Chapter Learning Outcomes
After reading Chapter 7, you should be able to:

1. List the primary functions of proteins in the body.
2. Identify the basic structural unit of proteins.
3. Distinguish between essential and nonessential amino acids.
4. Explain the basic steps of protein synthesis and digestion.
5. Discuss conditions that contribute to positive nitrogen balance, negative nitrogen balance, and protein balance.
6. Identify food sources of protein and foods that provide high- and low-quality proteins.
7. Plan meals and snacks that reduce animal protein intakes.
8. Discuss the pros and cons of vegetarian diets.
9. Describe how protein-energy malnutrition (PEM) can affect the body.

Since ancient times, many people have believed that eating animal foods, particularly meat, was necessary for good health and optimal physical performance. Milo of Croton, an ancient Greek Olympian wrestler with extraordinary strength, reportedly consumed about 20 pounds of meat daily. Although accounts of Milo’s superhuman capacity for eating meat are unreliable, modern athletes often make protein-rich foods and
protein supplements the foundation of their diets. Furthermore, it is not unusual for nonathletes to associate meat with protein and a lack of protein with physical weakness.

Protein is an important nutrient, but it is not more valuable to your health than other nutrients. Nutrients work together in your body like members of a well-trained basketball team on the playing court. Making one player the star while neglecting to develop the other athletes’ skills can have disastrous effects on the team’s success. Similarly, overemphasizing one class of nutrients in your diet, such as protein, while ignoring other nutrients, can lead to nutritional imbalances that result in health problems and poor functioning.

What Are Proteins?

Proteins are complex organic molecules that are chemically similar to lipids and carbohydrates because they contain carbon, hydrogen, and oxygen atoms. Proteins, however, contain nitrogen, the element cells need to make a wide array of important biological compounds. Plants, animals, bacteria, and even viruses contain hundreds of proteins.

Proteins are necessary for muscle development and maintenance, but the estimated 100,000 proteins in your body have a wide variety of functions. Skin, blood, nerve, bone—all cells in your body—contain proteins. Structural proteins such as collagen are in your cartilage, ligament, and bone tissue. Keratin is another structural protein; it is in your hair, nails, and skin. Contractile proteins in your muscles enable you to move, and the pigment protein melanin determines the color of your eyes, hair, and skin. Proteins are also necessary for your blood to clot properly.

Certain hormones, such as insulin and glucagon, are proteins. Hormones are chemical messengers that regulate body processes and responses, such as growth, metabolism, and hunger. Nearly all enzymes are proteins. Enzymes speed up the rate (catalyze) of chemical reactions without becoming a part of the products (see Fig. 4.8). Additionally, infection-fighting antibodies are proteins. Although cells can use proteins for energy, normally they metabolize very little for energy, conserving the nutrient for other important functions that carbohydrates and lipids are unable to perform.

In the bloodstream, proteins transport nutrients and oxygen. Proteins in blood, such as albumin, also help maintain the proper distribution of fluids in blood and body tissues (Fig. 7.1). The force of blood pressure moves watery fluid out of the bloodstream and into tissues. Blood proteins help counteract the effects

Quiz YOURSELF

How much protein is recommended for optimal health? Can people obtain enough protein by eating only plant foods? What happens if you eat more protein than your body needs? After reading Chapter 7, you will learn to identify good food sources of protein and understand the nutrient’s roles in the body. You will also learn how the amount and quality of the protein in your diet can affect your health. Before reading Chapter 7, take the following quiz to test your knowledge of protein. The answers are on page 221.

1. Animal foods such as meat and eggs are almost 100% protein. ____ T ____ F
2. Foods made from processed soybeans can be sources of high-quality protein. ____ T ____ F
3. An adult bodybuilder should consume about five times more protein than a healthy adult who is not a bodybuilder. ____ T ____ F
4. Registered dietitians generally recommend that vegetarians take amino acid supplements to increase their protein intake. ____ T ____ F
5. People can nourish their hair by using shampoo that contains protein. ____ T ____ F

proteins large complex organic molecules made up of amino acids
hormones chemical messengers that regulate body processes and responses
enzymes compounds that speed up chemical reactions
antibodies infection-fighting proteins

Figure 7.1 Fluid balance. (a) Proteins in blood, such as albumin, help maintain the proper distribution of fluids in blood and body tissues. (b) When blood pressure exceeds counteracting force of blood proteins, fluid remains in tissues, causing edema.
of blood pressure by attracting the fluid, returning it to the bloodstream. During starvation, the level of protein in blood decreases, and as a result, some water leaks out of the bloodstream and enters spaces between cells. The resulting accumulation of fluid in tissues is called edema (eh-dee’mah).

Proteins also help maintain acid-base balance, the proper pH of body fluids. To function properly, blood and tissue fluids need to maintain a pH of 7.35 to 7.45, which is slightly basic. To review the concept of pH, see Chapter 4.) Metabolic processes can produce acid or basic by-products. If a particular body fluid becomes too acidic or too basic, cells can have difficulty functioning and may die. A buffer is a substance or process that weakens an acid or base. Proteins can act as buffers, because they have acidic and basic components. For example, if cells form an excess of hydrogen ions (H$^+$), the pH of tissues decreases. To help restore the pH level to within the normal range, the basic portions of protein molecules bind to the excess H$^+$, neutralizing the excess ions and raising the pH.

### Amino Acids

Proteins are comprised of smaller chemical units called amino acids. The human body contains proteins made from 20 different amino acids (see Appendix E). To understand how the body uses amino acids, it is necessary to learn some basic chemistry that relates to these compounds.

Each amino acid has a carbon atom that anchors three different groups of atoms: the amino or nitrogen-containing group, R group (sometimes called the side chain), and acid group. The chemical structure of the amino acid alanine shown in Figure 7.2 indicates these three groups. Note that the nitrogen atom is in the amino group. The R group identifies the molecule as a particular amino acid, such as serine or lysine. When the nitrogen-containing group is removed, the R group, acid group, and anchoring carbon atom form the "carbon skeleton" of an amino acid (see Fig. 7.2). The carbon skeleton is an important component of an amino acid, because the body can convert the carbon skeletons of certain amino acids to glucose and use the simple sugar for energy.

### Classifying Amino Acids

Traditionally, nutritionists classify amino acids as either nonessential or essential according to the body’s ability to make them. A healthy human body can make 11 of the 20 amino acids. These compounds are the nonessential amino acids. The remaining nine amino acids are essential amino acids that must be supplied by foods, because the body cannot synthesize them or make enough to meet its needs. Sometimes, nonessential and essential amino acids are referred to as "dispensable" and "indispensable" amino acids, respectively. Table 7.1 lists amino acids according to their classification as essential and nonessential.

### Table 7.1 Amino Acids

<table>
<thead>
<tr>
<th>Essential</th>
<th>Nonessential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histidine</td>
<td>Threonine</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>Tryptophan</td>
</tr>
<tr>
<td>Leucine</td>
<td>Valine</td>
</tr>
<tr>
<td>Lysine</td>
<td>Glutamic acid</td>
</tr>
<tr>
<td>Methionine</td>
<td>Serine</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>Arginine*</td>
</tr>
</tbody>
</table>

* Under certain conditions, this amino acid can become essential.
Proteins in Foods

People often associate animal foods with protein, but beans, nuts, seeds, grains, and certain vegetables are good sources of protein too. In fact, nearly all foods contain protein, but no naturally occurring food is 100% protein. Protein comprises only about 20 to 30% of the weight of a piece of beef; 25% of the weight of drained, water-packed tuna fish; and only 12% of an egg’s weight. Nevertheless, animal foods generally provide higher amounts of protein than similar quantities of plant foods. A 3-ounce serving of broiled lean ground beef supplies 23 g of protein; a 3-ounce serving of steamed broccoli or cooked carrots provides only about 1 g of protein. In general, most plant foods provide less than 3 g of protein per ounce. Table 7.2 lists some commonly eaten foods and their approximate protein content per serving.

**TABLE 7.2  Protein Content of Some Commonly Eaten Foods**

<table>
<thead>
<tr>
<th>Food</th>
<th>Serving Size</th>
<th>Protein g/serving</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steak, rib-eye, lean, broiled</td>
<td>4 oz</td>
<td>32</td>
</tr>
<tr>
<td>Chicken, ½ breast, roasted, meat only</td>
<td>3 ½ oz</td>
<td>31</td>
</tr>
<tr>
<td>Ham, lean</td>
<td>4 oz</td>
<td>28</td>
</tr>
<tr>
<td>Pepperoni pizza, regular crust, 14&quot; pie</td>
<td>2 slices (200 g)</td>
<td>25</td>
</tr>
<tr>
<td>Tuna, canned, water-packed, drained</td>
<td>3 ½ oz</td>
<td>17</td>
</tr>
<tr>
<td>Miso (soybean product)</td>
<td>½ cup</td>
<td>16</td>
</tr>
<tr>
<td>Lasagna with meat sauce</td>
<td>8 oz</td>
<td>15</td>
</tr>
<tr>
<td>Cottage cheese, 2% low-fat</td>
<td>3 ½ oz</td>
<td>14</td>
</tr>
<tr>
<td>Milk, fat-free</td>
<td>1 cup</td>
<td>8</td>
</tr>
<tr>
<td>Peanut butter</td>
<td>2 Tbsp</td>
<td>8</td>
</tr>
<tr>
<td>Tofu, regular</td>
<td>½ cup</td>
<td>8</td>
</tr>
<tr>
<td>Bagel, plain</td>
<td>1 (3 ½ &quot; diam)</td>
<td>7</td>
</tr>
<tr>
<td>American processed cheese</td>
<td>1 oz</td>
<td>7</td>
</tr>
<tr>
<td>Baked beans, vegetarian</td>
<td>½ cup</td>
<td>6</td>
</tr>
<tr>
<td>Egg, hard cooked</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Vanilla ice cream</td>
<td>1 cup</td>
<td>4</td>
</tr>
<tr>
<td>White rice</td>
<td>1 cup</td>
<td>4</td>
</tr>
<tr>
<td>Peas, green</td>
<td>½ cup</td>
<td>4</td>
</tr>
<tr>
<td>Banana</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
Certain parts of plants contain more protein than other parts. Seeds, tree nuts, and legumes supply more protein per serving than servings of fruit or the edible leaves, roots, flowers, and stems of vegetables. Tree nuts include walnuts, cashews, and almonds; **legumes** are plants that produce pods that have a single row of seeds, such as soybeans, peas, peanuts, lentils, and beans (Fig. 7.3). A 3-ounce serving of almonds, dry roasted peanuts, or sunflower seed kernels supplies about 20 g of protein. Many seeds and nuts, however, pack a lot of calories from fat. Snack on just 3 ounces of almonds, dry roasted peanuts, or sunflower seed kernels, and you will add almost 500 kcal to your diet!

