

32.1 Nutrients and Homeostasis

VOCABULARY

mineral
vitamin
Calorie

KEY CONCEPT Cells require many different nutrients.

MAIN IDEAS

- ▶ Six types of nutrients help to maintain homeostasis.
- ▶ Meeting nutritional needs supports good health.

✦ Connect to Your World

Nowadays, many foods are enriched with essential vitamins, and you have been taught about nutrients that your body needs. But until the 1740s, British sailors on long voyages were crippled by scurvy, an illness that produced weakness, bruising, bleeding gums, and painful joints. Meanwhile, Dutch sailors who ate oranges at sea never got scurvy. British physician James Lind hypothesized that citrus fruits might not only cure the illness but prevent it as well. Lind divided the crew of one ship into six groups and gave each different foods. Sailors eating oranges and lemons remained healthy. Simply adding vitamin C eliminated scurvy at sea.

▶ MAIN IDEA

Six types of nutrients help to maintain homeostasis.

Today, scientists and health experts know a great deal more about how important nutrients are to maintain homeostasis in your body. You need to consume six types of nutrients every day to keep your body in good health: water, carbohydrates, proteins, fats, minerals, and vitamins. If any one of these nutrients is missing for too long, your body's cells will stop working properly, which also affects your organs.

Water

Your body is made up of 55 to 60 percent water. As a natural solvent, water is involved in nearly every chemical reaction in every cell of your body. It also helps you to digest food and eliminate waste products, maintain your blood volume, regulate your body temperature, and keep your skin moist. To maintain your fluid balance, you need to drink about 2 liters (8 cups) of water a day to replace the amount you lose through sweat, urine, and respiration.

Carbohydrates

Carbohydrates, shown in **FIGURE 1.1**, are the main source of energy for your body. Simple carbohydrates are sugars found in sugar cane, honey, and fruits. Complex carbohydrates are starches found in vegetables, grains, and potatoes. To be absorbed by your body, starches must be broken down during digestion into simple sugars, such as glucose. Excess supplies of glucose are converted to glycogen and are stored in the liver and muscle tissues for future use. Many grains, fruits, and vegetables also contain cellulose, a dietary fiber. Fiber cannot be digested, but it helps move food through your digestive system.

FIGURE 1.1 Complex carbohydrates (whole grains, potatoes, vegetables) must be broken down into sugars to be used as fuel. Simple carbohydrates, such as those found in fruits, do not need to be broken down as much.



Proteins

Proteins are the raw materials used for the growth and repair of the body's cells and tissues. In addition, proteins make up all enzymes and many hormones that are vital for cell metabolism. Proteins are composed of chains of amino acids. Your body can make only 12 of the 20 amino acids it needs to build proteins. The other 8, called essential amino acids, must come from the foods you eat. Foods such as meat, cheese, and eggs contain all eight essential amino acids. However, most plant proteins lack at least one essential amino acid. Vegans—people who do not eat meat, dairy products, or eggs—must eat plant foods in combination to obtain all the amino acids they need. For example, red beans and rice together contain all 20 amino acids.

Fats

Fats provide energy and key components in cell membranes, myelin sheaths for neurons, and certain hormones. Fats consist of long chains of fatty acids hooked to glycerol molecules. Your body can make some fatty acids, but you must obtain all of the essential fatty acids from the foods you eat. Fats are classified as either saturated or unsaturated, depending on the structure of their fatty acid chains. Saturated fats are solid at room temperature and are found in animal products. Most unsaturated fats are liquid at room temperature and are found in plant oils, such as corn or olive oils, and in some fish, such as cod or salmon. In general, unsaturated fats are considered more beneficial to people's health than are saturated fats.

Minerals

Small amounts of minerals and vitamins are also needed to maintain homeostasis. **Minerals** are inorganic materials the body uses to carry out processes in cells and to build or repair tissues. Some of the more common minerals are listed in **FIGURE 1.3**. Calcium, for example, is essential for bone and tooth formation, muscle contraction, and nerve transmission. Sodium and potassium help to maintain the body's fluid homeostasis. You are constantly losing minerals in sweat, urine, and other waste products. You can replace them by eating a variety of plant foods or by combining plant and animal foods.



