PROTEIN MODELING — Answer Key

PART ONE: MULTIPLE CHOICE (2 points each, NO PARTIAL CREDIT)

1) Anfinsen's dogma states that:
   a. Proteins are made up of a primary, secondary, tertiary, and quaternary structure
   b. Proteins' native structure is determined by the protein's amino acid sequence
   c. Proteins are denatured at high temperatures
   d. Proteins can fold in a multitude of different ways, depending on their environment
2) In protein denaturation, proteins lose their:
   I. Primary structure
   II. Secondary structure
   III. Tertiary structure
   a. I & II
   b. I & III
   c. II & III
   d. I, II, & III
3) Which of the following functions as the START amino acid for translation?
   a. Valine
   b. Glutamine
   c. Methionine
   d. Arginine
4) Which kinds of amino acids are unlikely to be found on portions of a protein facing outwards?
   a. Hydrophilic amino acids
   b. Acidic amino acids
   c. Hydrophobic amino acids
   d. Essential amino acids
5) Which of the following is NOT an essential amino acid?
   a. Histidine
   b. Leucine
   c. Tryptophan
   d. Alanine
6) Of the following amino acids, which can form a disulfide bridge?
   a. Cysteine
   b. Methionine
   c. Threonine
   d. Lysine
7) Which of the CRISPR Cas9 protein domains is responsible for finding and cleaving target DNA?
   a. Rec I
   b. Rec II
   c. PAM Interaction
   d. Bridge Helix
8) How is the inactive CRISPR Cas9 protein converted to its active form?
   a. Spontaneous activation

b. Change in environmental pH
c. Binding of target DNA
d. Presence of guide RNA

9) CRISPR Cas9 can be classified as a:
   a. Endonuclease
   b. Exonuclease
   c. Restriction enzyme
   d. Transcription factor
10) Bonds that distinguish a protein's secondary structure from its primary structure are:
   a. Covalent bonds
   b. Hydrogen bonds
   c. Disulfide bonds
   d. Peptide bonds

PART TWO: Short Answer

1) Explain the primary, secondary, tertiary, and quaternary structures of proteins. BE SPECIFIC! For secondary and tertiary structures, name and explain specific examples of interactions. (10 pts)
   - 1 pt: Mentions peptide bonds for primary structure AND that they are formed through dehydration synthesis/condensation reaction
   - 1 pt: Mentions that the primary structure consists of the specific amino acid sequence
   - 1 pt: Mentions that secondary structure consists of hydrogen bonds between R-groups of amino acids (MUST both mention "hydrogen bonds" and "R groups"
   - 1 pt: For secondary structure, states the example of alpha helices and explains that they form by hydrogen bonds that form and create the spiral shape. Award half a point if only the name is stated
   - 1 pt: For secondary structure, states the example of beta pleated sheets and explains that they form by hydrogen bonds between parallel/anti-parallel amino acid sequences
   - 1 pt: Mentions hydrophobic AND hydrophilic interactions for tertiary structure
   - 1 pt: Mentions disulfide bridges/disulfide bonds for tertiary structure
   - 1 pt: Mentions salt bridges for tertiary structure
   - 1 pt: Explains that quaternary structure refers to how the polypeptide subunits of a protein interact to form an aggregate protein complex
   - 1 pt: Mentions that quaternary structure can be stabilized with a range of interactions (must name at least 1): hydrogen bonding, disulfide bridges, salt bridges.

2) The following questions are about acidic and basic amino acids:
   a. What specific chemical property (functional group, element, or otherwise) makes certain amino acids basic? Explain how it makes the amino acid basic. (2 pts)
   - 1 pt: Mentions presence of nitrogenous side chains/side chains that contain nitrogen OR the functional group "amine group" or "amino group"
   - 1 pt: Explains that the side chains allow the amino acid to bind protons (H+)

b. What specific chemical property (functional group, element, or otherwise) makes certain amino acids acidic? Explain how it makes the amino acid acidic. (2 pts)

- 1 pt: Mentions presence of carboxylic acid groups
- 1 pt: Mentions that the carboxylic acid groups/side chains lose protons (H+)

c. Name the three basic amino acids: (3 pts)

