CHAPTER 16

The Nutrition Connection

After completing this chapter you should be able to:

- describe the anatomy and physiology of the digestive system;
- identify the nutritional requirements and components of a healthy diet;
- outline the official nutritional advice provided for the United States;
- explain the unique nutritional needs of various populations;
- describe the effects of nutrition on athletic performance.

Not all the factors associated with health can be controlled, but your attitude and habits related to diet can influence your health in a positive way. The role of diet in overall health is significant and has profound effects on general well-being. Poor diets are often associated with disease and illness, but healthy diets can be sources of energy and vigor. Choosing foods that provide the necessary nutrients, while limiting those associated with disease, can therefore significantly affect the course your life and health will take. Furthermore, proper nutrition is essential for getting the competitive edge that athletes require to win, since it allows the body to perform at its best.

An understanding of what constitutes a healthy diet will allow you to make informed decisions about your nutrition-related concerns. While you should enjoy eating well and staying active, you must not assume that a healthy diet needs to be restricted to fat-free, low-sugar, and high-fiber foods all the time; in fact, the basics of a healthy diet are variety, balance, and moderation. And although you don't often hear that you should enjoy eating, this should also be part of a healthy diet. Too often, people are in such a rush to eat that they do not even realize they have eaten! Following these basic rules will effectively guide you to eating sensibly.

It is also important to understand that all foods are good – with one distinction: that some are good to have more often than others. There is nothing wrong with eating ice cream or a candy bar on occasion, just as long as it is *on occasion*. Labeling foods as good or bad sends a negative message about eating that should be avoided. (Note, too, that individuals with specific diseases or food allergies may not be able to eat certain foods.) An overall pattern of healthy eating should be your practical nutritional goal. We must not take for granted the remarkable ability of our bodies to deal with foods and substances over time, because it may catch up with us in the long run.

Students, for example, are faced with nutritional concerns on a daily basis over a simple matter such as what to eat for lunch. Bringing a lunch from home is always an option, but what kind of selection is there in school cafeterias (e.g., nutrition-wise, vegetarian dishes, and so on)? Many students settle for what is available to them, and fast foods (purchased within school cafeterias and from fast food restaurants, which are often conveniently located near schools) would not be considered ideal foods to eat on a daily basis.

A similar concern arises for the regular party-goer whose selection of foods and snacks is often limited to potato chips, cookies, and soft drinks (or alcohol) – all low nutrition-dense choices. It is up to the hosts of these parties, as well as those attending, to ensure that a variety of food is available for those who would prefer to eat on the lighter side. More often than not, however, individuals expect fattier foods at parties and may binge on these foods and beverages. It is important to note that healthier foods can also be very enjoyable, and if offered at a party, people will consume them. Providing different options helps make everyone feel at ease and keeps the occasion enjoyable for all.

Clearly, many issues are related to your nutritional habits, and their impact on your daily life is considerable. This chapter will attempt to outline the dietary recommendations made for the United States, helping you attain the tools necessary to incorporate a healthy diet in your own life.

The Digestive System

You have probably wondered at one time or another how your body uses the food you eat to produce energy, and how energy-rich nutrients, water, and electrolytes are transferred into your body's internal environment. It is largely the role of the **digestive system**, composed of numerous structures and organs that work together, to accomplish this vital task. Although the components of the digestive tract are often discussed as separate structures according to the specialized functions they perform, the tract is actually continuous.

The **gastrointestinal tract** (digestive tract) portion of the system includes the mouth, pharynx, esophagus, stomach, small and large intestines, rectum, and anus; the **glandular organs** involved in the process include the salivary glands, liver, gallbladder, and pancreas (Figure 16.1). This effective organization allows food to be ingested and processed into forms that can be absorbed and used by the body. Keep in mind that the contents of the digestive tract actually remain part of the external environment until they have been absorbed across the gastrointestinal wall into the body.

The digestive system performs four basic digestive processes: digestion, secretion, absorption, and motility (Figure 16.2). Because the foods we eat contain nutrients that cannot cross the gastrointestinal wall (such as carbohydrates, proteins, and fats), the process of **digestion** is required to dissolve and break down these foods into molecules that can be absorbed by the body. Digestion works very closely with the **secretion** of numerous substances, including hydrochloric acid by the stomach, bile from the liver, and numerous other digestive enzymes. The **absorption** of the molecules produced by digestion occurs across a layer of epithelial cells lining the gastrointestinal wall to enter blood or lymph, where the circulatory system is able to distribute them to body cells. While foods are being digested, enzymes secreted, and digested molecules absorbed, the digestive tract is exercising **motility** through **peristalsis** – the muscular contractions that move the contents of the digestive tract forward. This process is important not only to propel the contents forward but also to mix food with digestive juices that promote digestion.

