1.

Certain human genetic conditions, such as sickle cell anemia, result from single base-pair mutations in DNA.

(a) **Explain** how a single base-pair mutation in DNA can alter the structure and, in some cases, the function of a protein. **(4 points maximum)**

DNA (3 points maximum)

- Define mutation; change in bases: A, C, G or T.
- Describe type of mutation: duplication, frameshift, nonsense, deletion, substitution (point mutation).
- Describe central dogma: DNA → RNA → protein.
- Describe process of central dogma: transcription → translation.
- Translation of codons: 3 nucleotides → 1 amino acid.
- Redundancy in genetic code: 64 combinations: 20 amino acids (or can result in "stop" codon).

Protein (3 points maximum)

- Describe altered protein structure: primary, secondary, tertiary, quaternary.
- Describe protein function change: active site conformation, oxygen binding.
- Describe structural change: hydrophobic/hydrophilic interactions, disulfide bonds, R-group interactions, hydrogen bonds.

(b) **Explain**, using a specific example, the potential consequences of the production of a mutant protein to the structure and function of the cells of an organism. **(4 points maximum)**

- Type of change: dominant, recessive.
- Changed protein → changed trait/character/function (gain or loss of function).
- Description of example (any trait).
- Description of protein structure or example after change.
- Description of function after change.
- Elaboration with sickle: mutation/effect in organism, Glu → Val, etc.
- Heterozygotic advantage (resistance to malaria).

2.

Biologists are interested in preserving the diversity of living organisms on the planet.

(a) **Explain** THREE of the following processes or phenomena, using an appropriate example for each.

- Mutation
- adaptive radiation
- polyploidy
- population bottlenecks
- growth of the human population

(b) For each process or phenomenon you selected in (a), **discuss** its impact on the diversity of life on Earth.

One point for each definition, example, impact and explanation.

	Definition	**Example**	**Impact on diversity of life on earth**	**Explanation**
mutation	change in DNA	deletion/insertion point mutation chromosomal aberration	increase or decrease	altered proteins new geno/phenotypes raw material for selection
adaptive radiation	multiple species from 1 ancestor	Galapagos finches mammals angiosperms	increase	new species co-existence of species

3.

(a) **Identify** FOUR organelles that should be present in the eukaryotic organism and **describe** the function of each organelle.
(5 points maximum)

Identify organelle (1 point for listing FOUR)	**Describe corresponding function (1 point for each function)**
Nucleus	Contains hereditary information/DNA/chromosomes or is the site of RNA synthesis.
Ribosomes	Site of protein synthesis.
ER (endoplasmic reticulum)	Internal transport or compartmentalization.
Rough ER	Protein synthesis/packaging/transport.
Smooth ER	Lipid synthesis or detoxification or transport.
Mitochondria	ATP synthesis or aerobic/cellular respiration.
Chloroplasts, plastids	Light absorption/photosynthesis/carbohydrate synthesis.
Vacuole, vesicles	Storage or transport.
Cilia/flagella	Motility.
Basal bodies	Support cilia/flagella.
Centrioles	Assist chromosome movement in mitosis.
Golgi bodies	Protein modification/packaging/transport.
Lysosomes	Enzymatic hydrolysis of wastes/metabolites/pathogens.
Peroxisomes	Catalase/peroxidase function or detoxification.

(b) Prokaryotic cells lack membrane-bound organelles found in eukaryotes. However, prokaryotes must perform many of the same functions as eukaryotes. For THREE of the organelles identified in part (a), **explain** how prokaryotic cells carry out the associated functions.
(3 points maximum)

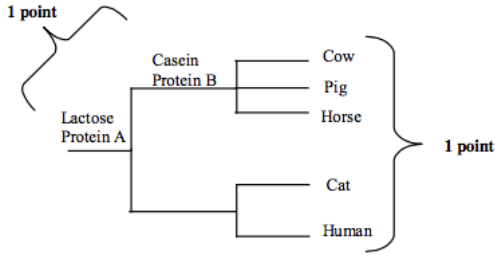
Eukaryotic organelle	**Explain how prokaryote carries out function (1 point each)**
Nucleus	Hereditary information/DNA/chromosomes or RNA synthesis in cytosol.
Ribosomes	Site of protein synthesis.
ER (endoplasmic reticulum)	Diffusion of molecules in cytosol.
Rough ER	Protein synthesis/transport in cytosol; may be linked to transcription.
Smooth ER	Lipid synthesis or detoxification occurs in cytosol.
Mitochondria	Other membranes or cytosolic molecules function in ATP synthesis.
Chloroplasts	Other membranes or cytosolic molecules function in light absorption/photosynthesis/carbohydrate synthesis.
Plastids	Pigments are distributed throughout cytosol or are associated with membranes.
Vacuole, vesicles	Inclusion bodies/granules/large molecules in cytosol.
Cilia or flagella	Motility via bacterial flagella.