Peas, lentils, and most kinds of beans contain more protein and complex carbohydrate than fat. Eating a 3-ounce serving of vegetarian baked beans, for example, adds about 4 g of protein, 14 g of carbohydrate, and less than 1 g of fat to your diet. Although soybeans contain more fat than carbohydrate, soy fat is high in unsaturated fatty acids. The health benefits of unsaturated fatty acids are discussed in Chapter 6.

**Protein Quality**

Foods differ not only in the amount of protein they contain, but also in their protein quality. A **high-quality or complete protein** contains all essential amino acids in amounts that will support protein deposition in muscles and other tissues, as well as a young child’s growth. High-quality proteins are well digested and absorbed by the body. Meat, fish, poultry, eggs, and milk and milk products contain high-quality proteins. Egg protein generally rates very high for protein quality because it is easy to digest and has a pattern of essential amino acids that closely resembles that needed by humans.

A **low-quality or incomplete protein** lacks or contains inadequate amounts of one or more of the essential amino acids. Furthermore, the human digestive tract does not digest low-quality protein sources as efficiently as foods containing high-quality protein.

**Did You Know?**

Gelatin is made from **collagen**, a protein derived from the connective tissue of animals, but it’s not a complete source of protein. Furthermore, eating gelatin will not make your fingernails stronger. Fingernails are composed of **keratin**, a protein that is different than collagen.
The essential amino acids that are in relatively low amounts are referred to as limiting amino acids, because they reduce the protein’s ability to support growth, repair, and maintenance of tissues. In most instances, tryptophan, threonine, lysine, and the sulfur-containing amino acids methionine and cysteine are the limiting amino acids in foods.³

Most plant foods are not sources of high-quality proteins. Soy protein is an exception. After being processed, the quality of soy protein is comparable to that of most animal proteins.⁴ Processed soybeans are used to make a variety of nutritious foods, including soy milk, infant formula, and meat substitutes. Furthermore, eating foods made from soybeans may reduce the risk of osteoporosis, cardiovascular disease, and certain cancers.⁵ More research, however, is needed to determine the health benefits of eating diets that contain soy products.

Understanding the concept of protein quality is important. Regardless of how much protein is eaten, a child will fail to grow properly if his or her diet lacks essential amino acids. A later section of Chapter 7 explains how you can obtain these and other essential nutrients by eating only plant foods.

Concept Checkpoint

6. Explain the difference between a high-quality protein and a low-quality protein.
7. Identify at least three dietary sources of high-quality protein and three dietary sources of low-quality protein.
8. List at least three essential amino acids that are most likely to be limiting amino acids.

What Happens to Proteins in Your Body?

In a television crime series, police in a major city are investigating what could be a homicide. A man has been reported missing by his parents, who suspect foul play and their daughter-in-law’s involvement in their son’s disappearance. While knocking on the door of the missing man’s house, police notice some dried blood on the front porch. The man’s wife, who lives in the house, tells police that the blood is from her injured dog. How can police know she is telling the truth? The blood holds important clues. Every organism synthesizes proteins—including those in blood—that are unique. Samples of the blood can be analyzed to determine whether it contains proteins from a dog or another animal, such as a human. We will leave it to your imagination to finish this story, but we will examine a real life story—how human cells make proteins.

How Your Body Synthesizes Proteins

Your body makes proteins by following information coded in your DNA or deoxyribonucleic (de-oxʻ-e-rye´-bow-new-klay´-ik) acid, the hereditary material in a cell’s nucleus. To make proteins, cells assemble the 20 amino acids in specific sequences according to the information provided by DNA. To understand this process, imagine proteins as various chains made from 20 different amino acid “beads.” Figure 7.4 illustrates some of these beads and how they can be assembled into chains. Note that each bead has two metal wires that are used to link it with another bead. To make a copy of a particular beaded chain, you would follow directions for connecting
The beads in a specific order and length by hooking the metal wires of each bead together. Consider the vast variety of beaded chains comprised of different bead sequences and chain lengths that you could make from just 20 different beads.

In living things, the beaded chains are proteins that contain amino acids. DNA supplies the instructions for synthesizing each protein and the "hook" on each bead is a peptide bond, a chemical attraction between the acid group of one amino acid and the amino group of another amino acid (Fig. 7.5). A dipeptide forms when two amino acids bond and a molecule of water is released in the process. Peptides usually contain fewer than 15 amino acids. Most naturally occurring proteins are polypeptides (poly = many; peptides = amino acids) comprised of 50 or more amino acids.

Figure 7.5 Peptide bond. A peptide bond is a chemical attraction between the acid group of one amino acid and the amino group of another amino acid. A dipeptide forms when two amino acids bond and a molecule of water is released in the process.

Figure 7.6 Protein synthesis. This illustration summarizes the basic steps of protein synthesis.

1. Protein synthesis begins with DNA in the cell’s nucleus. A section of DNA unwinds, exposing a single portion (a gene) that contains coded information concerning the order of amino acids that comprise a specific protein.

2. The gene undergoes transcription, that is, its code is used to form messenger RNA (mRNA).

3. mRNA transfers the information concerning the amino acid sequence from the gene to ribosomes, protein manufacturing sites in the cytoplasm.

4. Ribosomes "read" the gene's coded instructions for adding amino acids to the polypeptide chain.

5. During this translation process, transfer RNA (tRNA) conveys specific amino acids to the ribosomes. Each amino acid bonds to the peptide chain, lengthening it. When the translation process is complete, the ribosome releases the polypeptide, and then the new protein generally undergoes further processing at other sites within the cytoplasm.

Diet that contain low-quality protein can result in poor growth, slowed recovery from illness, and even death. These situations occur because protein synthesis in cells cannot proceed when the supply or "pool" of amino acids does not have one or more of the essential amino acids needed for constructing the polypeptide chain. When this happens, production of the protein stops. The partially made polypeptide chain is dismantled, and its amino acids are returned to the pool.
When assembly of the new protein has been completed, the polypeptide acid chain coils and folds into three-dimensional shapes that are characteristic of that particular protein. In some instances, more than one polypeptide chain curl around each other to form large protein complexes. For example, hemoglobin, a protein in red blood cells, is comprised of four polypeptide chains coiled together (Fig. 7.7). The shape of a protein is important because it influences the compound’s activity in the body.

Occasionally, the wrong amino acid is introduced into the amino acid chain during the protein synthesis process. Cells usually check for such errors and replace the amino acid with the correct one. If the DNA code is faulty, however, the wrong amino acid will be inserted into the chain consistently, forming an abnormal polypeptide. Such errors often cause genetic defects that have devastating, even deadly effects, on the organism. Sickle cell anemia, for example, is an inherited condition characterized by abnormal hemoglobin. Cells in red bone marrow synthesize hemoglobin by following DNA’s instructions concerning proper amino acid sequencing. If the DNA codes for the insertion of the wrong amino acid in two of hemoglobin’s four polypeptide chains, the resulting protein is defective and does not function correctly. Figure 7.8a shows a red blood cell that contains normal hemoglobin; the red blood cells shown in Figure 7.8b have the defective hemoglobin associated with sickle cell anemia. The crescent-shaped red blood cells cannot transport oxygen efficiently. As a result, the abnormal cells can clog small blood vessels, causing pain, organ damage, and premature death. Sickle cell anemia is a common genetic disorder that generally affects people with African, Caribbean, or Mediterranean ancestry.

Protein Denaturation

A protein undergoes denaturation when it is exposed to various conditions that alter the macronutrient’s natural folded and coiled shape (Fig. 7.9). We often cook protein-rich foods to make them more digestible and safe to eat, but heat also causes the proteins in foods to unfold. The protein in raw egg white, for example, is almost clear and has a jellylike consistency. When you cook egg white, it becomes white and firm as its proteins become denatured. Other treatments often used during food preparation also denature proteins, including whipping or exposing them to alcohol or acid. Wine, for example, is often used in marinades, because the alcohol it contains denatures proteins in meat, helping tenderize it. Adding acidic lemon juice to milk denatures (“curdles”) the proteins in milk. In your stomach, hydrochloric acid denatures food proteins, making them easier to digest. Denaturation does not “kill” a protein (because proteins are not living) but the process usually permanently alters the protein’s shape and functions. Once an egg white has been cooked or milk has curdled, the food cannot return to its original state.

Protein Turnover

Not all protein must be supplied by the diet. Protein turnover, the process of breaking down old or unneeded proteins into their component amino acids and recycling them to make new proteins, occurs constantly within cells. Amino acids that are not incorporated into proteins become part of a small amino acid pool, a readily available supply of amino acids that cells can use.
for future protein synthesis. The amino acid pool is an *endogenous*, or internal, source of nitrogen. Your body obtains about two-thirds of its amino acid supply from *endogenous* (internal) sources and the remainder from *exogenous* (dietary) sources.

