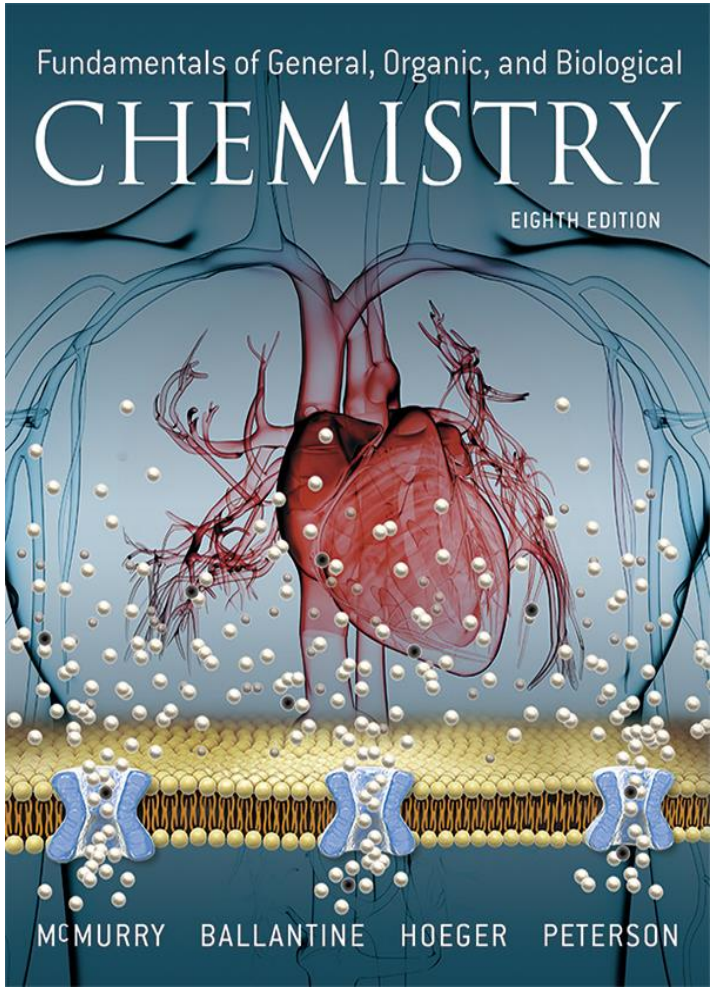
Chapter 18 Lecture



Fundamentals of General, Organic, and Biological Chemistry

8th Edition

McMurry, Ballantine, Hoeger, Peterson

Chapter Eighteen

Amino Acids and Proteins

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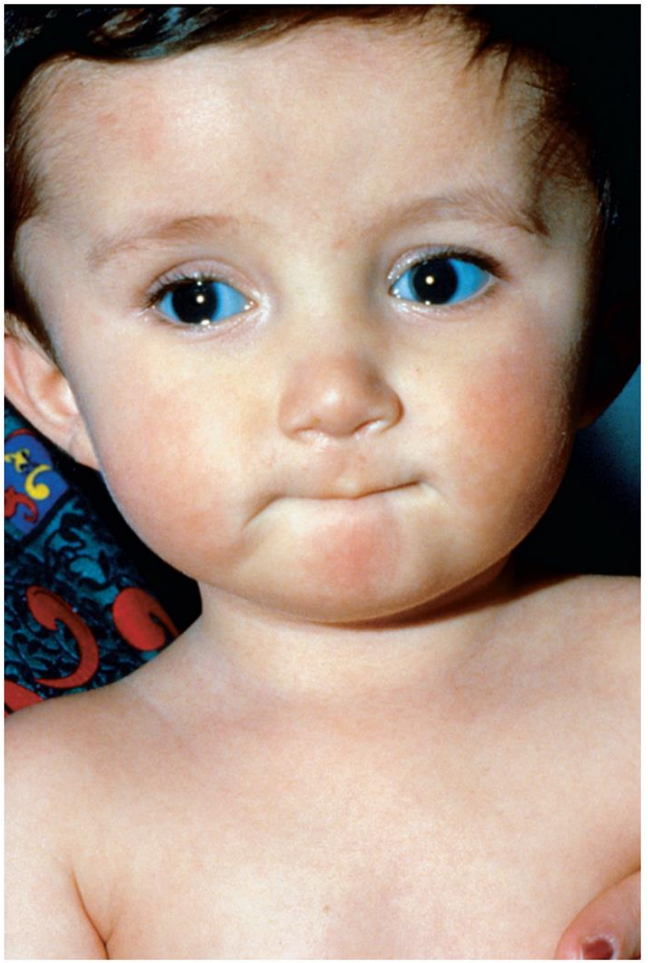
Outline

Concepts to Review

- Acid-Base Properties
  - Sections 5.4, 10.2, and 17.2
- Hydrolysis Reactions
  - Section 17.4
- Intermolecular Forces
  - Section 8.2
- Polymers
  - Sections 13.7 and 17.5

18.1 An Introduction to Biochemistry

Physicians are faced with biochemistry every day; all diseases are associated with abnormalities in biochemistry.