FIGURE 1.2 Proteins and fats are often found in the same foods. Beef, chicken, and eggs contain protein and saturated fats. Fish, nuts, beans, and seeds contain protein and unsaturated fats.

READING TOOLBOX

TAKING NOTES

Use a two-column chart to organize your notes about different nutrients and their functions.

Water	- makes up 55 to 60% of body - maintains blood volume

FIGURE 1.3 Important Minerals

MINERALS	SOURCES	IMPORTANT FOR
Calcium	dairy products, salmon, sardines, dark leafy greens	blood clotting, bone/tooth formation; muscle/nerve function
Iron	liver, dark leafy greens, whole grains	component in hemoglobin
Iodine	iodized salt, seafoods, sea vegetables	component in thyroid hormones
Magnesium	nuts, whole grains, leafy green vegetables	bone/tooth formation; coenzyme in protein synthesis
Phosphorus	meats, dairy products, nuts, dried peas and beans	bone/tooth formation; active in many metabolic processes
Potassium	meats, dairy products, many fruits and vegetables	regulation of pH, fluid balance, and muscle/nerve function
Sodium	table salt, seafoods, processed foods	regulation of pH, fluid balance, and muscle/nerve function
Zinc	meats, seafoods, grains	activation of many enzymes in metabolic processes

Vitamins

Vitamins are organic molecules that work with enzymes to regulate cell functions, growth, and development. As shown in **FIGURE 1.4**, these nutrients are divided into fat-soluble vitamins and water-soluble vitamins. Fat-soluble vitamins dissolve in fatty acids. The fat-soluble vitamins A, D, E, and K can be stored in the body's fatty tissues for future use. For this reason, taking high doses of these vitamins can actually create harmful, or toxic, levels in the body.

Water-soluble vitamins dissolve in water. The water-soluble vitamin C and the B vitamins cannot be stored and are excreted in urine and feces. As a result, you need to eat foods rich in these nutrients to keep replenishing them. The National Academy of Sciences publishes recommended daily amounts of minerals and vitamins based on your age, gender, and level of activity.

Apply Would a diet higher in protein or in complex carbohydrates give you more energy? Explain your answer.

FIGURE 1.4 Essential Vitamins

VITAMIN	SOURCES	IMPORTANT FOR
Fat-Soluble (Dissolves in Fat)		
A (retinol)	dark green, yellow, and orange vegetables, fortified milk, fish and liver oils	healthy skin, mucous membranes, vision
D (calciferol)	fortified dairy and whole grain products, egg yolks, fish and liver oils	bone and tooth formation, increase in calcium and phosphorus absorption
E (tocopherol)	vegetable oils, nuts, fish oils, meats, leafy green vegetables	prevention of cell damage
K	leafy green vegetables, egg yolks, liver; also made by intestinal bacteria	blood clotting and synthesis of clotting factors
Water-Soluble (Dissolves in Water)		
B ₁ (thiamine)	pork and red meats, whole grains, dried beans and peas, eggs	metabolism of carbohydrates
B ₂ (riboflavin)	dairy products, liver and organ meats, enriched whole grains	metabolism of carbohydrates and proteins, normal growth in skin, lips, and mucous membranes
B ₃ (niacin)	meats, dried peas and beans, whole grains	metabolism of glucose, fats, and proteins
B ₆ (pyridoxine)	meats, fish, peanuts, eggs, bran cereal	metabolism of amino acids
B ₁₂	liver, meats, eggs, dairy products	protein synthesis and red blood cell production
C (ascorbic acid)	citrus fruits, berries, tomatoes, broccoli, cabbage, potatoes, melons	antioxidant, maintenance of cartilage and bone, iron absorption, tissue repair, wound healing, healthy gums
Pantothenic acid	meats, dairy products, whole grains	metabolism of glucose, fats, and proteins
Folic acid	leafy green vegetables, liver, nuts, oranges, broccoli, peas, fortified cereals	amino acid synthesis and metabolism, prevention of neural tube defects in fetuses
Biotin	egg yolks, liver, soybeans	metabolism of carbohydrates, proteins, and fats
Choline	egg yolks, liver, whole grains	production of phospholipids and neurotransmitters

MAIN IDEA

Meeting nutritional needs supports good health.