### Transamination and Deamination

A healthy human body can make 11 of the 20 amino acids. The liver is the main site of nonessential amino acid production. Chemical reactions called deamination and transamination are involved in the synthesis of amino acids. **Deamination** is the process of removing the nitrogen-containing group (usually NH$_2$) from an unneeded amino acid. As a result of deamination, the amino acid that gives up its amino becomes a carbon skeleton (Fig. 7.10). **Transamination** occurs when the nitrogen-containing group is transferred to another substance to make an amino acid. To make the amino acid alanine, for example, liver cells remove the amino group (NH$_2$) from glutamic acid and transfer it to pyruvic acid (see Fig. 7.10). Transamination reactions are reversible.

Deamination occurs primarily in the liver. Liver cells remove NH$_3$ from glutamic acid, forming ammonia (NH$_3$), a highly poisonous waste product (Fig. 7.11). The liver can use the ammonia to make *urea*, a metabolic waste product that is released into your bloodstream. The kidneys filter urea, small amounts of ammonia, and *creatinine* (a nitrogen-containing waste produced by muscles) from blood and eliminate the compounds in urine. After an amino acid undergoes deamination, the carbon skeleton that remains can be used for energy or converted to other compounds, such as glucose. Muscle cells can deaminate certain amino acids and use their carbon skeletons for energy.

If you consume more protein than you need, what happens to the extra amino acids? The body does not store excess amino acids in muscle or other tissues. The unnecessary amino acids undergo deamination, and cells convert the carbon skeletons into glucose or fat, or metabolize them for energy.

### Nitrogen Balance

Although your body conserves nitrogen by recycling amino acids, each day you lose some protein and nitrogen from your body. Urinary elimination of urea and creatinine...
Positive Nitrogen Balance

- Growth
- Pregnancy
- Recovery from illness/injury
- Increased levels of the hormones insulin, testosterone, and growth hormone
- Resistance exercise

Nitrogen Equilibrium

- Healthy adult meets protein and energy needs

Negative Nitrogen Balance

- Inadequate protein intake or digestive tract diseases that interfere with protein absorption
- Increased protein losses resulting from certain kidney diseases or blood loss
- Bed rest
- Fever, injuries, or burns
- Increased secretion of thyroid hormone or cortisol (a “stress hormone”)

Figure 7.12 Nitrogen balance. This diagram illustrates the concept of nitrogen balance and lists conditions that result in positive and negative nitrogen balance. Note that nitrogen balance occurs when nitrogen intake and turnover equals nitrogen losses.

How Much Protein Do You Need?

The Estimated Average Requirement (EAR) for protein is 0.66 g of protein/kg of body weight. The EAR for protein increases during pregnancy, breastfeeding, periods of rapid growth, and recovery from serious illnesses, blood losses, and burns. Recall from Chapter 3 that scientists use EARs to establish Recommended Dietary Allowances (RDAs). A healthy adult’s RDA for protein is 0.8 g/kg of body weight. By reviewing DRI tables (inside cover of this book), you will note that the RDAs for protein vary during certain ages and conditions.
Protein Digestion and Absorption

When you eat oatmeal mixed with milk for breakfast, the large proteins in these foods must be digested before undergoing absorption. Protein digestion begins in the stomach where hydrochloric acid denatures food proteins and pepsin, an enzyme, digests proteins into smaller polypeptides. Soon after the polypeptides enter the small intestine, the pancreas secretes protein-splitting enzymes, including trypsin (trip’-sin) and chymotrypsin (ki’-mo-trip’-sin). Trypsin and chymotrypsin break down polypeptides into shorter peptides and amino acids. Enzymes released by the absorptive cells of the small intestine break down most of the shortened peptides into individual amino acids. The absorptive cells pick up the amino acids and any remaining dipeptides and tripeptides, compounds that consist of two and three amino acids, respectively. Within the absorptive cells, di- and tripeptides are broken down into amino acids. Thus, amino acids are the end products of protein digestion. After being absorbed, the amino acids enter the portal vein and travel to the liver where they may enter the general circulation. Protein digestion and absorption is very efficient—very little dietary protein escapes digestion and is eliminated in feces. Figure 7.13 summarizes protein digestion and absorption.

The liver keeps some amino acids for its needs and releases the rest into the general circulation. By the time cells obtain amino acids from blood, they cannot distinguish the ones that were originally in oat proteins from those that were in milk proteins. The cells, however, now have all the amino acids they need to make your body’s proteins.

What Is a Food Allergy?

Have you ever experienced an allergic reaction after eating certain foods or drinks? A food allergy is an inflammatory response that results when the body’s immune system reacts inappropriately to one or more harmless substances (allergens) in the food. In most instances, the allergen is a protein. For reasons that are unclear, some protein in a food that is eaten does not undergo digestion, and the small intestine absorbs the whole molecule. Immune system cells in the small intestine recognize the food protein as a foreign substance and try to protect the body by mounting a defensive response. As a result of the immune response, the person who
Proteins undergo partial digestion by pepsin and stomach acid.

Further digestion occurs as the pancreas secretes protein-splitting enzymes, including trypsin and chymotrypsin.

Final digestion occurs within absorptive cells.

After being absorbed, amino acids enter the portal vein and travel to the liver.

Very little dietary protein is excreted in feces.

Figure 7.13 Summary of protein digestion and absorption. This illustration summarizes protein digestion and absorption.

is allergic to that food experiences typical signs and symptoms. Common signs and symptoms of food allergies include hives, red raised bumps that usually appear on the skin; swollen or itchy lips; skin flushing; a scaly skin rash (eczema); difficulty swallowing; wheezing and difficulty breathing; and abdominal pain, vomiting, and diarrhea. Allergic reactions generally occur within a few minutes to a couple of hours after eating the offending food. In severe cases, sensitive people who are exposed to food allergens
can develop anaphylactic shock, a serious drop in blood pressure that affects the whole body. Anaphylaxis (an-a-pha-lax’-is) can be fatal, unless emergency treatment is provided.

Although any food protein has the potential to cause an allergic reaction in a susceptible person, the most allergenic proteins are in cow’s milk, eggs, peanuts and other nuts, wheat, soybeans, fish, and shellfish. Allergic responses to nonprotein food dyes or other food additives such as sulfites can also occur. Sulfites are a group of sulfur-containing compounds that can be found naturally in foods, but they are often added to wines, fruits, vegetables, and shellfish to prevent spoilage or preserve flavors. People who suffer from asthma often develop breathing difficulties after consuming food treated with the compounds. Other sulfite-sensitive people report skin flushing (redness and warmth), hives, difficulty swallowing, vomiting, diarrhea, and dizziness after consuming foods that contain the compounds.

Genetics play a major role in the risk of food allergies; people who have family histories of allergies to foods or other environmental triggers are more likely to develop food allergies. Approximately 4% of American children who are 5 to 17 years of age suffer from food allergies. Most children outgrow their food allergies by the time they are 5 years old. Allergies to nuts, seafood, and wheat, however, are usually not outgrown. According to the American Academy of Allergy, Asthma, and Immunology, 2% of adults in the United States suffer from food allergies.

Gliadin, a protein in wheat, buckwheat, barley, and rye, can trigger an inflammatory response in the small intestine, damaging intestinal cells and causing celiac disease in susceptible children. Gliadin is in gluten, elastic strands of protein that provide the chewy texture and stiff structure of breads and other products made from dough. Children with this condition suffer from chronic diarrhea, severe weight loss, and poor growth due to nutrient malabsorption and protein malnutrition. A gluten-free diet is necessary to treat the disorder, and the special diet must be followed for a lifetime.

Accurate diagnosis of a food allergy should be undertaken by an immunologist, a physician who specializes in the diagnosis and treatment of allergies. Skin testing is a reliable way to identify allergens. Although hair analysis, cytotoxic or electrodermal testing, and kinesiology are promoted by alternative medical practitioners to diagnose allergies, these are unproven diagnostic methods.

Treatment of food allergies involves strict avoidance of the offending foods. Parents or caregivers of young children with food allergies should read food labels carefully to check for allergens listed among ingredients. Additionally, they should educate teachers and other adults who associate with the allergic child about the importance of not exposing the youngster to specific foods. In 2004, the U.S. Congress passed the Food Allergen Labeling and Consumer Protection Act that required food manufacturers to identify potentially allergenic ingredients, such as milk and peanuts, on product labels.
According to the Food Allergen Labeling and Consumer Protection Act, food manufacturers must identify potentially allergenic ingredients, such as soy, milk, and peanuts, on product labels.

Chapter 7 Proteins

What Is PKU?

Phenylketonuria (fen-ul-key-toe-nur´-e-ah) or PKU is a rare genetic disorder that affects about 1 in every 15,000 infants in the United States. PKU usually occurs when cells are unable to produce an enzyme that converts the essential amino acid phenylalanine (fen-ul-al´-ah-nee) to other compounds. As a result, phenylalanine or its toxic by-products build up in tissues and damage cells, including nerve cells in the brain. If PKU is not diagnosed and treated within a few weeks of birth, the affected infant is likely to develop mental retardation by the end of the first year of life.