Child with osteogenesis imperfecta, a genetic disease. One characteristic of osteogenesis imperfecta is the blue color of the sclera (whites) of the eyes.

18.1 An Introduction to Biochemistry

- ***Biochemistry*** is the study of molecules and their reactions in living organisms.
  - Built upon the inorganic and organic chemical principles outlined in the first 17 chapters of this book
- Nutritionists evaluate dietary needs based on biochemistry.

18.1 An Introduction to Biochemistry

- The pharmaceutical industry designs molecules that mimic or alter the action of biomolecules.
- The goal of biochemistry is to understand the structures of biomolecules and the relationship between their structures and functions.

18.1 An Introduction to Biochemistry

- Biochemistry is the common ground for the life sciences, where answers to fundamental questions are being found at the molecular level.
- The principal classes of biomolecules are *proteins*, *carbohydrates*, *lipids*, and *nucleic acids*.

18.1 An Introduction to Biochemistry

- Biochemical reactions must continuously break down food molecules, generate and store energy, build up new biomolecules, and eliminate waste.
- Despite the huge size and complexity of some biomolecules, their functional groups and chemical reactions are no different from those of simpler organic molecules.

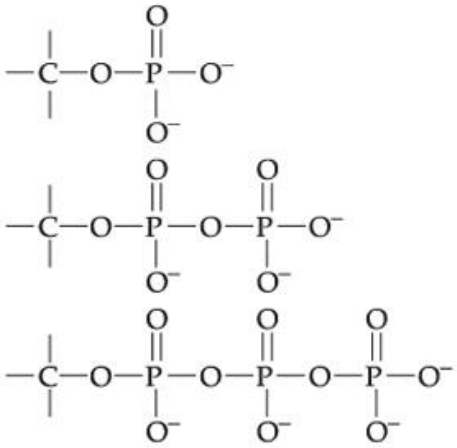
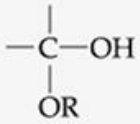
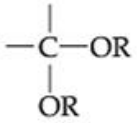
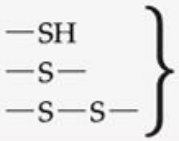
18.1 An Introduction to Biochemistry

All the principles of chemistry introduced thus far apply to biochemistry.

Table 18.1 Functional Groups of Importance in Biochemical Molecules

Functional Group	Structure	Type of Biomolecule
Ammonium ion, amino group	$-NH_3^+$, $-NH_2$	Amino acids and proteins (Sections 18.3 and 18.4)
Hydroxyl group	$-OH$	Monosaccharides (carbohydrates) and glycerol: a component of triacylglycerols (lipids) (Sections 20.3 and 23.2)
Carbonyl group	$-\overset{\overset{O}{\|}}{C}-$	Monosaccharides (carbohydrates); in acetyl group (CH_3CO) used to transfer carbon atoms during catabolism (Sections 21.4 and 21.8)
Carboxyl group, carboxylate anion	$-\overset{\overset{O}{\|}}{C}-OH$, $-\overset{\overset{O}{\|}}{C}-O^-$	Amino acids, proteins, and fatty acids (lipids) (Sections 18.3, 18.4, and 23.2)
Amide group	$-\overset{\overset{O}{\|}}{C}-\underset{\|}{N}-$	Links amino acids in proteins; formed by reaction of amino group and carboxyl group (Section 18.4)
Carboxylic acid ester	$-\overset{\overset{O}{\|}}{C}-O-R$	Triacylglycerols (and other lipids); formed by reaction of carboxyl group and hydroxyl group (Section 23.2)

18.1 An Introduction to Biochemistry

Phosphates, mono-, di-, tri-		Adenosine triphosphate (ATP) and many metabolism intermediates (Sections 17.6, 21.4, and throughout metabolism sections)
Hemiacetal group		Cyclic forms of monosaccharides; formed by a reaction of carbonyl group with hydroxyl group (Sections 15.7 and 20.4)
Acetal group		Connects monosaccharides in disaccharides and larger carbohydrates; formed by reaction of carbonyl group with hydroxyl group (Sections 15.7, 20.6, and 20.7)
Thiols Sulfides Disulfides		Found in amino acids cysteine, methionine; structural components of proteins (Sections 14.8, 18.3, 18.8, and 18.10)

In Table 18.1, both the amino group and the carboxyl group are shown having two different structures. This is explained in Section 18.4.

18.2 Proteins and Their Functions: An Overview

Approximately 50% of your body's dry weight is protein.

Learning Objective: Describe the different functions of proteins and give an example for each function.

18.2 Proteins and Their Functions: An Overview

- The word *protein* is taken from the Greek *proteios*, meaning “primary.”
- *Protein* is an apt description for the biological molecules that are of primary importance to all living organisms.

