WE HAVE all heard the saying, “You are what you eat.” This phrase refers to the relationship between a body’s overall health and the kinds of food eaten. For proper health, the body must take in the proper nutrients, or substances necessary for the functioning of an organism. Nutrition can be thought of as the process in which organisms eat food and use it for growth and the replacement of body tissues.

**Objective:**

- Explain why proper nutrition is important for all organisms.

**Key Terms:**

- adhesion
- amino acids
- capillarity
- carbohydrates
- catalysts
- cohesion
- deficient
- disaccharide
- DNA
- enzyme
- fat-soluble vitamins
- fatty acids
- hydrogenation
- inorganic
- lipase
- lipids
- macrominerals
- minerals
- monosaccharide
- nucleic acid
- nutrients
- nutrition
- organic
- polar
- polysaccharide
- RNA
- saturated fatty acids
- steroids
- trace elements
- triglycerides
- unsaturated fatty acids
- vitamins
- water
- water-soluble vitamins
- wax
The Importance of Nutrition

Organisms have three basic needs for survival. Shelter protects them from the extremes of the environment. Water is necessary for the variety of chemical reactions that occur within their bodies. Food provides the energy that their bodies need to live, grow, and reproduce.

Without proper nutrition, organisms experience stress that inhibits natural functions. Slow growth, low reproductive success, and poor health in general could be signs of poor nutrition. On the other hand, proper nutrition has a variety of positive effects on animals and plants. Some of these are an increased ability to digest and use food, more weight gain in a shorter time, and increased tolerance of adverse conditions.

Six essential nutrients are required for the healthy and productive functioning of an organism. They include water, minerals, vitamins, proteins, carbohydrates, and lipids.

WATER

Water, a molecule made up of two hydrogen atoms and one oxygen atom, is the most essential of all the nutrients. Water is required by every muscle, tissue, and cell of the body to carry out basic functions. Water is a polar compound, meaning it has both positive and negative attraction sites, or poles. Because of this quality, water molecules easily bond to each other to form the various states of water.

More than 75 percent of the muscles and internal tissues of animals are made up of water. Water is the most abundant inorganic substance in the body. An inorganic substance is one composed of noncarbon-based materials found in the earth, such as minerals. An organic compound, on the other hand, contains molecules derived from living things, such as plants or animals. Water is responsible for such activities as helping break down food, regulating body fluids and temperature, and providing internal pressure in plants to keep cells rigid.

The chemical properties of water also aid in the effectiveness of water to carry out various functions. Since water is a polar compound, it exhibits the
principle of **cohesion**, the bonding of two water molecules to each other. The hydrogen in water has a positive charge, while the oxygen has a negative charge. Water has a net charge of zero; but because of how the water molecule is structured, the molecule has one slightly positive pole and one slightly negative pole. This allows water molecules to bond to each other very easily. This can be seen if a small amount of water is poured on a smooth surface. The water tends to form puddles or droplets on the surface because the molecules are bonding, or sticking together.

This polarity of water also increases the amount of heat it takes to break the water molecule apart. A large amount of heat is needed to break the molecular bonds and cause the water to boil. This is good news for all water-based organisms, such as humans. Otherwise, a small amount of heat, even that from the sun, would cause our water molecules to break apart and boil us!

Because of the polarity of water, it likes to bond not only to other water molecules but to other substances as well. **Adhesion** is the bonding of one type of molecule to another type of substance or molecule. You have probably heard this term before when you used adhesive tape. Tape is known as an adhesive because it causes two different types of materials to adhere, or stick, to each other. Water bonds easily to most other substances, especially if the other substances are also polar compounds.

Take, for example, what happens when you wash your car. When you finish, water is still clinging to the surfaces of your vehicle (just waiting to make all those water spots)! If the droplets are small enough, they will adhere, or stick, to the molecules on the surface of the car. A spot-free rinse at the carwash covers your vehicle with a temporary liquid surface that does not allow water to adhere. Therefore, water slides off the car surface before the droplets can dry and leave spots.

Have you ever seen a magician levitate an assistant, seeming to defy gravity? We know that this levitation is an illusion, but water can actually move against gravity and pull itself upward. **Capillarity** is the ability of a liquid to move upward against the force of gravity because of the liquid’s molecular attraction to the surrounding surface.

Did you ever wonder how water travels from the soil all the way to the top of a tall tree? Using cohesion and adhesion, water can move up the small xylem cells in the plant, beginning in the roots and ending in the leaves. To explain this better, think of a glass cylinder. The water inside the cylinder will bond to the glass surface due to adhesion. At the same time, cohesion
between water molecules will pull more water up the cylinder. The smaller the cylinder, the smaller the amount of water that gravity is acting upon, causing the liquid to rise farther.

