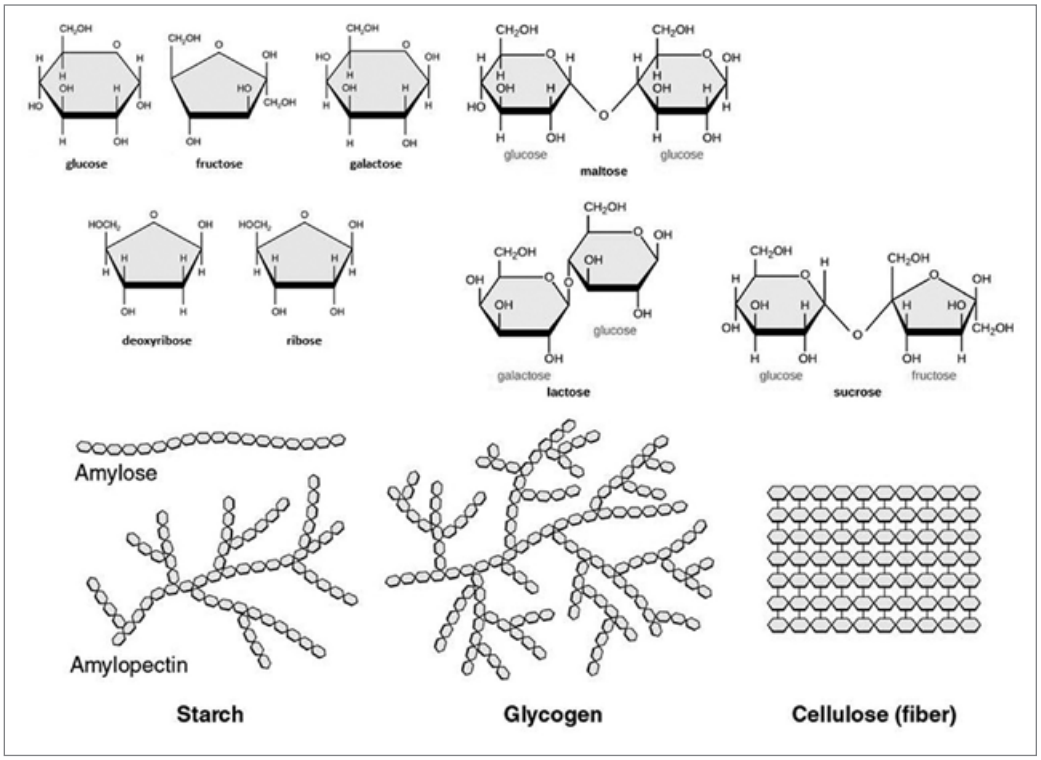

*Figure 2.1: Carbohydrates and their structures. Human nutrition includes three 6-carbon **monosaccharides** (glucose, fructose, and galactose), two 5-carbon monosaccharides (deoxyribose and ribose which found in DNA and RNA, respectively) and three **disaccharides** (maltose, sucrose, and lactose). Glucose polymers (polysaccharides), starch, glycogen and cellulose (an indigestible plant fiber) are a series of coupled glucose molecules in the form of long single chains or larger branched, tree-like structures.*

Carbohydrate-rich foods include bread, cereals, corn, grains, potatoes, pasta, and rice, which contain mostly starches and fiber, but a large percentage of carbohydrate intake in the Western world comes from sugar (for examples of carbohydrate sources see table 2.1 and photo 2.1). The most important carbohydrates in our diet are glucose, fructose, sucrose, short-chain glucose polymers **(maltodextrins)**, and starch **(amylopectin)**. Carbohydrates are typically divided into monosaccharides, disaccharides, polysaccharides, and **fiber**. The different classes of carbohydrate and some typical examples are shown in table 2.2.