To diagnose PKU, physicians generally rely on a simple blood test that is conducted on infants within 48 hours after their birth. In the United States, more than 98% of newborns undergo testing for PKU and several other treatable inherited diseases. Infants who have PKU are generally given special formulas that lack phenylalanine. Phenylalanine is essential for growth and development, therefore young children can consume a small amount of the amino acid. As the children grow and mature, fruits, vegetables, and special low-protein foods can be added to their formula diet. However, children and adults with the disorder need to avoid foods that are rich sources of phenylalanine, such as nuts, milk products, eggs, meats and other animal foods. Additionally, people with PKU should not consume diet soft drinks and other foods and beverages containing the alternative sweetener aspartame, because the sweetener is a source of phenylalanine (see Chapter 5 for information about aspartame).
Throughout their lives, individuals with PKU should follow the restrictive diet. Discontinuing the phenylalanine-restricted diet can lead to behavioral problems and brain damage. Furthermore, people with the disorder need to undergo frequent blood tests to make sure they are maintaining a healthy concentration of phenylalanine in their bodies. Monitoring blood phenylalanine is especially important during pregnancy. An expectant woman who has PKU must carefully control her phenylalanine level to avoid exposing her embryo/fetus to excessive amounts of the amino acid. If she fails to control the concentration of phenylalanine in her blood, she can give birth to a baby with severe birth defects, including a smaller than normal brain. The Real People, Real Stories in Chapter 7 features Dallas Clasen, a teenager who has PKU.

### Concept Checkpoint

9. Explain the basic steps involved in protein synthesis.
10. Define denaturation, deamination, and transamination.
11. Describe conditions that can cause the body to be in negative nitrogen balance. Describe conditions in which the body is in positive nitrogen balance.
13. Explain what happens to proteins in beans as they undergo digestion and absorption in the human digestive tract.
14. List three common signs or symptoms of food allergy.
15. Discuss what parents of infants with PKU can do to help their children grow and develop normally.
Dallas Clasen is an energetic teenager who loves mountain bike and road bike racing, downhill skiing, wrestling, and climbing ropes and trees. Not only is he athletic, he is also smart—his grades place him at the top of his class. According to his proud parents, Dallas is the perfect son—"a nice boy." Dallas is a special young man, but he also needs a special diet. Dallas was born with phenylketonuria (PKU).

A few days after birth, Dallas underwent standard newborn blood testing. The results of the test indicated that the level of phenylalanine in his blood was about 40 times higher than the normal amount, a sign of the inherited disorder PKU. To avoid developing severe brain damage and other physiological effects of PKU, the infant needed to receive the care of a physician who specializes in treating children with the disorder. The primary treatment for PKU is a low-phenylalanine diet.

Most foods that are rich sources of protein, especially high-quality animal proteins, contain more phenylalanine than people with PKU can tolerate. Thus, from the time Dallas was a week old, he has consumed a formula that does not contain the amino acid. In addition to the formula, Dallas eats special foods that resemble "regular" foods but are not available in supermarkets. To obtain low-phenylalanine foods, his parents order them from companies that manufacture such products. Dallas can eat limited amounts of grain products and most fruits and vegetables. To determine whether the diet is working, Dallas must have the level of phenylalanine in his blood checked weekly.

Dallas’ parents and his two younger sisters do not have PKU. At home, he eats the low-phenylalanine foods, while the other members of his family consume regular foods. Foods that are eaten away from home can present problems for people with PKU. In Dallas’ case, his mother provides his school with a supply of low-phenylalanine foods for the teen’s lunches. When the family visits restaurants, Dallas usually orders French fries, which are allowed in his diet. Dallas is so accustomed to his special diet, he thinks meat looks “gross.”

In the past, children with PKU were often allowed to eat regular foods after they were about 6 years of age. However, the importance of continuing the low-phenylalanine diet became evident when many of the children experienced learning and behavioral problems as they matured. Dallas is aware of the consequences that can occur if he does not limit his phenylalanine intake, and he accepts the need to follow the special diet for the rest of his life. According to Dallas, “Being on a strict diet has not only made me disciplined, it has taught me to do whatever is needed to always take good care of myself. I have learned that we are all different, anyway. So, accept who you are!”
Protein Consumption Patterns

In 2000, protein comprised about 16% of the typical adult American male’s total energy intake and 15% of the adult American female’s total energy intake. For healthy adults, this level of consumption is within the Acceptable Macronutrient Distribution Range (AMDR), which is 10 to 35% of energy from protein. Americans generally eat about the same amount of protein that they did in the early 1900s. Americans, however, now consume more protein from meat, fish, and poultry than from plant foods (Fig. 7.14). During 1909 to 1919, grain products contributed approximately 37% of the typical American’s protein intake. At that time, meat, fish, and poultry accounted for 30% of the protein in the typical American’s diet. By 2000, grain products supplied only 22% of the average American’s protein intake, whereas meat, fish, and poultry provided most of the protein (40%) in the diet. Over the last century, total meat consumption increased, although Americans ate less red meat and more poultry, fish, nuts, and legumes in 2000 than they did in the 1970s.

MyPyramid Plan: Recommendations for Protein Intake

Animal sources of protein are often rich sources of saturated fat and cholesterol. According to guidelines of the U.S. Department of Agriculture’s MyPyramid Plan, Americans should choose lean or low-fat meat and poultry. The leanest cuts of beef include round steaks, top round, loin, top sirloin, as well as chuck and arm.

Did You Know?

There is nothing inherently “bad” about eating small portions of red meat. Red meat is a good source of zinc and iron, minerals that are often less available from plant foods.
roasts. Before cooking a piece of beef, you can reduce its fat content by trimming the visible fat away from the meat. When buying ground beef, consider choosing “extra lean” products. The label on a package of extra lean ground beef should state that the meat is at least 90% lean. When cooked, extra lean ground beef can taste “dry.” You can improve the taste of the beef by adding a small amount of “heart healthy” olive oil to the raw meat before shaping it into hamburger patties. The leanest cuts of pork include pork loin, tenderloin, and center loin.

Recommendations of the MyPyramid Plan suggest consumers use lean turkey, roast beef, or low-fat luncheon meats for sandwiches, instead of processed meat products. Processed meat products, such as ham, bacon, sausage, frankfurters, and bologna and salami, generally contain a lot of fat and they also have high amounts of added sodium. Excessive sodium intakes are associated with increased risk of hypertension. If you decide to purchase processed meats, check the Nutrition Facts panels on products’ labels to compare fat as well as sodium contents.

The MyPyramid Plan also recommends varying your protein choices. For example, consider eating fish that are rich sources of beneficial omega-3 fatty acids, such as salmon, trout, and herring. You can also replace main menu items that contain meat with dishes made with dry beans, peas, or foods made from soybeans. Additionally, consider snacking on nuts, such as peanuts, almonds, cashews, walnuts, and pecans, instead of pieces of meat or cheese.

Concept Checkpoint

16. What is the AMDR for adult protein intake?
17. Describe how Americans’ food sources of protein changed since the early 1900s.
18. Consider your usual food choices. Using the recommendations of the MyPyramid Plan, discuss ways you can reduce your intake of protein from animal foods.

Understanding Nutritional Labeling

You can determine how much protein is in a packaged food product by reading the Nutrition Facts panel on the label. As you can see in Figure 7.15, one serving of whole-wheat bread contains 4 g of protein. The panel does not provide information about a product’s protein quality, but you can judge from the list of ingredients. This particular brand of bread, for example, contains proteins from various cereal grains and some seeds, but its ingredients do not include sources of high-quality proteins such as eggs, milk, or processed soybeans. Although this bread is not a source of complete protein, its protein quality is improved if the bread is eaten with foods that contain high-quality proteins, such as with a glass of milk, folded over a slice of cooked chicken, or spread with soy nut butter. The following section explains how you can use plant proteins to obtain high-quality protein.

Concept Checkpoint

19. Discuss how you can use information on a food product’s label to determine whether the food is a source of high-quality protein.
Part 2  Nutrients and Your Health

Eating Well for Less

Does your favorite breakfast include some slices of ham, two fried eggs, a slice of toast, and a glass of milk? For lunch, would you enjoy eating a submarine sandwich made with three different types of cold cuts and two kinds of cheese? Perhaps your mouth waters at the thought of a dinner eating "surf and turf"—lobster tail accompanied by a steak. If you are a typical American, animal foods contribute the largest share of the protein in your diet. In fact, animal foods, including eggs and milk products, supply about 70% of the protein in the American diet. Some of these foods, however, are among the most expensive items on our grocery lists, and you may be able to reduce your food costs if you eat less of them.

Since animal foods are among the best dietary sources of essential amino acids, is it safe to eat less animal protein? Yes! One way you can lower your intake is to include only one animal source of protein in a meal and reduce its serving size. For example, if your breakfast is a 6-ounce slice of ham with two large fried eggs, you are obtaining over 500 kcal and almost 60 g of high-quality protein. That is enough protein in one meal to meet the RDA for a person who weighs 132 pounds. Instead of eating such a large serving of ham with the fried eggs, have 3 ounces of ham without the eggs, or skip the ham and just eat the eggs. Two fried eggs supply 12.5 g of high-quality protein and only 180 kcal.

Many commonly eaten menu items provide the proper amounts and mixtures of essential amino acids without relying heavily on animal products. The following sections describe ways you can eat less meat and save money without sacrificing the nutritional quality of your diet.

How to Decrease Your Intake of Animal Foods

An easy way to reduce your meat consumption is to replace meat with other high-quality protein sources. Eggs, milk, cheese, and yogurt are animal sources of high-quality protein that you can substitute for meat, fish, or poultry items in your diet. For example, simply have a cheese sandwich instead of eating a submarine sandwich made with various luncheon meats and cheeses. If you are interested in eating less fat, a serving of low-fat cottage cheese or low-fat yogurt makes a protein-rich substitute for the "sub" or cheese sandwich.