A balanced diet is important throughout your life, but particularly during pre-teen and early teen years. During these years, you are growing and developing faster than at any other time since the first two years of your life. Your bone mass is increasing nearly 40 percent, you are gaining most of your adult body mass, and you are developing sexual characteristics.

To fuel this growth spurt, your body requires considerably more nutrients and more energy in the form of Calories consumed, as shown in **FIGURE 1.5**. A calorie, with a small *c*, is the amount of energy required to raise one gram of water one degree Celsius. One **Calorie** (capital *C*) from food equals one kilocalorie, or 1000 calories. Different foods contain different amounts of energy. One gram of protein or carbohydrate yields four Calories, while one gram of fat yields nine Calories.

Calories alone are not the whole story, however. The rapid changes in your body require adequate amounts of all six nutrients. Dietary experts recommend that most of your Calories come from eating whole grains, fruits, and vegetables, which are rich in fiber, vitamins, and minerals. Also, experts suggest drinking more low-fat milk or soy drinks and water, and fewer high-sugar soft drinks and juices. High-sugar foods provide Calories but very little nutritional value. Dietary experts also recommend eating more lean meats and fish, while cutting down on foods high in saturated fat.

It is also important to find a balance between food and physical activity so that you use about as many Calories as you consume. The U.S. Department of Agriculture (USDA) Web site provides information on how to develop a balanced diet.

CONNECT TO

CELLULAR RESPIRATION

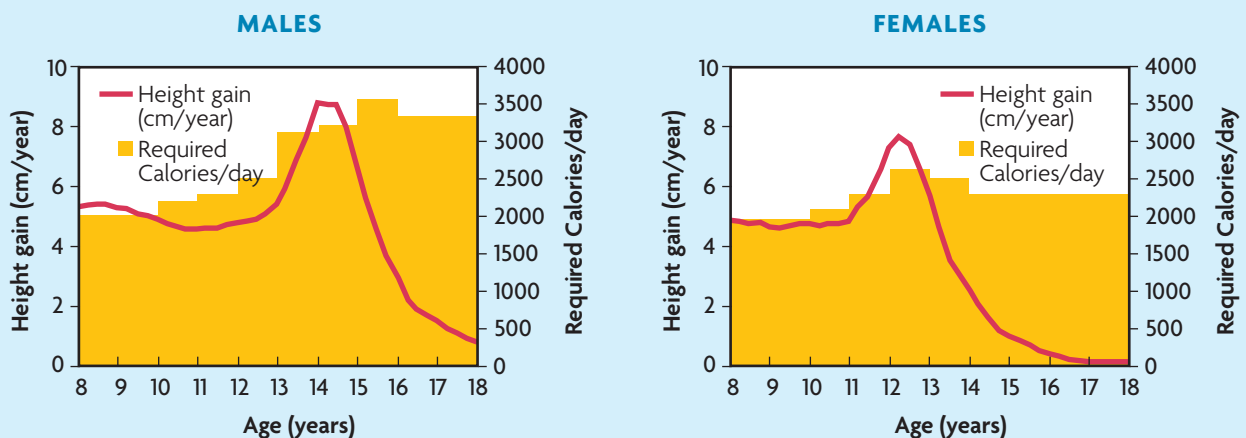
You read in **Cells and Energy** about the different ways that plant and animal cells obtain energy. In nearly all plant and animal cells, mitochondria use molecules broken down by digestion to build ATP, the main power source for cells.

FIGURE 1.6 Your food choices can help you consume high-quality energy and nutrients at a time when your body needs them the most.