Table 2.1: Types of carbohydrates and their food sources

Carbohydrate	Carbohydrate-rich foods
Sugars (simple carbohydrates)	Fruit juices, fruits, sweetened cereals and baked goods, candy, sweets, soft drinks, energy drinks, sports drinks, beet and cane sugar, brown sugar, table sugar, maple syrup, honey, treacle
Starches	Cereal products, corn, potatoes, sweet potatoes, pasta, macaroni, rice, bread
Fiber	Whole-grain cereals and breads, oats, dried beans and peas, fruits, and vegetables such as cabbage, zucchini (courgette), celery, spinach and salad leaves

Photo 2.1: A variety of high-carbohydrate foods

Table 2.2: Classes of carbohydrates

Carbohydrate	Examples and common sources
Monosaccharides	Glucose (grape sugar, blood sugar)
	Fructose (fruit sugar)
	Galactose (brain sugar)
Disaccharides	Maltose (malt sugar)
	Sucrose (table sugar, cane sugar, or beet sugar)
	Lactose (milk sugar)
	Trehalose (mushroom sugar, shrimp and insect sugar)
	Isomaltulose (sucrose substitute; small amounts found in honey)
Polysaccharides	Maltodextrin (sports drinks)
	Oligosaccharides (most vegetables)
	Starch (main plant polysaccharide)
	Amylose
	Amylopectin
	Glycogen (liver, muscle; main animal polysaccharide)
Fiber	Cellulose
	β-glucans
	Gums
	Pectins
	Hemicellulose
	Resistant starch (some forms)

THE SIMPLE SUGARS: MONOSACCHARIDES AND DISACCHARIDES

The monosaccharides represent the basic unit of a carbohydrate, and three monosaccharides—glucose, fructose, and galactose—are present in our diet. Glucose is often called dextrose or grape sugar, and fructose is commonly referred to as fruit sugar. Galactose is usually present in only small amounts in our diet, but relatively large amounts are released after the digestion of the disaccharide milk sugar (lactose). The monosaccharides glucose, fructose, and galactose have a similar structure, the same chemical formula ($C_6H_{12}O_6$), and an identical number of carbon, hydrogen, and oxygen atoms, but slightly different carbon–hydrogen–oxygen linkages (see figure 2.1) give these molecules different biochemical characteristics. Glucose is the only carbohydrate that can be oxidized in the cells of the body. Fructose and galactose must be converted into glucose before they can be oxidized. The conversion of fructose and galactose into glucose occurs in the liver at relatively slow rates.

Disaccharides are a combination of two monosaccharides. Disaccharides and monosaccharides are collectively called sugars, simple sugars, or simple carbohydrates. The most important disaccharides are sucrose, **lactose**, and **maltose (figure 2.1)**. Sucrose, which is mainly derived from cane or beet, is by far the most abundant dietary disaccharide and currently provides about 20% to 25% of the daily energy intake in the Western world. Sucrose is composed of a glucose molecule linked to a fructose molecule. Foods that contain sucrose include beet and cane sugar, brown sugar, table sugar, maple syrup, treacle, and honey. Lactose, or milk sugar, is found in milk and consists of glucose and galactose. Maltose, or malt sugar, is present in beer, cereals, and germinating seeds and consists of two linked glucose molecules. Maltose is present in only relatively small amounts in our diet.

THE COMPLEX CARBOHYDRATES: OLIGOSACCHARIDES AND POLYSACCHARIDES

Oligosaccharides are three to nine monosaccharides combined and can be found in most vegetables. Polysaccharides contain 10 or more monosaccharides combined in one molecule. Polysaccharides can contain 10 to 20 monosaccharides (often referred to as glucose polymers, or maltodextrins) or up to thousands of monosaccharides (starch, glycogen, or cellulose, and other forms of fiber). Starch, glycogen, and cellulose (figure 2.1) are the predominant forms of polysaccharides. Starch and glycogen are the storage forms of carbohydrate in plants and animals, respectively, whereas cellulose is a structural component of plant cell walls.

Starch, or **complex carbohydrate**, is present in seeds, rice, corn, and various grains that are used to make bread, breakfast cereals, pasta, and pastries. Starch is the storage form of carbohydrates in plants. There are two structurally different forms of starch known as amylopectin and **amylose**. Amylopectin is a highly branched molecule consisting of a large number of glucose molecules, whereas amylose is a long chain of glucose molecules (200–4,000) twisted into a coil. Starches with a relatively large amount of amylopectin are rapidly digested and absorbed, whereas those with high amylose content are digested more slowly. Most starches contain both amylose and amylopectin, and the relative contribution determines the properties of the food. For example, the quantity of amylose in rice kernels has a big effect on the properties of cooked rice kernels. That is, boiled or fried rice with little amylose will be sticky and soft, whereas rice with a large amount of amylose will be harder and much less sticky. Approximately 50% of our total daily carbohydrate intake is in the form of starch.