**MINERALS**

Along with water, minerals are also necessary for proper growth of plants and animals. Inorganic compounds found in rocks, soil, and water, among other places, are known as **minerals**. Several minerals have been identified as essential elements for proper life and growth. If any one of these elements is **deficient**, or lacking in the needed amount, an organism can experience serious, sometimes deadly, results.

The mineral elements have been divided into two general groups, macrominerals and trace elements. **Macrominerals** are those elements that are needed in larger quantities in the body. There are six macrominerals: calcium, phosphorus, magnesium, sodium, potassium, and chloride. Because most minerals are needed in very small amounts, “larger quantities” may mean only a few milligrams! **Trace elements**, often called microminerals, are those minerals that are needed in very small quantities but are just as important to growth and survival. There are nine trace elements: chromium, copper, fluoride, iodide, iron, manganese, molybdenum, selenium, and zinc.

Sickness and disease can commonly be the result of low mineral amounts in the diet. Do you ever take a mineral supplement? Chances are that most of us do not eat enough food with the proper minerals. Have you ever felt exhausted or run down? Feelings of tiredness can sometimes be attributed to low iron levels. Not enough magnesium can result in muscle tremors and shaking. Got milk? Low levels of calcium, a mineral commonly found in dairy products, can lead to osteoporosis (brittle bone disease) and to poor teeth, skin, and fingernails.

**VITAMINS**

Vitamins are similar to minerals in that they are needed in small amounts and are important for the proper functioning and growth of an organism. **Vitamins** are complex compounds, generally consisting of carbon, hydrogen, oxygen, and nitrogen molecules. Vitamins often serve as **catalysts**, compounds that cause other chemical reactions to occur. Think of your-
self jogging at a normal pace. If suddenly you found yourself being chased by a bear, you
would probably pick up the pace! The bear would be like a catalyst, causing a definite reaction
in your running speed.

Vitamins do not provide any energy for the body; they simply help the body carry out its
functions more efficiently. Vitamins can help your blood clot quickly, your bones form cor-
rectly, and your cells reproduce effectively (all important if you get caught by that bear)! Vita-
mins can also help organisms produce milk and prevent some nervous system disorders.

There are a vast number of vita-
mins to choose from when you
walk down the isle at your local
pharmacy. Generally, vitamins can
be classified into two categories.

**Water-soluble vitamins** must
be consumed anew each day, as the
vitamins are able to be dissolved in
water, and any excess will be
excreted from the body. Examples
of water-soluble vitamins are vita-
mins C and B. **Fat-soluble vita-
mins** are dissolved by fat and are
stored in the body for future use.
Examples of fat-soluble vitamins
are vitamins A, D, E, and K.

Vitamins, like minerals, are
essential but needed in small
amounts. Take vitamin C, for
example. The recommended daily
intake of vitamin C is 60 milli-
grams (a milligram is 1/1,000 of a
gram). Because vitamin C is water
soluble, any excess will be excreted
from the body (although toxicity
can occur with large doses).

More is not always better in the
case of vitamins. Large doses of
vitamins can be toxic to an organ-
ism. Most livestock animals do not
receive the proper vitamins they
need in their feed and must there-
fore have vitamin supplements
added to their rations to give them
healthy diets.
PROTEIN

Nearly everything we eat or grow has protein as part of its structure. Hair-care products boast “protein fortified” shampoos to strengthen your hair. Athletes sometimes drink protein shakes to help rebuild muscles after exercising. Next to carbohydrates, protein is the most common nutrient substance found in plant material. Protein is largely found in the seeds of most plants and is essential for the biological functions of both the plants and humans.

Most of us have been injured at some point in our lives. Proteins helped us and continue to help us repair our injuries and to grow. Of our cells, 3 to 5 percent must be repaired and rebuilt every day. Protein is also the main component of our genetic code, which passes on information from an individual to its offspring.

Proteins are formed by the joining of many single molecular units, known as monomers, into amino acids. The creation of amino acids involves the joining of a central carbon atom to other atoms. There are 20 known amino acids essential to human life and growth. Our bodies can produce 11 of the 20, but the other 9 must be consumed in the food we eat or in dietary supplements, like vitamins.

When two amino acids bond, the resulting compound is a dipeptide. When more than two amino acids bond, the resulting compound is a polypeptide. Proteins are formed by the linking of two or more polypeptides. From this progression, you can clearly see why protein is truly the building block of life!

