

Workbook



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Protein's Three Dimensional Structure

Primary Structure

Questions

- 1) What is the defining factor that distinguishes proteins, how do they differ chemically?
- 2) We introduced several Levels of Protein Structure have several levels of complexity. Please mention how many and what each one of them is.
- 3) Describe how differences in primary structure of proteins are informative.
- 4) Protein structure is dynamic, explain what this means and its significance.
- 5) What are the five themes of Protein structure as explained in the lesson?
- 6) What is a native conformation, a native protein?
- 7) What forces stabilize the native conformation/s of a polypeptide chain?
- 8) What is the Solvation layer, a hydration shell and the hydration number?
- 9) Explain this statement: Hydrogen bonds between groups in proteins form cooperatively.
- 10) Most of the structural patterns reflect two simple rule, what are these?
- 11) What can be said about the peptide C-N bond?

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12) Complete the sentence – fill in the blanks:

- a. The _____ atoms of the _____ group are in a _____ plane, with the oxygen atom of the carbonyl group and the hydrogen atom of the amide nitrogen _____ to each other.
- b. The peptide _____ that link amino acid residues in a polypeptide are formed in a _____ reaction between the acidic carboxyl group of one amino acid and the basic amino group of another amino acid. In the context of a peptide, the amide group (CO–NH) is referred to as the _____.

13) What did Linus Pauling and Robert Corey conclude with regard to the peptide bond in the late 1930s?

Answer Key

- 1) The defining factor that distinguishes proteins is structural.
- 2) There are 4 levels of protein structure that are commonly defined:
 - a. Covalent bonds linking amino acid residues in a polypeptide chain is its primary structure.
 - b. Secondary structure refers to particularly stable arrangements of amino acid residues giving rise to recurring structural patterns.
 - c. Tertiary structure describes all aspects of the 3-dimensional folding of a polypeptide.
 - d. When a protein has two or more polypeptide subunits, their arrangement in space is referred to as quaternary structure.
- 3) To view the answer to this exercise, please refer to the appropriate video on site.
- 4) The covalent backbone of a protein contains hundreds of bonds.
- 5) The 5 themes of Protein structure are:
 - a. The 3-dimensional structure of a protein is determined by its amino acid sequence
 - b. The function of a protein depends on its structure
 - c. An isolated protein usually exists in one or a small number of stable structural forms
 - d. The most important forces stabilizing the specific structures maintained by a given protein are noncovalent interactions
 - e. Among the huge number of unique protein structures, we recognize some common structural patterns that help organize our understanding of protein architecture
- 6) The spatial arrangement of atoms in a protein is called its conformation. Proteins in their functional, folded conformations are called native proteins.
- 7) hydrogen bonds, the hydrophobic effect, and ionic interactions.
- 8) Solvation layer - it is what forms when water surrounds a hydrophobic molecule; the optimal arrangement of hydrogen bonds results in a highly structured shell. When the solvent is water it is often referred to as a hydration shell or hydration sphere. The number of solvent molecules surrounding each unit of solute is called the hydration number of the solute.
- 9) Formation of one hydrogen bond facilitates the formation of additional hydrogen bonds.
- 10) 1. Hydrophobic residues are buried in the protein interior, away from water.
2. The number of hydrogen bonds within the protein is maximized.
- 11) To view the answer to this exercise, please refer to the appropriate video on site.
- 12) a. 6, peptide group, single, trans.
b. bonds, condensation, peptide group.
- 13) The peptide C-N bonds are unable to rotate freely because of their partial double-bond character.

Higher Order Structure

Questions

- 1) Explain what the term **secondary structure** refers to in a protein.
- 2) Which statement is false and why?
 - a. Pauling and Corey were scientists that studied peptides and that predicted the existence of protein secondary structures.
 - b. Common Secondary Structures have characteristic bond angles and amino acid content.
 - c. The α helix and β conformation are the major repetitive secondary structures in a wide variety of proteins.
 - d. Other repetitive structures exist in some specialized proteins.
 - e. Some Secondary structures can be described by the bond angles ϕ and ψ at each residue.
- 3)
 - a. What is the simplest arrangement a polypeptide chain could assume, and what is it specifically called?
 - b. Mention 2 characteristics of this arrangement.
- 4) Why does the α helix form more readily than many other possible conformations, and approximately what portion of amino acid residues are found in such arrangements?
- 5) What can be said about the α helix with regard to stereoisomers and L- or D- amino acids?
- 6) Explain this statement and elaborate, give examples: Amino Acid Sequence affects α Helix Stability.
- 7) Complete the statements by filling out the blanks:
In 1951 Pauling and Corey predicted a _____ type of repetitive structure, the _____, which is a more extended conformation of polypeptide chains. The backbone of the polypeptide in this arrangement is extended into a _____ rather than helical structure. The arrangement of several such _____ segments side by side, all of which are in the _____ is called the _____, and has pleated appearance.

