Chapter 13: Detailed Summary

Nutrients of Life

There are four basic types of molecules produced and used by living organisms. Because they are used by living organisms, they are also called *biomolecules*. They include the carbohydrates, lipids, proteins, and nucleic acids. After discussing the chemistry of these biomolecules, this chapter explores the chemistry concepts underlying nutrition.

A carbohydrate is a polymer made of saccharide monomers, sometimes called *monosaccharides*. There are many different kinds of monosaccharides but they all consist of a chain of carbon atoms joined together in a ring by an oxygen atom. Monosaccharides are also characterized by their many hydroxyl groups, which makes them polar. Glucose and fructose are two of the most common monosaccharides. The combination of a glucose and fructose monomers makes the sucrose (table sugar) molecule, which is a *disaccharide*. A long string of glucose units creates either starch or cellulose, which are examples of *polysaccharides*. Animals produce and use starch as a source of food. Plants likewise produce starch for food (through photosynthesis), but they also produce cellulose (also through photosynthesis), which they use for structural purposes.

Lipids are characteristically nonpolar, hence, water insoluble. Two types of lipids include the *fats* and *steroids*. A fat molecule consists of three fatty acid chains bonded to a single glycerol molecule. If the fatty acid chains of a fat molecule contain all carbon-carbon single bonds, then the fat is *saturated*. The molecules of saturated fats align nicely with each other, which gives the saturated fat a relatively high melting point—they tend to be solids at room temperature. If the fatty acid chain contains one or more double bonds, then the fat is said to be *unsaturated*. The double bond of unsaturated fats forms a bend within the fatty acid chain. This, in turn, inhibits the alignment of unsaturated fat molecules, which thus have lower melting points—they tend to be liquid (oil) at room temperature. The body uses fat molecules for their large energy content and also for insulation. Steroids are structurally quite different from fats, consisting of a series of adjoining carbon rings. The body produces and uses steroids as hormones.

Like the carbohydrates, *proteins* are also polymers. The monomer unit of a protein is the *amino acid*, which polymerizes into a *polypeptide*. There are about 20 amino acids that life-forms on Earth use to build proteins. The structure of a protein can be described on four structural levels. The primary structure is simply the sequence of amino acids. The secondary structure describes how various short portions of a chain are either wrapped into a coil or in sheets. The teritary stucture is the way in which an entire polypeptide chain may either twist into a long fiber or bend into a globular clump. The quaternary structure describes how separate proteins may join to form one larger complex. Each level of structure is determined by the level before it. A protein's structure is readily destroyed by large changes in pH or temperature. Such a destroyed protein is said to be *denatured*. An important class of proteins that

serve as biochemical catalysts are *enzymes*. They work to facilitate biochemical reactions by offering a receptor site where reactants are readily converted to products. As discussed in Chapter 14, many drugs work by acting upon the receptor sites of enzymes.

Nucleic acids are polymers that hold the information for producing proteins. The monomer unit of the nucleic acid is the *nucleotide,* and there are five different types of nucleotides. *DNA* is the nucleic acid that holds the "blueprint" for the building of proteins, and it consists of the nucleotides adenine, guanine, cytosine, and thymine. *RNA* reads this blueprint and is more actively involved in the actual protein-building process. RNA consists of the nucleotides adenine, guanine, cytosine, and uracil.

DNA is found within the cell's nucleus. As a cell divides, the DNA undergoes the process of *replication,* whereby the DNA strand is duplicated so that both daughter cells contain the same DNA. Within DNA are sequences of nucleotides, called *genes*, that hold the code for a particular sequence of amino acids. The number of genes contained by human DNA is estimated to be around 25,000. The process of using a gene to create a sequence of amino acids for a protein involves two major RNA-mediated steps, which are transcription followed by translation. During *transcription*, a portion of the DNA unwinds and serves as a template for the formation of a strand of messenger RNA. The mRNA then migrates to the cell's cytoplasm, where it binds to *ribosomes*. A sequence of three nucleotides on the mRNA, called a *codon*, binds to the *anticoden* of a transfer RNA molecule. At the other end of the tRNA molecule is an amino acid. As tRNA molecules attach themselves to the mRNA in an adjacent manner, the amino acids of the tRNA molecules are also brought together. These amino acids react (via enzymes) with one another to form the polypeptide, which upon release folds itself into a functional protein. Genetic engineering is a method by which scientists can produce proteins of their own design using these same mechanisms, usually within bacteria.

This chapter concludes with a discussion about vitamins and minerals, which we must obtain through our diet, followed by a discussion about how our bodies extract energy from the food we eat. Carbohydrates, both digestible (sugars and starch) and nondigestible (fiber) make up the bulk of most diets. Fats are transported through the body within lipoproteins, some of which can form arterial plaque. Proteins are digested for their amino acids, which the body uses for building its own proteins. The amino acids we must obtain through our diet are known as the essential amino acids.

Summary of Terms

Amino acid The monomers of polypeptides, each monomer consisting of an amine group and a carboxylic acid group bonded to the same carbon atom.

Anabolism A general term for all the energy-requiring chemical reactions that produce large biomolecules from smaller molecules.

Carbohydrate Organic molecules produced by photosynthetic plants containing only carbon, hydrogen and oxygen.

Catabolism Chemical reactions that break down biomolecules in the body.

Chromosomes An elongated bundle of DNA and protein that appears in a cell's nucleus just prior to cell division.

Deoxyribonucleic acid (DNA) A nucleic acid containing a the sugar deoxyribose and having a double helical structure, as well as carrying genetic code in the nucleotide sequence.

Enzymes A protein that catalyzes (speeds up) biochemical reactions.

Fat A biomolecule that packs a lot of energy per gram and consists of a glycerol unit attached to three fatty acid molecules.

Gene A particular sequence of DNA nucleotides along the DNA strand that leads a cell to manufacture a particular polypeptide.

Glycogen A polymer made of hundreds of glucose monomers and sometimes referred to as animal starch.

Lipid A broad class of biomolecules not soluble in water because their structures are largely of a hydrocarbon nature.

Metabolism The general term describing the sum of all the chemical reactions in the body.

Mineral Inorganic chemicals that play a wide variety of roles in the body and are obtained from our diet.

Nucleic acid A long polymeric chain of nucleotide monomers holding the information for how amino acids need to be linked together to form the organism.

Nucleotide A nucleic acid monomer consisting of three parts: a nitrogenous base, ribose (in RNA) or deoxyribose (in DNA), and a phosphate group.

Protein A polymer of amino acids having some biological function.

Replication The process by which DNA strands are duplicated.

Ribonucleic acid (RNA) A nucleic acid containing a fully oxygenated ribose and which executes protein synthesis based on code read from DNA.

Saccharide Another term for carbohydrate. The prefixes *mono-*, *di-*, and *poly-* are used with this term to indicate the size of the carbohydrate.

Vitamins Organic chemicals that assist in various biochemical reactions in the body and are obtained from our diet.