1.

Death is a natural and necessary part of life cycles at all levels of organization.

(a) Discuss **TWO** examples of how cell death affects the development and functioning of a multicellular organism.

(b) Discuss **ONE** example of how substances are degraded and reused in cells.

(c) Discuss the evolutionary significance of death.

(a) Maximum 6 points (3 points per example)

- 1 pt. Example of cell death leading to a change in development
- 1 pt. Example of cell death leading to a change in function
- 1 pt. Discussion of ***how*** cell death occurs or an extension of cell death significance

Examples (categories) of cell death
- elimination of cells, tissues, and organs
- tissue remodeling / reconstruction
- destruction that poses a threat to the survival of the organism
- repair / maintenance
- cell death as a result of severe injury
- cell death as a result of exposure to toxins / altered chemical balance
- cell death as a result of aging

(b) Maximum 3 points

1 pt. Substance: ***how*** degraded to product
1 pt. Product: ***how*** reused in cells
1 pt. Discussion / elaboration on process to degrade or reuse

* "Energy" is not a substance in this response.

(c) Maximum 3 points

Relate evolution to death:
- change in allele or phenotype frequency / removal of individuals from a population based on phenotype / differential reproduction
- selection based on variation
- competition (struggle, resource availability, overpopulation) having an effect on reproductive success
- speciation / mass extinction / adaptive radiation
- genetic drift
- cell death genes preserved early in evolution
- **mechanism** of apoptosis (changes that occur within the cell)
- activation / inhibition of cell death genes
- effect on embryonic development

2.

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.

(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

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.

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.

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.

3.

Reproduction can be either asexual or sexual.

(a) Using a specific example, **describe** how organisms can reproduce asexually. **Discuss** TWO evolutionary advantages of asexual reproduction.

(b) **Identify** THREE ways that sexual reproduction increases genetic variability. For each, **explain** how it increases genetic diversity among the offspring.

(c) **Discuss** TWO prezygotic isolating mechanisms that prevent hybridization between two species. Include in your discussion an example of each mechanism.

(a) Using a specific example, **describe** how organisms can reproduce asexually.
(3 points maximum)

Specific examples (include but are not limited to)	**Describe corresponding reproduction (1 point each)**
Bacteria, archaea, protists	Binary fission splits cell into two cells.
Yeast, sponges, hydra, jellyfish	Budding by mitosis.
Fungi, conidia	Produce haploid spores.
Fungi, sponges	Fragments form new individual.
Rotifers, nematodes, flatworms, gastropods, insects, crustaceans, fish, amphibians, reptiles, bees, wasps, ants, Komodo dragon	Parthenogenic development of unfertilized eggs.
Strawberries	Runners or modified shoots.
Irises, bamboo, beach grasses, rushes, sand verbena	Modified shoots/stolons/rhizomes.
Potato tubers	Modified shoots with buds/eyes.
Kalanchoe leaves	Leaves generate new plants.
Black locust, pear, apple, cherry, blackberry, aspen	Runners/root sprouts/suckers.
Lilies, tulips, onions, daffodils, garlic	Bulbs or corms form modified underground buds.
Crocus, *Gladiolus*, *Cyclamen*, taro	Short, erect underground stems.
Dandelions, blackberries, citrus trees, Kentucky bluegrass	Apomixis produces seeds without pollination.
Agricultural crops	Grafting/cutting/cell culture.

Discuss TWO evolutionary advantages of asexual reproduction.
(2 points)

- It is successful at low population density.
- It eliminates the energy cost of finding a mate.
- It exploits stable environments.
- It is rapid and efficient.
- It eliminates the energy cost of fertilization/pollination.
- It eliminates the need for pollinators in plants.

Identification (1 point each; 3 points maximum)	**Explanation (1 point each; 3 points maximum)**
Crossing over or recombination	Generates new combinations of alleles.
Independent assortment	Random alignment on metaphase plate during meiosis.
Random fertilization	Nonspecific gamete selection.
Random mating	Nonspecific mate selection.
Diploidy or polyploidy	Harmful recessive mutations may not be expressed.

Discussion of isolating mechanism (1 point each) with a reasonable example (1 point each)	
Habitat/ecological isolation	Preferences for living/mating in different habitats/microenvironments.
Geographical isolation	Living or mating in different geographic areas with a physical barrier.
Mechanical isolation	Structural differences of reproductive organs.
Temporal isolation	Different mating time of day or season of year.
Behavioral isolation	Different mating rituals between species.
Gametic isolation	Molecular incompatibilities between sperm and egg OR Chemical incompatibilities limit sperm viability.