> **The Digestive Processes**
>
> The digestive system allows food to be ingested and processed into molecules that can be absorbed and used by the body by performing four basic digestive processes: *digestion, secretion, absorption,* and *motility*.

Although the purpose of the digestive system is to digest then absorb nutrients, some material is obviously excreted via the gastrointestinal tract as waste. This material is **feces**, consisting mainly of bacteria and ingested material that was not digested and absorbed (including fiber). Therefore, this system effectively allows us to absorb what we need and excrete what we don't need. Nonetheless, we do sometimes excrete what we need. Substances such as fiber, oxalates, and phytates can bind with minerals, for example, and prevent their absorption. This does not necessarily mean that you will be deficient in these nutrients, because the body will absorb more of a nutrient if it needs it; however, high consumption of substances that can decrease absorption *may* lead to a deficiency over time.

Functional Overview of the Gastrointestinal Organs

Thus far, we have discussed the functions and processes involved with the digestive system as a whole; but each portion of the system actually performs a specialized role. Digestion begins in the mouth, as chewing breaks food up into smaller pieces (bolus) that can be swallowed without choking. Further, **saliva** produced by three salivary glands in the head contains important mucus that moistens and lubricates food, as well as the enzyme **amylase**, which begins the digestion of carbohydrates.

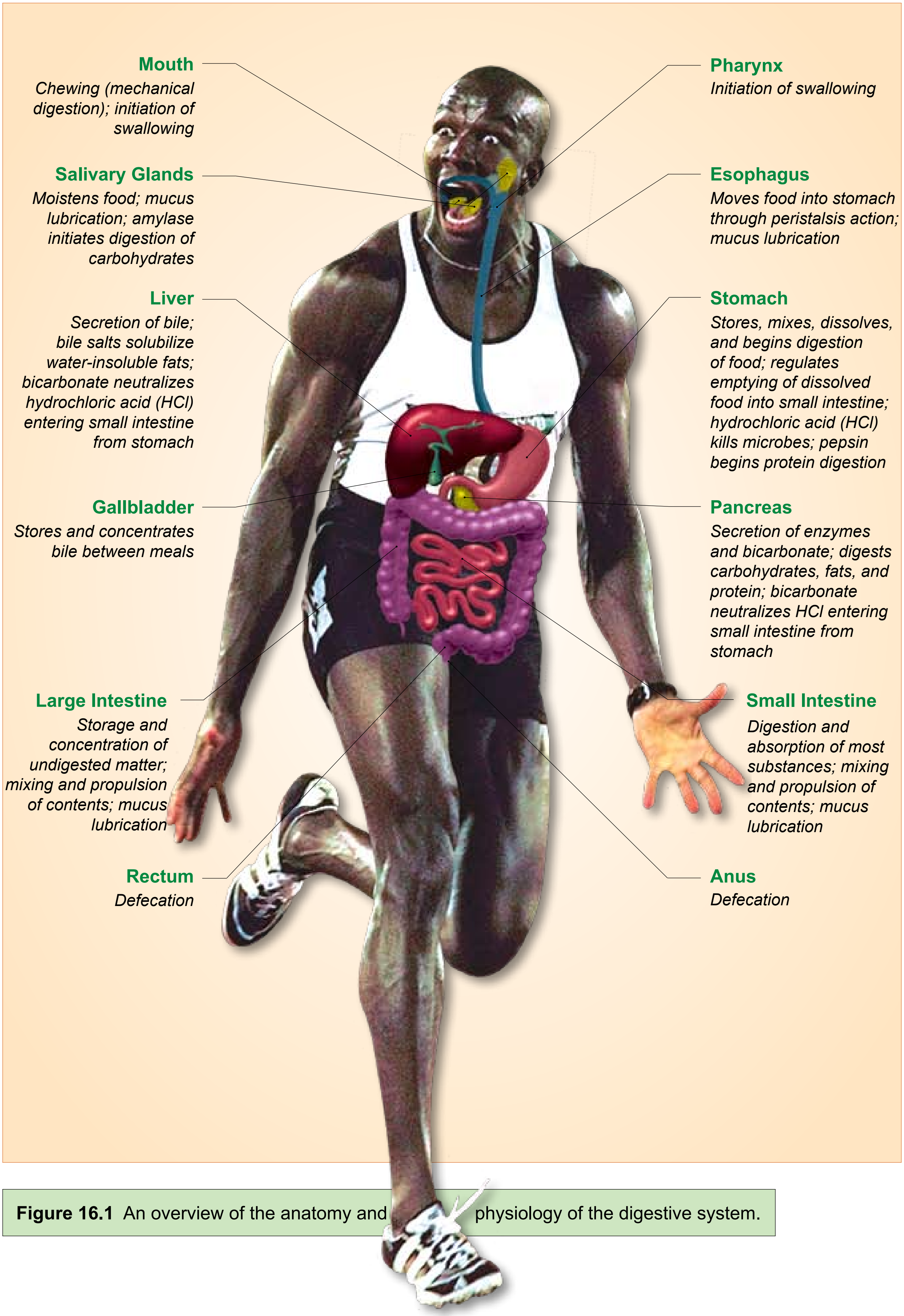

Figure 16.1 An overview of the anatomy and physiology of the digestive system.

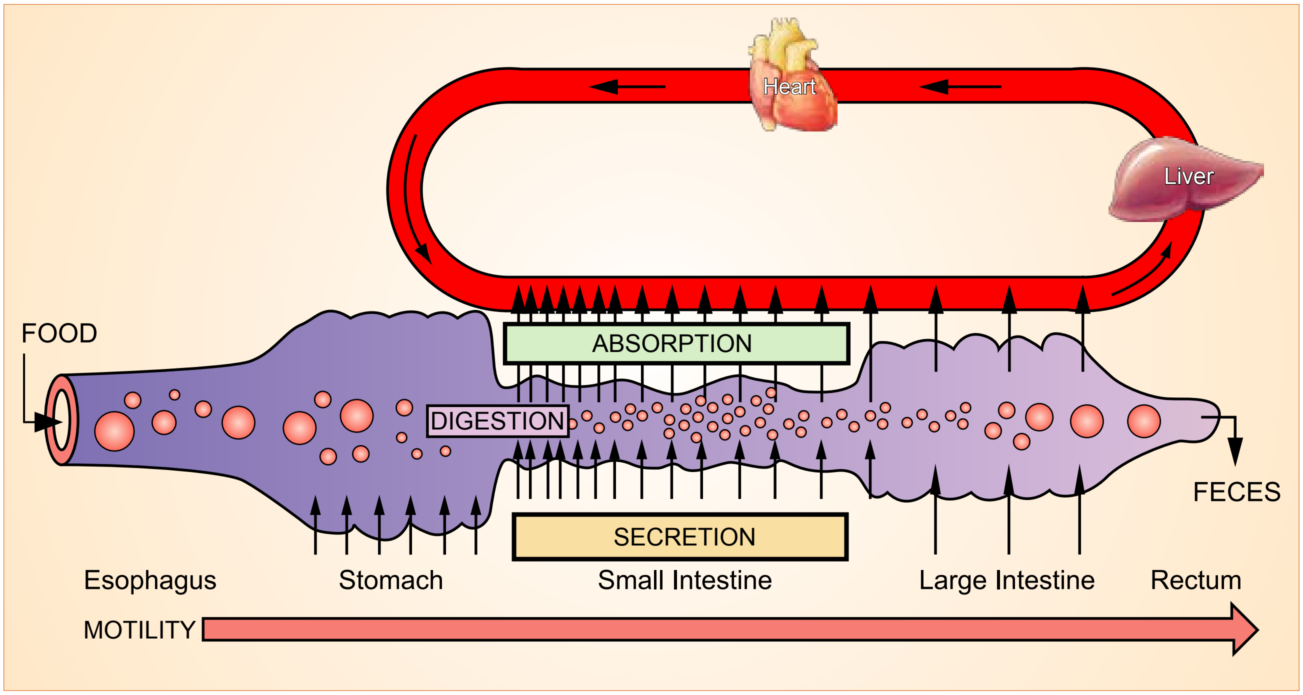

Figure 16.2 Schematic of the basic digestive processes: digestion, secretion, absorption, and motility.

The voluntary act of swallowing, initiated in the posterior mouth or **oropharynx**, results in movement of the food bolus into the **pharynx** and **esophagus**, where involuntary muscular contractions (peristalsis) take over and move the food down into the stomach. The **stomach** (a sac-like organ) serves as a storage site, dissolves and partially digests food, and prepares food for optimal digestion and absorption in the small intestine. Glands in the stomach's lining secrete a strong **hydrochloric acid** that serves to dissolve the particulate matter in food (except fat), and also kills bacteria that may have entered along with the food (though some do survive to flourish in the intestines). An enzyme called **pepsin** is also formed from the secreted precursor called **pepsinogen**. Pepsin begins protein digestion, and amylase (from the salivary glands) continues to break down carbohydrates into smaller fragments. However, despite the digestive actions that occur in the stomach, little absorption occurs across the stomach wall.