- 8) Which statement about the β sheet is false?
- Hydrogen bonds are formed between the adjacent segments of polypeptide chains in the β sheet.
 - The individual segments that form a β sheet are usually nearby on the polypeptide chain, but can also be distant from each other in the linear sequence of the polypeptide; they may even be segments in different polypeptide chains.
 - The R groups of adjacent amino acids protrude from the zigzag structure in opposite directions, creating an alternating pattern.
 - The adjacent polypeptide chains in a β sheet are parallel to each other.
 - When two or more β sheets are layered close together within a protein, the R groups of the amino acid residues on the touching surfaces must be relatively small.
 - None of the above.
- 9) What is an additional type common β conformation other than the β Sheet and describe this?
- 10) What is protein tertiary and quaternary structure?
- 11) a. In considering the higher levels of protein structure covered in this lesson, it is useful to classify proteins into 2 major groups, list these and define them.
b. Explain the differences between these 2 types of protein classes.
- 12) Which statement with regard to protein quaternary structures is false?
- Protein Quaternary Structures Range from Simple Dimers to Large Complexes.
 - The quaternary structure of a protein is the association of several protein chains or subunits into a closely packed arrangement.
 - Many proteins have multiple polypeptide subunits that are part of their quaternary structure, and these can take on separate but related functions, (such as catalysis and regulation).
 - All of the subunits of the multiple polypeptide that makes up the quaternary structure have different primary but the same secondary, and tertiary structure.
 - The subunits of the multiple polypeptide are held together by hydrogen bonds and van der Waals forces between nonpolar side chains.
- 13) What are the 4 classes protein structures are divided into?

- 14)** Proteins can be organized based on the presence of the various motifs and their arrangements. Which statements in this regard are true:
- a. The top two levels of organization, class and fold, are purely structural.
 - b. Below the fold level, categorization is based on evolutionary relationships.
 - c. Many examples of recurring domain or motif structures reveal that protein tertiary structure is not as conserved as protein primary sequence.
 - d. The comparison of protein structures can provide information about evolution.
 - e. A, B, C, and D.
 - f. A, B, and C.
 - g. A, B, and D.
- 15)** Define a protein family and a superfamily.

Answer Key

- 1) The term **secondary structure** refers to any chosen segment of a polypeptide chain and describes the local spatial arrangement of its main-chain atoms, without regard to its side chains or its relationship to other segments.
- 2) e - Every type of Secondary structure can be completely described by the bond angles ϕ and ψ at each residue.
- 3) a. Helical one, and it is called the α helix.
b. To view the answer to this exercise, please refer to the appropriate video on site.
- 4) Generally, about one-fourth of all amino acid residues in polypeptides are found in α helices, with the exact fraction varying greatly from one protein to the next.
- 5) To view the answer to this exercise, please refer to the appropriate video on site.
- 6) To view the answer to this exercise, please refer to the appropriate video on site.
- 7) Second, β conformation, zigzag, zigzag, β conformation, β sheet.
- 8) d.
- 9) β Turns Are Common in Proteins.
- 10) The overall 3-dimensional arrangement of all atoms in a protein is referred to as the protein's tertiary structure. The arrangement of these protein subunits in 3-dimensional complexes constitutes quaternary structure.
- 11) a. Fibrous proteins – these have polypeptide chains arranged in long strands or sheets.
Globular proteins - these have polypeptide chains folded into a spherical or globular shape.
b. The structures that provide support, shape, and external protection to vertebrates are made of fibrous proteins. Most enzymes and regulatory proteins are globular proteins
- 12) d.
- 13) All α , All β , α/β , α & β .
- 14) g.
- 15) Proteins with significant primary sequence similarity, and/or with demonstrably similar structure and function, are said to be in the same protein family.