Proteins, however helpful they seem, would be useless in our bodies without the presence of enzymes. An enzyme works as a catalyst to reduce the amount of energy needed for a chemical reaction to occur. Enzymes are essential in our bodies to help digest, or break down, the proteins we consume into usable energy. Without enzymes, pro-
proteins would be unable to be digested and pass through our systems without much benefit to us.

One of the most important functions of protein is the formation of nucleic acids. **Nucleic acids** are organic molecules found in the nucleus of a cell that contain genetic information. There are two main nucleic acids, DNA and RNA, which are essential to all life on Earth. **DNA** (deoxyribonucleic acid) is a large molecule built from the bonding of the four nucleotides adenine, thymine, guanine, and cytosine. Through the arrangement of different protein groups, a DNA molecule codes all the genetic and hereditary information for an organism. **RNA** (ribo-

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**FIGURE 9.** DNA molecules store and transfer heredity information from one generation to the next.
nucleic acid) is a smaller molecule formed from sections of DNA. The purpose of RNA is to store information for the manufacture of proteins that will be used for body functions. Unlike DNA, which is found only in the cell nucleus, RNA is found in both the nucleus and the cytoplasm of a cell.

“How do I know whether there is enough protein in my diet?” you ask. Chances are if you are eating well-balanced meals, you are consuming the proper amount of daily protein. Meats, dairy products, eggs, beans, and nuts are all great sources of protein. Most livestock producers, however, feed their animals preformulated protein supplements that meet the daily requirements of their animals instead of feeding raw soybeans or peanuts.

**CARBOHYDRATES**

**Carbohydrates** are organic compounds, usually starches and sugars, which are the primary sources of energy for an organism. Americans typically consume nearly half their calorie intake from carbohydrates, while Asians and Africans may consume closer to fourth-fifths, because of the amount and type of food they eat. Examples of foods that are rich sources of carbohydrates are rice, corn, potatoes, and wheat.

Carbohydrates are composed of carbon, hydrogen, and oxygen. The number of carbon atoms in a particular carbohydrate may vary from the number in another carbohydrate, but there are always two hydrogen atoms and one oxygen atom in each molecule. This 2:1 ratio of hydrogen to oxygen is the same ratio present in a common water molecule.

There are three main types of carbohydrates: monosaccharides, disaccharides, and polysaccharides. All three are simple sugar compounds that vary only by the number of molecules in each structure. Look at the prefix of each word (mono-, di-, and poly-) to get a hint as to how many molecules will make up the final carbohydrate.

**Monosaccharides** are simple, single-molecule sugars that contain the ratio of one carbon atom : two hydrogen atoms : one oxygen atom. Some common monosaccharides are glucose,
fructose, and galactose. All three of these monosaccharides have a chemical formula of C₆H₁₂O₆ but are structured in different ways. Compounds of this type are called isomers.

Take a moment and think about the three monosaccharides just listed. Can you think of where each of these could be found? The main purpose of photosynthesis is to produce food for plants, and the food created is known as glucose. We, as well as other animals, benefit from glucose when we eat the stem, roots, seeds, and leaves of a plant. Fructose is a very sweet-tasting monosaccharide found in fruit, while galactose is a monosaccharide found in milk.

When two monosaccharides, or single-molecule sugars, join, they form a disaccharide, or double-sugar molecule. Lactose, a milk sugar, is formed from the combination of both glucose and galactose. Maltose is created when two glucose molecules combine. Sucrose, or what we commonly know as sugar, is actually the joining of fructose and glucose. Sucrose is commonly found in plants that we harvest and use for their sweet taste, such as sugar cane and sugar beets.

ON THE JOB...

CAREER CONNECTION: Food Scientist

Without food scientists, many of our favorite foods would simply not exist. Food scientists dream up new foods and new combinations of ingredients to give us different flavors, textures, and smells from our food. In addition to the creation of new foods, they also work to ensure that our food supply is safe from contaminants that could harm consumers.

Food scientists use a vast amount of scientific knowledge in their daily routines. Chemistry, biology, microbiology, and physics all play roles in the education of food scientists. These scientists may work independently, for companies or corporations, or for the government. They develop and refine preservation, processing, packaging, and production techniques to be used in the food industry. They also make sure that all food products are meeting regulations and guidelines for quality, safety, and waste management during production.

One aspect of the agriculture industry that employs food scientists is research in the uses of soybeans. Scientists are continually developing new ways to increase the protein content of other foods by using soybeans. Sometimes, food scientists may even develop nonfood items from food sources, as in the case of soy ink from soybeans!