The next segment of the tract is the **small intestine**, where digestion is completed and most absorption occurs. The small intestine is approximately 20 feet (6 meters) in length and consists of three segments: the **duodenum**, **jejunum**, and **ileum**. Most absorption occurs in the duodenum and jejunum, including the absorption of vitamins, minerals, and water, which do not require enzymes to be digested. The existing molecules of carbohydrates, proteins, and fats are further broken down by hydrolytic enzymes into monosaccharides, amino acids, and fatty acids (absorbable units) respectively. While some of the necessary enzymes are located on the surface of the intestinal wall, others are provided by the pancreas and liver, which enter the duodenum of the small intestine via ducts.

The **pancreas** secretes both digestive enzymes, for each type of organic molecule, and an alkaline fluid consisting mainly of bicarbonate ions. The latter secretion serves to neutralize the acidic contents coming from the stomach to prevent damage to the small intestine wall and to provide an optimal pH for enzymes to function.

The **liver** also provides an important secretory product – **bile**. While the liver performs a myriad of functions, its exocrine functions related to the secretion of bile will be the focus here. Bile from the liver contains cholesterol, bicarbonate ions (like those from the pancreas), and **bile salts**. Bile salts are essential to the digestion and absorption of dietary fats, as they solubilize fats that are otherwise insoluble in water and convert large fat globules into smaller fat droplets (the process of homogenization). The **gallbladder** serves as a storage site for bile secreted from the liver; during a meal, the walls of the gallbladder contract to move the concentrated bile into the duodenum via ducts to exert its actions (mainly on fat).

In the small intestine, the molecules and ions are absorbed in a variety of ways, including diffusion (fatty acids), osmosis (water), active transport (mineral ions), and carrier-mediated transport (monosaccharides and amino acids). As the motility of the small intestine moves and mixes its contents, the material slowly moves toward the large intestine. By the time the contents reach the **large intestine**, which is approximately six feet in length, very little water, salts, and undigested material are left. It is the role of the large intestine to temporarily store these materials and concentrate them by reabsorbing salt and water. Once this is complete, the material (now feces) is moved to the **rectum** to be eliminated from the body through contractile activities, including associated sphincter muscles (the process is called **defecation**). This completes the long road that food must travel when providing us with the essential nutrients we need to lead a healthy life. The following sections will present the components of a healthy diet, what it means to eat well, and the importance of proper nutrition to healthy living.

Nutritional Requirements: Types and Sources of Nutrients

Nutrition, the science of food and how the body uses it in health and disease, encompasses a wide variety of topics and issues. When you consider what your diet is composed of, you probably think about the foods you eat. Really, what is important is what nutrients are contained in the foods you eat. Your body requires six categories of **essential nutrients**: proteins, fats, carbohydrates, vitamins, minerals, and water. The term "essential" refers to the fact that the body is unable to manufacture these substances (or not in adequate amounts to meet body needs), so they must be obtained from outside the body in the form of food or supplements. We rely on food to provide the nutrients we need to ensure proper growth and development (Figure 16.3). These nutrients are obtained when the foods we eat are digested (broken down) into compounds that can be absorbed and used by the body. It is vital to have a diet containing adequate amounts of all essential nutrients since they provide energy, as well as the ability to help build and maintain tissues and regulate body functions.

Figure 16.3 A balanced diet that includes all the essential nutrients is necessary to promote optimal growth and development.

There are three nutrients that provide your body with energy (**kilocalories**): proteins, fats, and carbohydrates. One kilocalorie (kcal) represents the amount of heat it takes to raise the temperature of 1 kg of water 1 degree Celsius. An average person needs approximately 2,000 kcal per day to meet his or her energy needs. Note that "energy" is the overarching term for kilocalories, calories, kilojoules, megajoules, and the like; different countries use different units to refer to energy. Therefore, "energy" will also be used in this chapter to represent kilocalories. Of the three classes of nutrients that supply energy, fats are the most energy dense, providing 9 kcal per gram.

Kilocalories Versus Calories

In common usage, you will find that kilocalories are often referred to simply as **calories** (i.e., 1 kilocalorie contains 1,000 calories).

In contrast, proteins and carbohydrates each provide 4 kcal per gram. This difference is one reason why fats are recommended to be consumed in smaller amounts. Another source of energy (though not an essential nutrient) is alcohol, which provides 7 kcal per gram. Alcohol has no nutritional value, but its high energy content creates a problem with excess kilocalories being consumed (which often replace energy from nutritional sources).