Another way to reduce the amount of animal food in your diet and your food costs is to make meals that contain less animal protein and more plant protein. In many parts of the world, people with limited access to meat and other animal foods rely heavily on recipes that combine small amounts of animal protein with larger portions of certain plant proteins. Proteins in animal foods contain enough essential amino acids to extend or "beef up" the lower quality plant proteins in peas, beans, cereals, and other grain products. Pasta made from white flour, for example, contains cereal (wheat) proteins that have limiting amounts of lysine. By mixing large amounts of cooked pasta with smaller amounts of lysine-rich meat, seafood, chicken, or cheese, the proteins in the animal foods enhance the quality of the wheat proteins. As a result, the body can use the amino acids in pasta for growth, repair, and maintenance of tissues.

Pancakes, waffles, crepes, and cornflakes with milk are examples of breakfast foods that extend egg and milk proteins with large amounts of cereal proteins. Many popular Asian dishes mix small amounts of chicken, beef, or seafood with large portions of rice;
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Italian dishes often combine pasta with small amounts of cheese or meat sauce. Serving meals that extend the high-quality protein in animal foods is an economical way to feed large numbers of people. For example, you can use one pound of ground meat to make a single hamburger for each of your four friends. However, you will have enough chili con carne to feed six or more friends if you combine that pound of ground meat with three cans of kidney beans and a couple of large cans of tomatoes. The ground meat has plenty of cysteine and methionine, the essential amino acids that are low in kidney beans. By mixing plant and animal sources of protein together in chili con carne, the beef protein extends the quality of the protein in the kidney beans. Although the chili recipe calls for adding tomatoes to the meat and beans, tomatoes are botanically classified as fruit, so they add very little protein to the dish. (Imagine eating chili con carne without tomatoes!) If you want to extend the chili even more, add cooked macaroni to the mixture. Macaroni is made from wheat, so it contains cereal proteins that are enhanced by the proteins in the meat and beans.

Combining Complementary Proteins

Although research findings indicate that it is not necessary to consume all essential amino acids during a meal for the body to utilize them for growth, certain plant-based recipes ensure that these compounds are consumed at one time. Complementary combinations are mixtures of certain plant foods that provide all essential amino acids without adding animal proteins. However, to make dishes that contain complementary amino acid combinations, you must know which plant foods are good protein sources and which essential amino acids are limiting or low in those plant foods. In general, plant foods are poor sources of one or more essential amino acids, particularly tryptophan, threonine, lysine, and methionine. Green peas, for example, are good sources of lysine, but they contain low amounts of tryptophan and methionine. Cereal grains such as wheat, rice, and corn are good sources of tryptophan and methionine, but they tend to be low in lysine. Wheat germ, however, is a rich source of lysine. Legumes are generally low in methionine. Although most fruits and some kinds of vegetables are poor sources of protein, they add appealing colors and textures as well as vitamins, minerals, and phytochemicals to plant-based meals.

Many cultures have traditional foods that combine complementary plant proteins. For example, a peanut butter sandwich combines two foods that supply complementary plant proteins. Peanuts are a fair source of lysine. Bread contains some methionine, but the grain product is very low in lysine. Serving the two foods together as a peanut butter sandwich provides adequate amounts of these essential amino acids. Table 7.3 lists some other foods that are examples of complementary protein combinations. When menu planning, you can combine a variety of legumes, tree nuts, seeds, and grains with vegetables.

**TABLE 7.3  Complementary Protein Dishes**

<table>
<thead>
<tr>
<th>Complementary Protein Dishes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red beans and rice</td>
</tr>
<tr>
<td>Peanut or soy nut butter on bagel, sprinkled with wheat germ</td>
</tr>
<tr>
<td>Hummus (mashed chickpeas/garbanzo beans) with sesame seeds*</td>
</tr>
<tr>
<td>Hummus on whole-grain pita bread</td>
</tr>
<tr>
<td>Black beans and cornmeal tortilla*</td>
</tr>
<tr>
<td>Split pea soup with toasted whole-wheat bread</td>
</tr>
<tr>
<td>Meatless kidney bean chili with macaroni</td>
</tr>
<tr>
<td>Cornmeal tortilla with black bean salsa</td>
</tr>
<tr>
<td>Peanut butter on whole-grain crackers, sprinkled with wheat germ</td>
</tr>
<tr>
<td>Green beans with brown rice and cashews</td>
</tr>
</tbody>
</table>

*See the Recipes for Healthy Living feature for hummus and black bean recipes.
Figure 7.16 Complementary combinations. Combining certain plant foods can result in complementary combinations of essential amino acids. To assure an adequate mix of proteins, combine one or more foods from at least two different food groups (legumes, grains, tree nuts, and seeds).

tips

The following information describes popular soybean foods and tips for how to use them in menu planning.

- Tofu is made from pureed soybeans and has the consistency of thick jelly. Plain tofu has little flavor, so it can be added to a variety of foods including stir-fried vegetables and scrambled eggs.
- Tempeh is a fermented soybean and grain mixture that can substitute for meat in sandwiches and casseroles.
- Miso is also made from fermented soybeans. Miso can be used to boost the protein content and add flavor to other foods.
- Soy nuts are roasted soybeans that are often eaten as a snack. Ground soy nuts form a spread that is used like peanut butter.
- Soy milk is made from crushed soybeans. Soy milk is usually fortified with calcium and vitamins A, D, B-12, and riboflavin. Regular soy milk can substitute for cow’s milk as a beverage or in recipes. Soy milk cheeses and yogurt are also available.
- Texturized soy protein (TSP) is made from soybean flour. TSP is often processed to imitate the texture, taste, and appearance of meat or poultry. A TSP product that resembles ground beef can be used to replace half or all of the ground beef in meatloaf, meatball, chili, taco, or meat sauce recipes.
- Soy protein concentrate is a high-protein, high-fiber refined soybean product that is used to boost the protein content of foods.
foods, but they are generally poor sources of protein. Combining Boston, iceberg, and romaine varieties of lettuce with carrots and onions makes a tasty salad, but simply mixing leafy greens with other vegetables does not make a complementary combination, because vegetables have small amounts of protein that tend to contain low amounts of essential amino acids. However, adding sunflower seed kernels, kidney or black beans, cashews, and bread cubes to the salad, boosts the amount of protein and provides a complete mix of amino acids. To increase the essential amino acid content of the salad even further, you can add a small amount of hard-cooked egg, shredded cheese, or bits of tofu, a soybean product, to it. Processed soybean foods are good sources of essential amino acids. If you are interested in trying foods made from soybeans, the Food & Nutrition Tips on page 208 provides information about some of the more popular foods made from soybeans.

### Concept Checkpoint

20. Explain the difference between substituting high-quality proteins and extending high-quality proteins. Give examples of common foods that are high-quality substitutes for meat and foods that extend a source of high-quality protein.

21. Does a recipe that combines apples and oranges with peanuts provide a complementary mixture of proteins? Explain why or why not.

22. A recipe mixes cereals made from wheat, rice, and corn. What plant foods could you add to this combination of cereals to make the recipe a source of high-quality protein?

### Vegetarianism

Are you or anyone you know vegetarian? If you are vegetarian, do you eat any animal foods? A growing number of Americans are adopting vegetarian diets. Vegetarians rely heavily on plant foods and may or may not include some animal foods in their diets. There are many different types of vegetarian diets, including some that contain animal foods. A semivegetarian, for example, avoids red meat but consumes other animal foods including fish, poultry, eggs, and dairy products. Other vegetarians have more restrictive diets, particularly when choosing whether to eat animal foods. A lactovegetarian (lacto = milk) consumes milk and milk products, including yogurt, cheese, and ice cream, to obtain animal protein. An ovo vegetarlan (ovo = egg) eats eggs, and a lactoovo vegetarlan consumes milk products and eggs. A vegan, or total vegetarian, eats only plant foods.

Vegetarians have various reasons for eating little or no animal products. Many vegetarians have religious, ethical, and other philosophical beliefs that do not support the practice of killing and eating animals. For others, vegetarianism is a matter of economics; plant foods are generally less expensive than animal foods. Some vegetarians believe that humans are not physically able to digest animal foods. This is not true. The omnivore’s intestinal tract is able to obtain nutrients from both plants and animals, and humans are omnivores. Nevertheless, eating more plant than animal sources of protein may provide important health benefits.
Is Vegetarianism a Healthy Lifestyle?

Vegetarians are generally healthier than people who eat “Western diets” that contain animal foods, particularly plenty of red meat. Vegetarians tend to weigh less and are less likely to die of heart disease than nonvegetarians. It is difficult to pinpoint diet responsible for vegetarians’ health status. Why? Vegetarians often adopt other healthy lifestyle practices such as exercising regularly; practicing relaxation activities, such as meditation; and avoiding tobacco products and excess alcohol. Causes of death for nonvegetarians who are also health conscious are similar to causes of death for vegetarians.

Compared to the typical American diet, vegetarian diets provide more fiber, folate (a B vitamin), vitamin C, and the minerals magnesium and copper. Furthermore, vegetarian diets often supply less saturated fat and cholesterol than diets that include animal foods. If poorly planned, however, plant-based diets may not contain enough energy, high-quality protein, omega-3 fatty acids, vitamins B-12 and D, and minerals zinc, iron, and calcium to meet a person’s nutritional needs. In general, plant foods have low energy density—they add bulk to the diet without adding a lot of calories. Thus, vegetarians may feel “full” soon after eating a meal of plant foods, and they may not consume as much energy, vitamins, and minerals as they need. When compared to people who eat large amounts of animal foods, total vegetarians are less likely to be overweight.