Food scientists need a bachelor’s degree in food science or related field, with most people going on to receive their master’s or doctorate degree.
FIGURE 11. These three monosaccharides have the same molecular formula (the same number and type of atoms), but each has a different structural formula because the atoms are arranged differently.

FIGURE 12. Chemical structure of a disaccharide.
Sometimes, more than two monosaccharides will join, forming what is known as a **polysaccharide**. Three common polysaccharides are starch, cellulose, and glycogen. When plants complete photosynthesis and create glucose, a monosaccharide, they form long chains of glucose into starches that are stored for an energy supply later. We as humans also benefit from starches. This is why we harvest certain plants—potatoes, corn, and rice, for example—when the levels of starches being stored are highest. Without plants, the amount of carbohydrates in our diets would be severely lacking.

Cellulose is also a chain of glucose molecules that are joined differently than starch molecules. Cellulose makes up much of plant cell walls and adds support and structure to plants. Humans and all nonruminant animals are unable to digest cellulose. Good examples of cellulose are the veins in a stalk of celery. We may be able to chew them into small pieces, but our digestive system cannot dissolve and use them, passing them out with our waste. A ruminant animal, such as a cow, has specialized bacteria in the rumen compartment of its stomach that can break down cellulose, allowing the animal to benefit from grasses and other plants.

As we eat food sources that contain glucose, we are sure to ingest glycogen, the storage form of glucose in our bodies. All animals, including humans, store energy for later use, just as plants do. Glycogen is commonly found in muscle tissue and can be used for energy if other sources—namely, our fat supplies—begin to run low. This is why extreme dieting can destroy muscle mass and damage internal organs.

**LIPIDS**

All living organisms, including plants and animals, require lipids to carry out basic life functions. **Lipids** are fatty compounds made up of carbon, hydrogen, and oxygen. Lipids are not water soluble. This means they cannot be dissolved in water. There are many uses of lipids, including storing energy for later use, adding bulk or flavor to our food, adding insulation to our bodies, and being part of various other chemical reactions. Lipids are commonly added to livestock feed to improve the flavor, palatability, and texture, as well as the energy levels gained from the feed. As mentioned earlier in this E-unit, some vitamins are fat soluble. Lipids are therefore required to carry and store these vitamins for later use. Vitamins A, D, E, and K are fat-, or lipid-, soluble vitamins.
Now that we understand what a lipid is, we should focus on what a lipid does. Three main types of lipids are found in plants and animals: triglycerides, wax, and steroids.

**Triglycerides** are lipids composed of three fatty-acid molecules and one glycerol molecule. Glycerol is an alcohol molecule that provides the framework for various types of triglycerides to form substances we commonly know as oils or fats. When we eat triglycerides, our bodies use a substance called a lipase, an enzyme that breaks down lipids, cutting the triglycerides into smaller chains of molecules. Our bodies can then restructure these broken chains into the appropriate form for use or storage. If a triglyceride is in a liquid state at room temperature, it is called an oil. Oils are commonly found stored in the seeds of plants, such as soybeans, canola, and peanuts. Triglycerides that are in a solid state at room temperature are known as fats. Fats are commonly found covering organs and muscle tissues in animals.

**Wax** is another common form of lipid that is actually a long fatty acid connected to a long alcohol chain. Because of the structure of wax, it is highly waterproof and is often found as a coating on leaves to help conserve water and reflect the rays of the sun. Wax is a solid at room temperature but changes to a liquid when subjected to heat. When the heat is removed, the wax cools and returns to a solid state basically unchanged.

Our final group of lipids to discuss is steroids. **Steroids** are lipids that include cholesterol and cortisone and are found in hormones, nerve tissues, and plant poisons. Steroids have the ability to cause changes or chemical reactions to occur.
Steroids are essential for the functioning of our bodies; however, the addition of artificial steroids to our bodies can be dangerous.

**Lipids in Our Diet**

All lipids are created when a molecule of glycerol, an alcohol, is linked to any number of fatty acids, or long chains of carbon molecules joined to an acid molecule. Some examples of fatty acids are lauric acid, butyric acid, and caproic acid. Our bodies have the ability to produce some fatty acids that can be used in the creation of lipids. However, other fatty acids, known as essential fatty acids, are not produced in our bodies and must be consumed in our daily intake of food. Therefore, a diet that has no fat may sound appealing to someone trying to lose weight, but it is actually very damaging to the body.