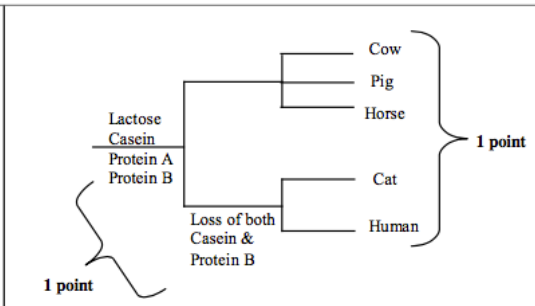
Basal bodies	Other structures support flagella.
Centrioles	Enzyme-mediated chromosome movement.
Golgi bodies	Protein modification/packaging/transport in cytosol.
Lysosomes	Secreted enzymes hydrolyze wastes/metabolites/pathogens.
Peroxisomes	Production/secretion of catalase or detoxification.

4.

(a) Using the data in the table, **construct** a cladogram on the template provided to indicate the most likely evolutionary relationships among the different mammals. **Indicate** on the cladogram where each of the characters most likely arose in the evolutionary process, and **justify** the placement of the characters on the cladogram. (**3 points maximum**; LO 1.18, 1.19)

NOTE: Points are earned in one column only.





Justification (**1 point**)	Justification (**1 point**)
Lactose and Protein A arose in a common ancestor to all 5 animals. Protein B and Casein arose only in the common ancestor to the pig/cow/horse clade/branch.	Lactose, Casein, Protein A, and Protein B arose in a common ancestor to all 5 animals. Protein B and Casein were lost in the common ancestor to the cat/human clade/branch.

5.

Phylogeny reflects the evolutionary history of organisms.

(a) **Discuss** TWO mechanisms of speciation that lead to the development of separate species from a common ancestor.
(2 points maximum)

Mechanisms that lead to the development of separate species from a common ancestor (1 point each)

- Geographic isolation (or allopatric speciation) takes place when a population of one species becomes physically separated by some geographic barrier such as a river, mountain range, etc. Long-term isolation of two populations eventually leads to reproductive isolation.
- Sympatric speciation happens when new species arise as a result of reproductive isolation within the population range — for example, because of polyploidy or switching mating behaviors (fruit flies going from hawthorn to apple to lay eggs). Eventually the two populations are unable to interbreed.
- Reproductive isolation by prezygotic barriers, such as habitat, temporal, behavioral, mechanical, or gametic incompatibility.
- Reproductive isolation by postzygotic barriers (e.g., reduced hybrid viability or fertility) leads to speciation.

(b) **Explain** THREE methods that have been used to investigate the phylogeny of organisms. **Describe** a strength or weakness of each method.
(6 points maximum)

Response earns 1 point for each method explained and 1 point for either a strength *OR* a weakness.

Methods (1 point)	**AND Strengths (1 point)**	**OR Weaknesses (1 point)**
Fossils (paleontology)	Determine time; reveal extinct species.	Not all species leave fossils. Fossil record is incomplete.
Anatomy/morphology	Homologous structures indicate evolutionary relationships.	Analogous structures. Some taxa have little diversity (e.g., bacteria). Some morphology reflects environment or diet.
Embryology/development	Reveals similarities in structures and patterns of development that are not evident in adults.	Similarities between species may be lost in later development.
Molecular traits (amino acid sequence in proteins or base sequence in DNA)	Large numbers of traits. Allow study of evolution between closely related species. Most accurate.	No (or little) data for extinct species. Variation within species blurs differences between species.
Behavioral traits	Some behaviors are genetic (e.g., frog calls).	Behavior maybe culturally transmitted or learned (e.g., bird calls).

- For each tree, **describe** a monophyletic group, the closest relative to the whale, and the point at which the pulley astragalus was lost or gained.
  (3 points maximum)

  - Correctly identifying a monophyletic group in *BOTH* Tree I and II (a number of correct possibilities) or correctly defining a monophyletic group as a species and all of its descendants. **(1 point)**
  - Correctly identifying the camel as the closest relative to the whale in Tree I *AND* the hippo in Tree II. **(1 point)**
  - Stating that the gain of the pulley astragalus bone in Tree I occurs between the whale and the camel, *OR* that the loss of the bone occurs on the line to whales, *AND* that the loss of the pulley astragalus bone in Tree II occurs between the common ancestor of the hippo and the whale. **(1 point)**

- Based on the principle of parsimony (the simplest explanation is the best) and the genomic information in the table shown, **identify** which tree is the best representation of the evolutionary relationship of these animals, and **justify** your answer.
  (1 point maximum)

Identification of correct tree	**Justifications include but are not limited to**
Tree II	• The camel is the out-group, with none of the 13 sequences. • The peccary and pig have the fewest sequences, but they are similar. • The deer and cow share the same half of the 13 sequences. • The whale and hippo have a similar pattern of DNA sequences.

Note: No point is earned for using the pulley astragalus bone to justify Tree II, nor for discussing common environments, body shapes, or feeding habits.

1.B FRQ Formatives

1.B FRQ Formatives