Glycogen is the storage form of carbohydrate in animals, including humans. It is stored mostly in the liver (80 to 100 g) and in skeletal muscles (300 to 900 g), and its structure is similar to amylopectin. It is very important as a fuel for prolonged, intensive exercise. However, it is not an important source of carbohydrate in our diet.

Fiber used to be known as roughage. It comprises the edible parts of plants that are not broken down and absorbed in the human **gastrointestinal tract**. Fiber consists of structural plant polysaccharides such as **cellulose**. The human small intestine has no enzymes to break down these polysaccharides (and so they cannot be digested here; some digestion can occur, however, in the large intestine due to the presence of large numbers of bacteria). Although cellulose may be

the most common type of fiber, there are many other types of fiber including gums, hemicellulose, β-glucans, and pectin.

Dietary fiber is also often divided into soluble and **insoluble fiber**. **Soluble fiber** dissolves well in **water**, whereas insoluble does not. Both types of fiber are present in plant foods. Some plants contain more soluble fiber, and others have more insoluble fiber. For example, plums have a thick skin covering a juicy pulp. The skin is an example of an insoluble fiber source, whereas the pulp contains soluble fiber sources. Soluble fiber undergoes metabolic processing through fermentation by bacteria that are present in our large intestine, yielding end products such as **short-chain fatty acids** that can be absorbed and have broad, significant health effects. Good sources of fiber are listed in table 2.3, and several can be seen in photo 2.2.

Table 2.3: Dietary fiber and food sources

Type of fiber	Food sources
Soluble fiber	Legumes (peas, soybeans, and other beans)
	Oats, rye, and barley
	Some fruits and fruit juices (particularly prune juice, plums, and berries)
	Certain vegetables such as broccoli and carrots
	Root vegetables such as potatoes, sweet potatoes, and onions (the skins of these vegetables are sources of insoluble fiber)
Insoluble fiber	Whole-grain foods
	Bran
	Nuts and seeds
	Vegetables such as green beans, cabbage, cauliflower, zucchini (courgette), and celery
	Skins of some fruits, including grapes, plums, and tomatoes

Photo 2.2: A variety of high-fiber foods

FUNCTIONS OF CARBOHYDRATE

All carbohydrates contain about 4 kilocalories (kcal) or 17 kilojoules (kJ) of energy per gram and they play an important role in energy provision for many cells of the body but particularly for those in the brain, nerves, muscles, and blood. Energy is considered in detail in chapter 5. Carbohydrates are the predominant fuel used during moderate to high intensity exercise. Carbohydrate is stored in relatively small amounts as glycogen in muscle and liver and can become completely depleted after prolonged strenuous exercise. This can result in fatigue, and in marathon running it is commonly referred to as "hitting the wall". Ingestion of carbohydrate will rapidly replenish carbohydrate stores, and excess carbohydrate from food is converted into fat and stored in adipose tissue.

In normal conditions, blood glucose is the only fuel used by the nerve cells of the brain and spinal cord (known collectively as the central nervous system). After prolonged **fasting** (about three days), **ketone bodies** are produced by the liver (from **fatty acids**), which can serve as an alternative fuel for the central nervous system. The central nervous system functions optimally when the blood glucose concentration is maintained above 4 **millimoles** per liter (mmol/L). Normal blood glucose concentration is about 5 mmol/L (equivalent to 0.9 g/L). At concentrations below 3 mmol/L, symptoms of **hypoglycemia** (low blood sugar) may develop, including weakness, hunger, dizziness, and shivering. Prolonged and severe hypoglycemia can result in unconsciousness, coma, and irreversible brain damage. Therefore, tight control of blood glucose concentration is crucial. Blood glucose also provides fuel for the red and **white blood cells**. New dietary guidelines for children