Energy Densities of Various Energy Sources

Fats	9 kcal per gram
Alcohol	7 kcal per gram
Carbohydrates	4 kcal per gram
Proteins	4 kcal per gram

Energy needs are not our only concern. We also need a balanced intake of all the essential nutrients to achieve optimal growth and development. Just as the human body is largely composed of water (about 60 percent), the major component in foods is also water. Most foods, however, are composed of a mixture of nutrients, including vitamins and minerals, that perform special functions and fill unique roles. We take a closer look at each class of nutrient in the following section.

Proteins

Proteins may be found in every living cell, and they represent the basis of our body structure. Proteins not only provide important structural components or parts for muscles, bones, blood, enzymes, some hormones, and cell membranes but also function as an energy source. Proteins themselves are composed of chains of **amino acids**, the building blocks of life. There are 20 commonly recognized, naturally occurring amino acids; of these, the body can synthesize all but 9 – the so-called **essential amino acids** (*histidine*, *isoleucine*, *leucine*, *lysine*, *methionine*, *phenylalanine*, *threonine*, *tryptophan*, and *valine*).

Because amino acids are the building blocks of proteins, they are essential for our existence. But some sources of proteins are better than others in providing these essential amino acids. Individual protein sources are "complete" if they supply all 9 essential amino acids. Such **complete protein** sources are animal products, such as meat, fish, poultry, eggs, milk, and cheese. Sources of food that do not contain all the essential amino acids are called **incomplete protein** foods. These usually come from plant sources such as grains, beans, peas, and nuts. Although these sources are usually low in 1 or 2 amino acids, they are still good sources of essential amino acids.

Although incomplete protein sources on their own will not provide the appropriate complement of amino acids, various sources may be combined to achieve the full range to make a meal complete (Figure 16.4). This can be particularly important for vegetarians who must prepare meals consisting of plant foods, combining foods that account for the essential amino acids missing in some foods. Some common combinations include peanut butter and bread, rice and beans, milk and cereal, and macaroni and cheese. It used to be thought that protein complementation had to be conducted in the same meal; however, research has shown that as long as people consume different sources of protein

Figure 16.4 Rice and beans are examples of complementary protein sources.

throughout the day, not necessarily within the same meal, they will meet their needs. Nonetheless, most individuals will naturally combine, for example, milk and cereal in the same meal because these foods go well together.

Protein is essential for promoting growth and the maintenance of body tissues; but eaten in excess, protein can pose a problem. Any protein consumed beyond the body's needs is synthesized into fat for storage or used as a source of energy. The **dietary reference intake (DRI)** for protein for adults is 0.8 grams per kilogram of body weight. On average, this equals about 10 to 15 percent of your total daily energy intake; however, the DRI states that the **acceptable macronutrient distribution range (AMDR)** for protein is from 10 to 35 percent for individuals 19 years of age and older. On the other end of the spectrum, a drop in energy intake below your needs can lead to protein being selectively broken down to provide glucose for the body, which can hamper the growth and repair of body tissues. In *extreme* situations where your diet lacks an adequate amount of proteins and carbohydrates, the body turns to its own proteins, which causes damaging muscle wasting. Thus, an intermediate range of kilocalories must be consumed for optimal development. Therefore, starving yourself, even for short periods of time, can lead to muscle being used for energy, which is not a good thing. It is a myth that fat is burned first – protein is used first so your body can protect itself with the fat that surrounds your organs.

Fats

Negative associations around the word "fat" would appear to be general and widespread. Anything in excess can be detrimental to your health, but fat in moderation is essential.

Fat (also known as **lipids**) is an important nutrient in our diets for many reasons. It represents a source of usable energy, serves to insulate our bodies, cushions our organs, is involved in the synthesis of many hormones, and aids in the absorption of the fat-soluble vitamins (which would otherwise pass through our bodies). Further, the presence of fats in foods adds important flavor and texture (palatability), which is one reason why many people find it difficult to cut down on some of their favorite foods (which happen to contain fat). Still, being the most concentrated source of energy, the consumption of fat should be closely monitored. The DRI for fat ranges from 20 to 35 percent of total energy for individuals 19 years of age and older.

The fats in food are mostly in the form of **triglycerides**, composed of groupings of a glycerol (an alcohol) and three fatty acid molecules. Fats can be classified as saturated, monounsaturated, and polyunsaturated, based on the degree of saturation (the number of double bonds contained between the carbon atoms) of the fatty acid molecules. If no double bonds exist, these are **saturated fats**. When one double bond exists, the fatty acids are called **monounsaturated fats**, while those with two or

Figure 16.5 Foods containing high levels of saturated fat have been linked to heart disease.