BIOLOGY
SECTION II
Time—1 hour and 30 minutes

Directions: Answer all questions.

Answers must be in essay form. Outline form is not acceptable. Labeled diagrams may be used to supplement discussion, but in no case will a diagram alone suffice. It is important that you read each question completely before you begin to write. Write all your answers on the pages following the questions in the pink booklet.

1. The physical structure of a protein often reflects and affects its function.

   (a) **Describe** THREE types of chemical bonds/interactions found in proteins. For each type, **describe** its role in determining protein structure.

   (b) **Discuss** how the structure of a protein affects the function of TWO of the following.

   - Muscle contraction
   - Regulation of enzyme activity
   - Cell signaling

   (c) Abnormal hemoglobin is the identifying characteristic of sickle cell anemia. **Explain** the genetic basis of the abnormal hemoglobin. **Explain** why the sickle cell allele is selected for in certain areas of the world.

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Question 1

1. The physical structure of a protein often reflects and affects its function.

(a) **Describe** THREE types of chemical bonds/interactions found in proteins. For each type, **describe** its role in determining protein structure. **(6 points; 1 point for bond/interaction description, 1 point for description of role)**

Bond/interaction	Description	Role associated to bond/interaction
Covalent/ peptide	sharing electrons **OR** linking amino acids together	amino acid sequence **OR** primary structure (no credit for chain or polypeptide alone)
Disulfide/ covalent	disulfide, S–S bond (bridges); sulfur-containing R group bonding	tertiary or quaternary structure
Hydrogen	H–O or H–N interactions	α helix, β sheet; secondary, tertiary, or quaternary structure
van der Waals	unequal electron clouds in R group; dipole moments	tertiary or quaternary structure
Hydrophobic	nonpolar R groups	tertiary or quaternary structure
Ionic	charged R groups	tertiary or quaternary structure

(b) **Discuss** how the structure of a protein affects the function of TWO of the following. **(3 points maximum)**

Muscle contraction **(1 point for each bullet; 2 points maximum)**

- Actin (thin filaments) and myosin; cross-bridges OR filamentous proteins slide past each other.
- Troponin/tropomyosin interaction blocks binding of myosin to actin.
- Ca^{2+} changes troponin shape/binding of troponin-tropomyosin to actin altered.
- ATP/ADP changes myosin structure.

Regulation of enzyme activity **(2 points maximum)**

- Shape change caused by **(1 point for each bullet)**
  - Binding of allosteric or noncompetitive inhibitor.
  - Binding of allosteric activator.
  - Feedback control.
  - pH or temperature changes.
  - Cleavage of pre-enzyme (e.g., zymogen).
  - Cooperativity; coenzymes; cofactors.
  - Covalent modification (e.g., phosphorylation).
- Competitive inhibitors binding in the active site prevent substrate binding.

NOTE: The active site regulating enzyme activity is not enough to earn a point.

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Question 1 (continued)

Cell signaling **(2 points maximum)**

- Receptor-ligand binding **(1 point for each bullet)**
  - Event: Ligand binds specifically to receptor.
  - Result: Receptor structure altered by binding, transducing signal through membrane.

  Examples may include hormones, neurotransmitters.
- Enzyme-linked receptors: binding of ligand causes enzyme to catalyze reaction.
- Gap junctions: shape of junctions allows for passage of regulatory ions or molecules.
- Ligand-gated channel: binding of ligand opens channel.
- Immune signaling: leads to activation of cells.

(c) Abnormal hemoglobin is the identifying characteristic of sickle cell anemia. **Explain** the genetic basis of the abnormal hemoglobin. **Explain** why the sickle cell allele is selected for in certain areas of the world. **(3 points maximum)**

Genetic basis **(2 points maximum)**

- Point mutation in DNA; base substitution leading to a different amino acid in the hemoglobin.
- Changing glutamate (glutamic acid) to valine (in β-globin).

Selection **(2 points maximum)**

- Sickle cell condition protects against or resists malaria.
- Changed hemoglobin leads to oxygen-deprivation minimizing malarial infection.
- Heterozygotes maintain a reproductive advantage/success.

NOTE: Stating that sickle cell confers immunity to malaria does not earn a point.