- 1 pt: Arginine
- 1 pt: Lysine
- 1 pt: Histidine

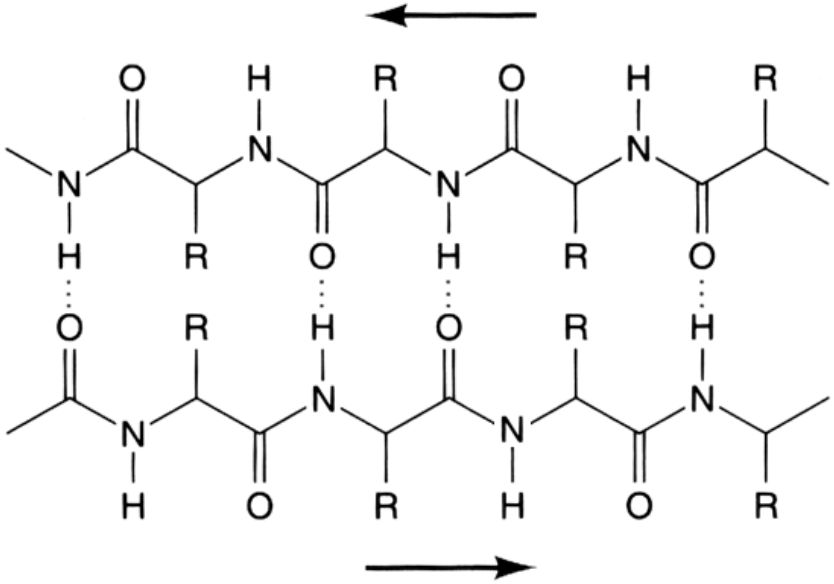
d. Name the two basic amino acids: (2 pts)

- 1 pt: Aspartate OR Aspartic acid
- 1 pt: Glutamate OR Glutamic acid

3) List three reasons why a protein may become denatured and explain how they cause denaturation. (6 pts)
   - Award 1 pt each to any of the following reasons:
     - Heat/Temperate change
     - Changes in pH
     - Salinity
     - Polarity of solvent
   - Award 1 pt for a correct explanation of each of the correctly mentioned reasons:
     - Heat/Temperature change: increase in kinetic energy causes molecules to vibrate, disrupting bonds
     - Change in pH: Protonation of acidic amino acids and basic amino acids. Change in charges of side chains changes hydrophilic/hydrophobic properties
     - Salinity: Salt interferes with intramolecular interactions such as hydrogen bonds/van der Waals forces OR removes water from protein's hydration sphere, encouraging hydrophobic portions to move outwards
     - Polarity of solvent: Interferes with proteins' hydrophobic/hydrophilic properties

4) Draw a diagram that depicts hydrogen bonding within anti-parallel beta pleated sheets (4 pts)

Example:



- 1 pt: generally comprehensive diagram that shows repeating subunits
- 1 pt: shows backbone of the protein's primary structure (correct placement and sequence of carbon, nitrogen, and oxygen)
- 1 pt: correct ANTI-PARALLEL structure (The hydrogen bonds should be straight, backbones in opposite orientations)
- 1 pt: hydrogen bonds drawn with dotted lines

5) CRISPR-Cas9 system is adapted from a naturally-occurring mechanism bacteria use. What is its function in bacteria, and how does it work? (4 pts)
   - 1 pt: Mentions that bacteria use it to protect against invading viruses
   - 1 pt: Mentions that bacteria take parts of viral DNA to create CRISPR arrays
   - 1 pt: Mentions that these arrays let bacteria "remember" the viruses
   - 1 pt: Mentions that the bacteria can produce guide RNA segments from the arrays to guide the Cas9 enzyme in cutting the viral DNA apart

6) What is the PAM sequence? Describe in terms of what the sequence consists of, and the specific role it plays in allowing the Cas9 protein to cut target DNA. (5 pts)
   - 1 pt: Mentions the PAM-Interaction domain
   - 1 pt: Mentions that the PAM sequence is a 2-3 base sequence
   - 1 pt: Mentions that the PAM sequence is located directly downstream of the region complementary to guide RNA
   - 1 pt: Mentions that recognition of the PAM sequence by Cas9 destabilizes the adjacent sequence, which is complementary to guide RNA
   - 1 pt: Mentions that recognition of the PAM sequence allows guide RNA to bind to target DNA