Although animal foods are excellent sources of high-quality protein, total vegetarians, including vegan athletes, can obtain adequate amounts of the essential amino acids by eating foods that combine complementary plant proteins. Plant foods, however, do not contain vitamin B-12, and there are few dietary sources of vitamin D other than fortified cow’s milk. Furthermore, mineral nutrients such as calcium and iron are more available from animal than from plant foods. Plants often contain phytochemicals that interfere with the body’s absorption of minerals, particularly iron, zinc, and calcium. Nevertheless, vegans can obtain vitamin B-12, vitamin D, iron, zinc and many other micronutrients by consuming fortified foods such as soy milk, nutritional yeast, and breakfast cereals. Vegetarians can also take a multiple vitamin/mineral supplement to provide dietary “insurance.”

Children have higher protein and energy needs per pound of body weight than an adult. Since plant foods add bulk to the diet, vegan children are more likely to eat far less food than adult vegans because they become full sooner during meals. Thus, very young vegans may be unable to eat enough plant foods to meet their protein and energy needs. Therefore, it is very important for parents or other caretakers to plan nutritionally adequate diets for vegetarian children and monitor the youngsters’ growth rates.

Vegan women who breastfeed their infants may produce milk that is deficient in vitamin B-12, particularly if the mothers’ diets lack the vitamin. These infants of vegan mothers have a high risk of developing severe developmental delays associated with neurological damage, especially when breast milk is their only source of vitamin B-12. Pregnant vegan women should consult with their physicians about the need to take a vitamin B-12 supplement to reduce the likelihood of having a baby who is deficient in this nutrient. Additionally, vegan mothers who breastfeed their infants may need to provide the babies with a source of vitamin B-12 as well.

Many American teenagers and young adults are adopting vegetarian diets. Switching from the typical Western diet to vegetarianism can be a healthy practice for teens; vegetarian youth often eat more fruits and vegetables and fewer fast foods than their nonvegetarian peers. On the other hand, vegetarian teenagers may have a higher risk of eating disorders, such as anorexia nervosa, than young people who eat meat. Anorexia nervosa (“anorexia”) is a serious psychological disorder that can result in starvation and suicide. The Chapter 10 Highlight provides more information about anorexia nervosa and other eating disorders.
Meatless Menu Planning

Many common menu items can be converted into vegetarian foods by removing the meat, fish, or poultry. For example, pizza and lasagna can be prepared without meat and still provide plenty of protein from the cheese as well as the crust or pasta. Stir-fried foods can also be a reliable source of protein without adding meat, fish, or poultry. To stir-fry, heat a small amount of peanut or canola oil in a frying pan and add cooked rice and pieces of raw vegetables. While the mixture is heating, add a beaten egg to it and stir so the egg cooks thoroughly. Before serving the dish, sprinkle cashews or sunflower seed kernels over the hot rice and vegetable mixture. Table 7.4 presents more meatless menu suggestions.

Commercially prepared vegetarian foods that substitute for meat, fish, and poultry items are often available in the frozen food section of supermarkets. These vegetarian products can look and taste like their nonvegetarian counterparts, but they generally do not contain cholesterol and may be lower in saturated fat. Such foods include soy-based sausage patties or links, soy hot dogs, “veggie” burgers, and soy “crumbles” that look like bits of cooked ground beef. Asian restaurants usually offer vegetarian dishes. Some “Western-style” restaurants offer vegetarian menu items, or their cooks can modify menu items by substituting meatless sauces, omitting meat from stir-fries, and adding vegetables or pasta in place of meat.

With careful planning, vegetarians can overcome the nutritional limitations of a plant-based diet and consume adequate diets. If you are interested in learning more specific details about vegetarian cookery and menu planning, contact a registered dietitian (R.D.) or University Extension nutritionist in your area. The MyPyramid Plan also offers suggestions for planning nutritionally adequate meatless meals. For more information, visit the MyPyramid site at www.mypyramid.gov/tips_resources/vegetarian_diets.html.

TABLE 7.4 Meatless Menu Ideas

- Cooked pasta with marinara sauce and grated Parmesan or part-skim mozzarella cheese
- Vegetable lasagna with layers of thinly sliced zucchini, mushrooms, and bell peppers
- Vegetable stir-fry with bits of tofu and cheese
- Grilled vegetable kabobs served over cooked rice and black beans
- Black or red bean burritos
- Bean tacos

Concept Checkpoint

23. Describe how the diets of semivegetarians differ from other vegetarian diets.
24. Identify nutrients that are most likely lacking in a vegan’s diet.
25. Explain why vegans must be careful when planning vegan meals for children.
Part 2  Nutrients and Your Health

Protein Adequacy

If some protein is necessary for proper growth and good health, can eating extra amounts of the nutrient make you extra healthy or physically fit? Intuitively, the idea of eating more protein to improve your health seems logical, but protein is no different than the other nutrients. If your diet contains adequate amounts of protein, then eating “more is not better.” You may, however, be able to reap substantial health benefits by reducing your animal protein intake and increasing your consumption of plant foods.

In many parts of the world, the lack of foods containing high-quality proteins is a serious problem, particularly for young children. Protein deficiency interferes with a child’s normal growth and development, and contributes to many childhood deaths. The following sections examine protein malnutrition.

Excessive Protein Intake

Heart disease and cancer are the leading causes of death in developed countries, including the United States. In these nations, the typical Western diet that contains high amounts of animal proteins may increase the risk of certain chronic diseases, particularly heart disease, colorectal cancer, and probably prostate cancer. Consumption of red meats and processed meats, such as ham and sausage, are associated with increased risk of pancreatic cancer as well as stomach cancer. Furthermore, high intakes of red meat may increase the risk of certain breast cancers among women of childbearing age.

Healthy individuals may adapt to protein intakes that are higher than the AMDR for the macronutrient, and they do not experience health problems as a result. However, bodybuilders and other athletes often consume amino acid or protein supplements along with dietary sources of protein. Taking amino acid supplements can cause imbalances that interfere with the body’s absorption and use of these nutrients. Additionally, high-protein diets can lead to more urinary losses of the mineral nutrient calcium. Excessive loss of urinary calcium may be more likely to occur when people, particularly elderly women, consume diets that contain more animal than vegetable proteins. Some nutrition experts suspect that high-protein diets are associated with osteoporosis, a condition characterized by thin bones that fracture easily. Chapter 9 discusses dietary and other factors that contribute to osteoporosis.

In addition to increasing urinary losses of calcium, excess amino acid or protein intake can lead to dehydration, because the kidneys need more water to dilute and eliminate the toxic waste products of amino acid metabolism in urine. Dehydration is a potentially life-threatening condition in which the body’s water level is too low. People with liver or kidney diseases may need to avoid protein-rich diets and amino acid supplements because metabolizing the excess amino acids is a burden to their bodies. The Chapter 7 Highlight provides more information about the use of amino acid and protein supplements.

What About High-Protein Weight-Loss Diets?

Certain popular weight-loss diets, such as the Atkins, Protein Power, and Sugar Busters diets, promote high intakes of protein. While following high-protein diets to lose weight, people often report decreased feelings of hunger and increased sense of fullness (satiety) after meals. However, results of one study indicated subjects following high-protein/low-carbohydrate, low-fat, or moderate-calorie controlled diets for a year lost similar amounts of weight. Chapter 10 provides information about the safety and effectiveness of various popular weight-loss diets.

Protein Deficiency

Although food insecurity exists in the United States, protein deficiency is uncommon. (See the Chapter 1 Highlight for information about food insecurity.) People...
people suffering from alcoholism, anorexia nervosa, or certain intestinal tract disorders are at risk of protein malnutrition. People with low incomes, especially elderly, are also at risk of protein deficiency. Many elderly Americans have limited incomes and must make difficult choices concerning their expenses. If you were 80 years old and needed to take several medicines daily to treat heart disease, abnormally high fluid pressure in your eyes, and breathing problems, what would you think is more important—purchasing costly prescription medications or nutritious foods?

As discussed in the Chapter 1 Highlight, undernutrition, the lack of food, is often widespread in poor nations in which populations endure frequent famine resulting from crop failures, political unrest, or civil wars. In these countries, protein-energy malnutrition (PEM) affects people whose diets lack sufficient protein as well as energy. The failure to consume nourishing food also results in vitamin and mineral deficiencies.

When food is limited, it is often more difficult for children to obtain nutritionally adequate diets than adults. Why? Adults may be able to consume enough plant proteins to meet their protein and energy needs, but children have smaller stomachs and higher energy and protein needs per pound of body weight than adults. They are unable to eat enough plant foods to meet their relatively high protein and other nutrient requirements.

According to the World Health Organization (WHO), PEM affects one of every four children and results in almost 11 million childhood deaths each year. Impoverished children in Asia and Africa are most likely to develop PEM, and the effects of PEM are especially devastating for the very young. Children with PEM do not grow and are very weak, irritable, and vulnerable to dehydration and infections, such as measles, that can kill them. If these children survive, their growth may be permanently stunted and their intelligence may be lower than normal because malnutrition during early childhood can cause permanent brain damage.

### Kwashiorkor and Marasmus

At one time, nutritionists thought there were only two types of PEM, kwashiorkor and marasmus. The distinctions between these conditions, however, are often blurred, because protein deficiency is unlikely when a person’s energy intake is adequate. Nevertheless, the World Health Organization identifies kwashiorkor, marasmic kwashiorkor, and marasmus as forms of PEM.