18.2 Proteins and Their Functions: An Overview

- What roles do proteins play in living things?
  - They provide *structure* (keratin) and *support* (actin filaments) to tissues and organs throughout our bodies.
  - As *hormones* (oxytocin) and *enzymes* (catalase), they control aspects of metabolism.

18.2 Proteins and Their Functions: An Overview

- In body fluids, water-soluble proteins pick up other molecules for *storage* (casein) or *transport* (transferrin, Fe^{3+}).
- Proteins of the immune system provide *protection* (Immunoglobulin G) against invaders, such as bacteria and viruses.

The overall shape of a protein molecule is essential to the role of that protein in our metabolism.

18.2 Proteins and Their Functions: An Overview

Table 18.2 Classification of Proteins by Function

Type	Function	Example
Enzymes	Catalyze biochemical reactions	*Amylase*—begins digestion of carbohydrates by hydrolysis
Hormones	Regulate body functions by carrying messages to receptors	*Insulin*—facilitates use of glucose for energy generation
Storage proteins	Make essential substances available when needed	*Myoglobin*—stores oxygen in muscles
Transport proteins	Carry substances through body fluids	*Serum albumin*—carries fatty acids in blood
Structural proteins	Provide mechanical shape and support	*Collagen*—provides structure to tendons and cartilage
Protective proteins	Defend the body against foreign matter	*Immunoglobulin*—aids in destruction of invading bacteria
Contractile proteins	Do mechanical work	*Myosin* and *actin*—govern muscle movement

18.3 Amino Acids

Proteins are polymers of amino acids.

Learning Objectives:

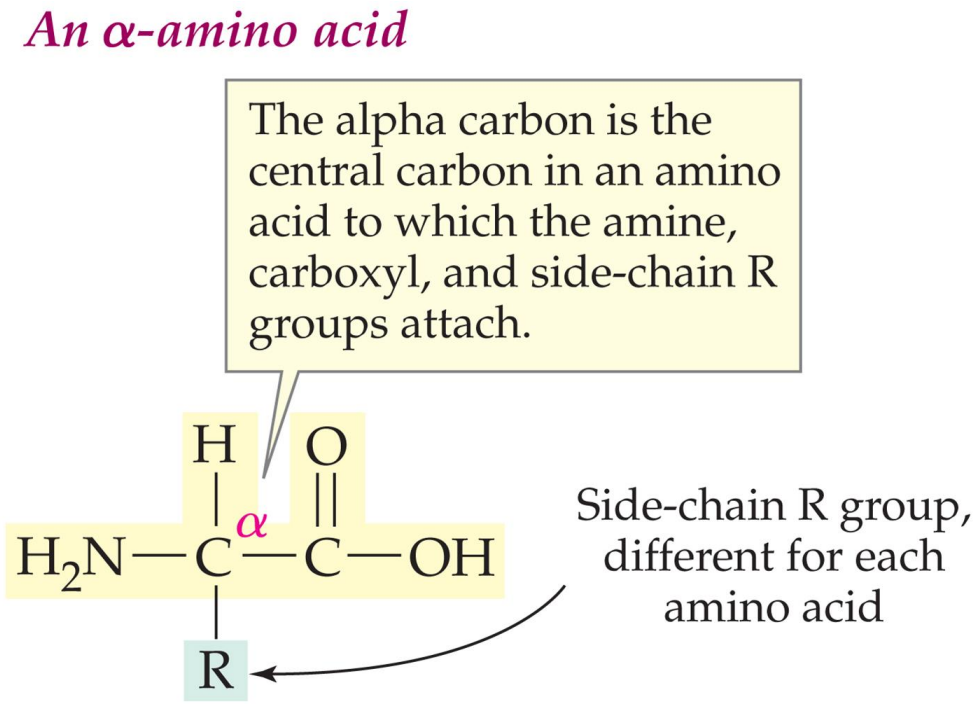
- Describe and recognize the 20 alpha amino acid structures and their side chains.
- Categorize amino acids by the polarity or neutrality of the side chain and predict which are hydrophilic and which are hydrophobic.
- Explain chirality and identify which amino acids are chiral.

18.3 Amino Acids

- Every amino acid contains an amine group ($–NH_2$), a carboxyl group (–COOH), and an R group called a **side chain**, bonded to a central carbon atom.
- The central carbon is the alpha carbon, named so because it is the carbon atom directly adjacent to a carboxyl functional group.

18.3 Amino Acids

- Amino acids in proteins are **alpha-amino (*α-amino*) acids** because the amine group in each is connected to the alpha carbon.



18.3 Amino Acids

- Each α-amino acid has a different R group. This is what distinguishes them from one another.
- R groups may be hydrocarbons, or may contain a functional group.

18.3 Amino Acids

- All of the proteins in living organisms are built from 20 amino acids.
- Each amino acid has a three-letter shorthand code.
- For 19 of these amino acids, only the identity of the side chain attached to the carbon differs.
- The remaining amino acid (proline) is a secondary amine whose nitrogen and carbon atoms are joined in a five-membered ring.