**UNDER INVESTIGATION...**

**LAB CONNECTION: Testing for Carbohydrates, Fats, and Proteins**

Human beings, and most living organisms for that matter, require six essential nutrients for proper growth and health. Water can usually be readily found and is normally not deficient in our diets. The other five (minerals, vitamins, proteins, carbohydrates, and lipids) are sometimes overlooked in our daily diets. This can lead to serious health concerns.

Food scientists, along with plant scientists and breeders, have found that plants can provide many of the essential nutrients in our diet. From the carbohydrate storage cells in the roots to the protein-packed seeds in the fruit, plants are producing these essential nutrients in great quantities. But sometimes quantity does not equal quality. Scientists are now changing the nutrient content of various plant products to meet an ever-changing demand for nutritious food and balanced livestock feed. From corn to soybeans, scientists are altering the amounts of nutrients with techniques as complex as DNA manipulation and as simple as selective breeding.

However complex or simple the process of nutrient altering may be, it still must begin with a base knowledge of what nutrients are already present and in what quantities these nutrients are present in the plant material. A laboratory experiment can be conducted to test foods for carbohydrates, fats, and proteins. The instructor will provide specific instructions. A variety of foods should be tested. Then, the foods can be compared based on the presence of sugar, starch, fats, and proteins.
You have probably heard of saturated and unsaturated fatty acids but, like most consumers, are unaware of what makes one fatty acid saturated and one unsaturated. The terms actually refer to the number of hydrogen molecules linked to the fatty acids. **Saturated fatty acids** are linked to the maximum number of hydrogen molecules and are therefore “saturated” with hydrogen. **Unsaturated fatty acids** are exactly what they sound like, “unsaturated” with hydrogen molecules. Saturated fatty acids are more likely to appear as solids at room temperature and are present in such foods as meats, butter, and coconuts. Unsaturated fatty acids are in a liquid form at room temperature and are commonly found in the oils of fish and plants.

Sometimes, a food producer wishes to have an unsaturated fatty acid in a solid state at room temperature. For this to occur, the unsaturated fatty acid must undergo a process called **hydrogenation**, in which hydrogen molecules are added to the unsaturated fatty acid to give it the qualities of a saturated fatty acid. Margarine, a substitute for butter, is an example of an unsaturated fatty acid that has undergone hydrogenation to become solid at room temperature.

Unlike people of other countries, we in the United States consume quite a bit of fat in our diets. Nearly 50 percent of the calories consumed by Americans are in the form of fat. As we said earlier, some fat in our diets is necessary, but most doctors agree that people should limit fat calories to about 30 percent of their total caloric intake. Some medical studies have shown that a high-fat diet can contribute to a variety of unhealthy medical conditions, ranging from obesity and high cholesterol to cardiovascular disease and heart attacks.
To reduce the amount of fat in our diets, we must monitor our intake of high-fat foods, such as fast foods and snack chips. We must also be aware of the amount of saturated fatty acids in a food product. Most food items, even saturated fat items, are safe to eat as long as we remember that the key is moderation. Too much of a good thing (or something that tastes good) can turn out to be a bad thing!

Summary:
Proper nutrition is critical to all living organisms because it provides the energy needed for life, growth, and reproduction. Water, the most critical nutrient, is required on a cellular level and allows our most basic processes to be carried out. Minerals are inorganic compounds needed in various amounts to prevent disease and poor health in organisms. Vitamins are compounds that provide nutrients to the body for tissue maintenance and growth, among other processes. Proteins are the building blocks for amino acids, which, in turn, are essential to the formation of DNA and life in general. Carbohydrate, our most abundant nutrient, is responsible for the energy needed to carry out our daily metabolic functions. Lipids are primarily used to store energy until our bodies require its breakdown and use.

Checking Your Knowledge:

1. What is nutrition, and why is it important for a body to take in nutrients?
2. What are the six essential nutrients required for the healthy and productive functioning of an organism?
3. How can water move itself upward against the force of gravity?
4. What is the difference between water-soluble and fat-soluble vitamins?
5. Why are enzymes essential to your body’s functioning?
6. List and briefly describe the three main types of carbohydrates.
7. How does wax, a lipid, help protect leaves during the summer?
Expanding Your Knowledge:

Bring five different food items with nutrition labels to class. Using the nutritional information and the ingredients listed on each package, sort each ingredient into one of the six categories of essential nutrients. Use the Internet to classify any unknown additives.

Web Links:

USDA Food and Nutrition Information Center

U.S. Department of Labor—Food Scientist
http://www.bls.gov/oco/ocos046.htm

Agricultural Career Profiles
http://www.mycert.com/career-profiles