**Kwashiorkor** (kwash’-e-or’-kor) primarily occurs in developing countries where mothers commonly breastfeed their infants until they give birth to another child. The older youngster, who is usually a toddler, is fairly healthy until abruptly weaned from its mother’s milk to make way for the younger sibling. Although the toddler may obtain adequate energy by consuming a traditional diet of cereal grains, the diet lacks enough complete protein to meet the youngster’s high needs, and he or she soon develops signs of protein deficiency. Children affected by kwashiorkor have stunted growth (see Fig. 1.C); unnaturally blond, sparse, and brittle hair; and patches of skin that have lost its normal coloration. Children with kwashiorkor have some subcutaneous (under the skin) fat and swollen cheeks, arms, legs, and bellies that make them look well fed, but their appearance is misleading. An important function of certain proteins in blood is to maintain proper fluid balance within cells and blood vessels as well as between cells. During starvation, levels of these proteins decline, resulting in edema, which makes the protein-deficient child look plump and overfed instead of thin and undernourished. In many cases, the child suffering from kwashiorkor does not obtain enough energy and eventually develops marasmic kwashiorkor, a condition characterized by edema and wasting (Fig. 7.17). Wasting is the loss of...
organ and muscle proteins as the body tears down these tissues to obtain amino acids for energy metabolism.

Severe PEM causes extreme weight loss and a condition called marasmus (mah-raz’-mus), which is commonly referred to as starvation (Fig. 7.18). Obvious signs of marasmus are weakness and wasting. The body of a starving person loses most of its subcutaneous fat and deeper fat stores. The marasmic person is so thin, his or her ribs, hip, and spinal bones are visible through the skin. People suffering from marasmus avoid physical activity to conserve energy, and they are often irritable.

The World Health Organization has guidelines for identifying and treating children with PEM. According to these guidelines, treatments for kwashiorkor, marasmic kwashiorkor, and marasmus are similar. The sickest children need hospitalization, carefully controlled refeedings, and frequent health assessments to recover from PEM.

**Concept Checkpoint**

26. In the United States, which groups of people are most likely to suffer from protein malnutrition?

27. Define protein-energy malnutrition.

28. Police bring a 2-year-old child into a clinic; the child has a swollen belly and feet, but the arms and upper legs are so thin, the skin hangs from them. The police report indicates the child was severely neglected by the parents. According to this information, is this child suffering from PKU, marasmic kwashiorkor, marasmus, sickle cell anemia, or anorexia nervosa? Choose one of these conditions and explain why you selected it.

**Chapter 7 Highlight**

**Building a Bulkier Body**

It’s not surprising that people associate protein with muscle. Skeletal muscle mass comprises the largest share (approximately 43%) of protein in your body. Although many athletes and bodybuilders consume large quantities of protein-rich animal foods and supplements to increase their muscle mass, this practice does not build bigger stronger muscles. A fitness program that includes resistance training is the only safe and reliable way to increase muscle mass.

During resistance exercise, proteins in working muscles break down, but protein synthesis occurs during the recovery period that follows and lasts about 24 to 48 hours. As a result, muscles grow larger, particularly when amino acids are available. Over time, resistance training induces a state of positive nitrogen balance. It should be noted, however, that 70% of muscle tissue is water and only about 22% is protein. Thus, resistance training adds a considerable amount of water to muscle tissue.
To gain a pound of muscle in a week, a healthy young person undergoing resistance training needs to increase the RDA level of his or her protein intake only by about 14 g/day.\textsuperscript{2A} For example, a 22-year-old woman who weighs 70 kg has an RDA for protein of 56 g (70 kg \times 0.8 g of protein/kg). While undergoing resistance training, she’ll need to consume 70 g of protein daily (14 g + 56 g) to gain a pound of muscle in a week. Since the average American eats more than 100 g of protein a day, registered dietitians generally do not recommend adding protein or amino acid supplements to the diets of athletes.\textsuperscript{3A}

**Proteins: General Advice for Athletes**

Carbohydrate spares protein for muscle maintenance and growth, therefore, athletes should not overly focus on their protein intake. Eating a snack that supplies both protein and carbohydrate before or after exercise is recommended.\textsuperscript{2A} Nutritious choices include a bowl of cereal and fat-free milk, low-fat cottage cheese and a whole-wheat bagel, or a sandwich made with lean meat or poultry. If you don’t have time to prepare these foods, energy drinks and bars are convenient ways to obtain carbohydrate and protein. Chapter 11 provides more information about nutrition for athletes and other physically active people.

The results of studies indicate that injecting various amino acids into the blood can stimulate the pituitary gland in the brain to release human growth hormone (HGH). Although HGH fosters muscle tissue growth, the results of studies examining the effects of consuming individual amino acids on HGH release do not support the use of these nutrients for stimulating muscle growth. Nevertheless, supplements that contain the amino acids arginine, lysine, and ornithine are popular among resistance athletes.

Taking protein supplements is not recommended for healthy persons, especially if the products supply individual amino acids. Why? The human digestive system is designed to digest large protein molecules from the mixture of proteins that naturally occurs in foods. Consuming supplements that supply large amounts of individual amino acids can upset intestinal cells’ ability to absorb other amino acids. Moreover, excessive intakes of certain amino acids, particularly methionine and tyrosine, can be toxic.

For thousands of years, humans have obtained amino acids directly by eating plants and animals. The use of amino acid and protein supplements as sources of the nutrient is a relatively recent development, and little is known about the long-term safety of using these products. Chapter 11 examines the evidence concerning the value and safety of using certain foods and dietary supplements to enhance physical performance.

High-protein diets are not recommended for athletes. Eating generous portions of animal foods, especially red meats, can contribute excessive amounts of cholesterol and saturated fat to diets. Although physically active people may be able to tolerate high-protein, high-fat, and high-cholesterol diets, the only effective way to increase muscle mass safely is to combine a nutritionally adequate diet with a program of muscle-strengthening exercises. An athlete’s diet should supply enough calories from carbohydrate and fat to support energy needs for increased physical activity and spare the use of protein for growth, repair, and maintenance of muscle tissue.

**References for Chapter 7 Highlight**


SUMMARY

Proteins are organic compounds that contain nitrogen, the element cells need to make a wide array of important biological compounds with structural or metabolic functions in the body. Proteins, for example, participate in muscular movement, catalyze chemical reactions, transport nutrients, and help maintain proper fluid and acid-base balance. Additionally, a relatively small amount of protein contributes to the body’s energy needs. Numerous vital functions as well as physical growth and development would not be possible without specific proteins.

The typical amino acid has amino, acid, and “R” groups. The diet must supply nine of the amino acids, because the body cannot make them or make enough of them to meet its needs. Cells can synthesize the remaining amino acids if the raw materials are available.

Human proteins are comprised of 20 different amino acids arranged in various combinations. Cells produce proteins by linking amino acids together in specific sequences that are dictated by instructions coded in DNA. Faulty DNA results in the wrong amino acids being inserted into peptide chains, causing genetic defects. If an essential amino acid is not available when protein synthesis occurs, proteins in muscles and organs can provide the essential amino acids. Otherwise, protein synthesis halts, and the amino acids in the unfinished peptide are removed and returned to the amino acid pool. Excess amino acids are metabolized for energy or converted into body fat.

Protein turnover is the process of breaking down old or unneeded proteins into their component amino acids and recycling them to make new proteins. The body conserves nitrogen by recycling amino acids, but each day it loses some protein and nitrogen primarily in urine, nails, hair, feces, and skin. Amino acids from food replace the lost nitrogen. An adult’s body maintains its protein content by carefully balancing nitrogen intake and losses. In positive nitrogen balance, the body retains more nitrogen than it loses; in negative nitrogen balance, the body loses more nitrogen than it retains.

A healthy adult requires only about 0.5 g of protein/kg of body weight daily. The protein requirement increases during pregnancy, breastfeeding, periods of growth, and recovery from serious illnesses, blood losses, and burns. The adult RDA for protein is 0.8 g/kg of body weight daily.

Protein digestion begins in the stomach where hydrochloric acid denatures food proteins and pepsin breaks proteins into polypeptides. In the small intestine, enzymes secreted by the pancreas and absorptive cells digest polypeptides into amino acids and di- and tri-peptides. The absorptive cells pick up these compounds and break the remaining peptides into amino acids. The end-products of protein digestion, amino acids, travel to the liver. The liver uses the amino acids or releases them into the general circulation.

The AMDR for adults is 10 to 35% of energy intake from protein. Although total meat consumption increased over the past century, Americans ate less red meat and more poultry, fish, nuts, and legumes in 2000 than they did in the 1970s. People can reduce their intake of animal protein without sacrificing the protein quality of their diets.

The average American consumes over 100 grams of protein daily, well over the RDA. Protein-rich diets that contain animal products generally contain high amounts of saturated fat and cholesterol, and such diets are associated with increased risk of certain chronic diseases, particularly heart disease and certain cancers. High-protein diets may result in amino acid imbalances, high urinary losses of calcium, and dehydration.

Animal foods generally provide more protein than similar quantities of plant foods. High-quality or complete protein is well digested and contains all essential amino acids in amounts that will support protein deposition and a young child’s growth. Low-quality or incomplete protein is low in one or more of the essential amino acids and often is poorly digested. In general, meat, fish, poultry, eggs, milk, and milk products contain high-quality proteins. When compared to animal foods, plant foods provide low-quality protein, except for foods made from processed soybeans.
Vegetarian diets are based on plant foods and limit animal foods to some extent. Although vegetarians are generally healthier than people who eat Western diets, it is difficult to pinpoint diet responsible for vegetarians’ better health. If not properly planned, plant-based diets may not contain enough energy, high-quality protein, omega-3 fatty acids, vitamins B-12 and D, and zinc, iron, and calcium to meet a person’s nutritional needs, especially children’s needs.

PEM affects people whose diets lack sufficient protein as well as energy; children are more likely to be affected by PEM than adults. In impoverished developing countries, PEM is a major cause of childhood deaths. Severely undernourished children do not grow and are very weak, irritable, and vulnerable to dehydration and life-threatening infections. Undernutrition during early childhood can cause permanent brain damage.