FIGURE 1.5 Growth and Energy Needs

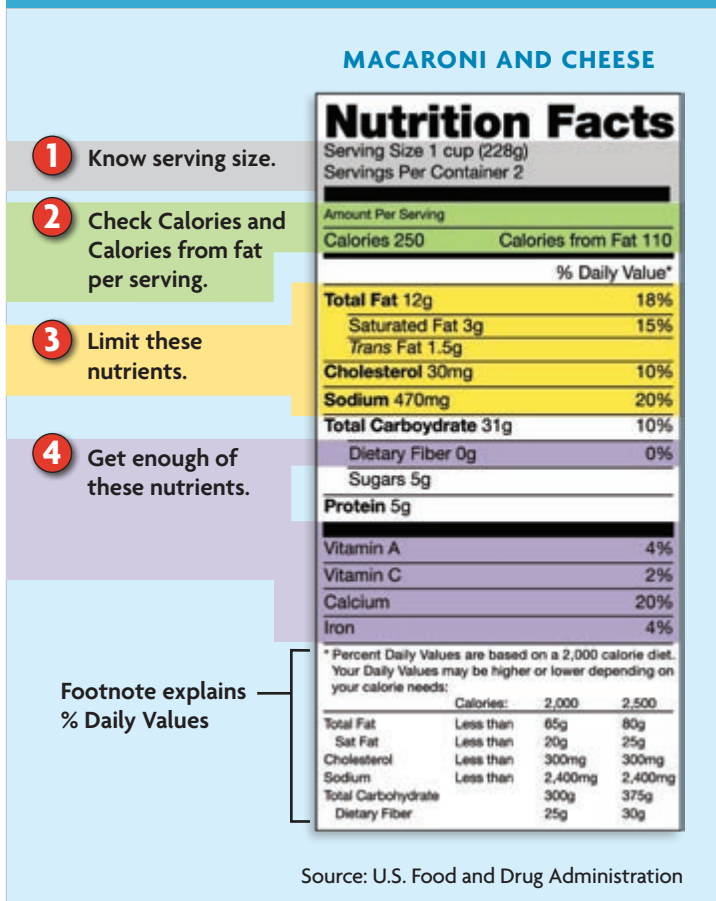
During rapid growth, the body requires significantly more energy.



Contrast What differences do you notice between the two charts?

Sources: Adapted from JM Tanner: *Growth at Adolescence*, ed.2, Oxford; Food and Nutrition Board: *Recommended Dietary Allowances*, ed. 10, National Academy Press; Institute of Medicine, Food and Nutrition Board, *Dietary Reference*, National Academies Press.

FIGURE 1.7 READING A FOOD LABEL



The information on a food label, such as the one in **FIGURE 1.7**, can help you make good choices and compare the values of different foods. The label shown here is from a box of macaroni and cheese.

- 1 Serving size and number** This measurement varies from one product to another. In this case, one serving equals one cup. Notice that this container holds *two* servings.
- 2 Calories and Calories from fat** The numbers listed on the label are for *one serving only*. If you eat both servings, you are actually getting 500 Calories, nearly half from fat.
- 3 Nutrients to limit** Americans usually consume too much saturated fat, trans fat, cholesterol, and sodium. Trans fat is a type of fat that can cause cell damage. A diet high in these nutrients is linked to obesity, which affects more and more Americans of all ages. Too much sodium can raise blood pressure by causing the body to retain water.
- 4 Nutrients to target** Americans need to consume enough of these nutrients each day. Notice that this product is low in vitamins and minerals, except for calcium, and has no dietary fiber. The wheat used in the macaroni has been processed until there is no fiber left.

As the label shows, if you eat this product, you will also need to eat whole grains, vegetables, and fruits during the day to obtain the nutrients that are missing from this food.

Analyze What nutritional advantages do unprocessed foods offer over processed foods?

WebQuest

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Obesity

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PREMIUM CONTENT

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CELLULAR RESPIRATION

5. All cells need ATP to power their metabolic processes. Explain why eating carbohydrates is so important to the process of cellular respiration.

32.1 Formative Assessment

REVIEWING MAIN IDEAS

1. What six types of nutrients must you consume to stay healthy? Give two examples of how nutrients help to maintain homeostasis.
2. What information besides the number of **Calories** can help you make good food choices?

CRITICAL THINKING

3. **Apply** Explain why vegans—people who eat no animal products—may have trouble getting all the essential amino acids from their diet.
4. **Contrast** How do the functions of **vitamins** and **minerals** differ from the functions of proteins and carbohydrates?