Recipes for Healthy Living

**Trendy Black Beans**

You’ve probably eaten ordinary canned baked beans as an accompaniment to hot dogs and hamburgers. If you’re interested in eating a more trendy kind of bean, try this recipe for black beans. Although canned black beans are more convenient to use in recipes than dried black beans, the canned products generally contain a lot of salt.

This black bean recipe makes about four ½ cup servings. Each serving supplies approximately 120 kcal, 8 g protein, less than 1 g fat, 7.5 g fiber, 340 mg potassium, 70 mg sodium, and 130 mcg folate (a B vitamin). To make the beans a complementary protein source, serve them wrapped in a soft burrito or on cooked rice.

**PREPARATION STEPS:**

1. Rinse dried beans in cold water, draining excess water.
2. Place the beans in a saucepan and add 1 ¾ cups of water.
3. Heat beans and water on high heat until mixture boils. Boil for 2 minutes, then turn off heat, and remove saucepan from the burner. Cover saucepan and allow beans to remain in the hot water for 1 hour. While beans are soaking, prepare green pepper, onion, and garlic.
4. Do not drain water from beans. Simmer beans on low heat, in the covered saucepan, for 45 minutes. Stir occasionally.
5. Add green pepper, onion, garlic, black pepper, and salt. Simmer for an additional 15 minutes.
6. Serve hot. Cooked beans can be frozen.

**Hummus**

Hummus may have originated in the Middle East, but it’s become popular in this country as a dip for vegetables or bread. Hummus is a good source of protein, monounsaturated fat, fiber, the minerals potassium and iron, and the B vitamin folate. This hummus recipe makes about eight ¼ cup servings. If you don’t have a blender, you can mash the chickpeas and garlic with a fork before you add the other ingredients. To make hummus a complementary protein source, serve it with whole-grain crackers, tortilla chips, or pita bread. Each serving (with no added salt) supplies about 130 kcal, 4 g protein, 7 g fat, 4 g fiber, 0.8 mg iron, 120 mg potassium, 5 mg sodium, and 80 mcg folate.

**INGREDIENTS:**

- 2 cups unsalted, cooked garbanzo beans (chickpeas)
- 1 Tbsp lemon juice
- 1 medium clove garlic, peeled
- ¼ cup cold water
- ¼ cup olive oil
- pinch salt and paprika (optional)

**PREPARATION STEPS:**

1. Drain beans. Place the beans, lemon juice, garlic clove, oil, and water in a blender. Blend until the mixture is smooth.
2. Serve in a bowl. If desired, sprinkle paprika on top of hummus.
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Personal Dietary Analysis

1. Refer to the 3-day food log from the Personal Dietary Analysis feature in Chapter 3. Calculate your average protein intake by adding the grams of protein eaten each day, dividing the total by three, and rounding the figure to the nearest whole number.

Sample Calculation:

<table>
<thead>
<tr>
<th>Day</th>
<th>Protein (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>76</td>
</tr>
<tr>
<td>2</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>103</td>
</tr>
</tbody>
</table>

Total grams: \( \frac{234}{3} = 78 \) g/day

Your Calculation:

<table>
<thead>
<tr>
<th>Day</th>
<th>Protein (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>_____</td>
</tr>
<tr>
<td>2</td>
<td>_____</td>
</tr>
<tr>
<td>3</td>
<td>_____</td>
</tr>
</tbody>
</table>

Total grams: \( \frac{_____}{3} = _____ \) g/day

My average daily protein intake was _____ g.

2. The RDA for protein is based on body weight. Using the RDA of 0.8 g of protein/kg of body weight, calculate the amount of protein that you need to consume daily to meet the recommendation. To determine your body weight in kilograms, divide your weight (pounds) by 2.2, then multiply this number by 0.8 to obtain your RDA for protein. Then round the figure to the nearest whole number.

My weight in pounds _____ ÷ 2.2 = _____ kg

My weight in kg _____ × 0.8 = _____ g

My RDA for protein = _____ g

a. Did your average intake of protein meet or exceed your RDA level that was calculated in step 1? _____ yes _____ no

b. If your answer to 2a is “yes,” which foods contributed the most to your protein intake?

3. Review the log of your 3-day food intake. Calculate the average number of kilocalories that protein contributed to your diet each day during the 3-day period.

a. Each gram of protein provides about 4 kcal, therefore, you must multiply the average number of grams of protein obtained in step 1 by 4 kcal to obtain the average number of kcal from protein.

Sample Calculation:

\[ 78 \text{ g/day} \times 4 \text{ kcal/g} = 312 \text{ kcal from protein} \]

Your Calculation:

_____ g/day \times 4 \text{ kcal/g} = _____ average number of kcal from protein
4. Determine your average energy intake over the 3-day period by adding the kilocalories for each day and dividing the sum by 3, and round to the nearest whole number.

**Sample Calculation:**

Day 1 2500 kcal  
Day 2 3200 kcal  
Day 3 2750 kcal  

**Total kcal** 8450 \( \div 3 \text{ days} = \frac{8450}{3} \text{ kcal/day (average caloric intake)} \)

**Your Calculation:**

Day 1 _____ kcal  
Day 2 _____ kcal  
Day 3 _____ kcal  

**Total kcal** _____ \( \div 3 \text{ days} = _____ \text{ kcal/day (average)} \)

5. Determine the average percentage of energy that protein contributed to your diet by dividing the average kilocalories from protein obtained in step 3 by the average total daily energy intake obtained in step 4. Then round this figure to the nearest one-hundredth. Multiply this value by 100, move the decimal point two places to the right, drop the decimal point, and add a percent symbol.

**Sample Calculation:**

\[ \frac{312 \text{ kcal from protein}}{2817 \text{ kcal intake}} = 0.11 \text{ (rounded)} \]

\[ 0.11 \times 100 = 11\% \]

**Your Calculation:**

_____ kcal from protein \( \div _____ \text{ kcal intake} = _____ \)

_____ \( \times 100 = _____ \% \)

6. Did your average intake of protein meet the recommendation of 10 to 35% of total calories? If your average protein intake was below 10%, list at least five foods you could eat that would boost your intake.
CRITICAL THINKING

1. Are you a vegetarian? If so, describe your dietary practices (e.g., vegan or semivegetarian) and explain why you decided to become vegetarian. If you are not a vegetarian, explain why you would or would not consider this lifestyle.

2. Have you used or are you currently using protein or amino acid supplements? ______ yes ______ no If you answered "yes," explain why you use these supplements.

3. Plan a day’s meals and snacks for a healthy 132-pound (60 kg) adult female who is not pregnant or breastfeeding. The menu should contain all essential amino acids but contain no animal foods other than eggs and foods from the milk group. Your meal plan can range from 1800 to 2200 kcal, and it should include foods from the major food groups and follow the recommendations of the USDA’s MyPyramid Plan.

4. Using only plant foods, plan a day’s meals and snacks for a healthy 154-pound (70 kg) adult male. The menu should supply at least 2200 kcal, follow the recommendations of the USDA Food Guide Pyramid and include foods from the major food groups (except for the milk foods group).

5. A recipe for bean salad has the following main ingredients:
   - 1 cup kidney beans
   - 1 cup green beans
   - 1 cup butter beans
   - 1 cup black beans
   - 1 ½ cups wine vinegar
   - 1/3 cup canola oil
   - ¼ cup chopped onion

   Explain why this recipe is not a complementary mixture of plant proteins. What plant foods could you add to the recipe to make it a complementary mixture?

PRACTICE TEST

Select the best answer.

1. A protein
   a. is comprised of glucose molecules.
   b. has nitrogen in its chemical structure.
   c. provides more energy per gram than carbohydrate.
   d. is a complex inorganic molecule.

2. Which of the following statements is false?
   a. Certain hormones are proteins.
   b. Nearly all enzymes are proteins.
   c. Proteins are part of triglycerides.
   d. The body uses protein to make antibodies.

3. Which of the following foods generally provides the least amount of protein per serving?
   a. fruits
   b. milk
   c. nuts
   d. seeds
4. Which of the following foods is not a source of complete protein?
   a. peanut butter
   b. cheese
   c. fish
   d. eggs

5. In cells, _____ controls the assembly of amino acids into proteins.
   a. food
   b. DNA
   c. insulin
   d. the nervous system

6. _____ is the process of removing nitrogen from an amino acid.
   a. Transamination
   b. Denaturation
   c. Hydrogenation
   d. Deamination

7. Which of the following physical states are characterized by positive nitrogen balance?
   a. starvation
   b. illness
   c. puberty
   d. all of the above

8. What is the RDA for protein of a healthy adult woman who weighs 62 kg?
   a. 49.6 g
   b. 59.6 g
   c. 69.6 g
   d. 79.6 g

9. Which of the following foods is not a source of complementary protein?
   a. red beans and rice
   b. hummus on pita bread
   c. cereal with milk
   d. whole-wheat bread with fruit spread

10. A person following a vegan diet would eat
    a. eggs.
    b. cheese.
    c. nuts.
    d. fish.

11. By eating more protein than needed, a person can
    a. build bigger muscles.
    b. lose weight.
    c. absorb more calcium.
    d. become dehydrated.

12. Strength and endurance athletes
    a. should take amino acid supplements.
    b. need about double the RDA for protein.
    c. do not need more protein than the RDA.
    d. should eliminate protein from plant sources.

Answers to Chapter 7 Quiz Yourself

1. Animal foods such as meat and eggs are almost 100% protein. False. (p. 191)
2. Foods made from processed soybeans can be sources of high-quality protein. True. (p. 193)
3. An adult bodybuilder should consume about five times more protein than a healthy adult who is not a bodybuilder. False. (p. 215)
4. Registered dietitians generally recommend that vegetarians take amino acid supplements to increase their protein intake. False. (p. 210)
5. People can nourish their hair by using shampoo that contains protein. False. (p. 198)