

SECTION A

Question 1

(a)(i) State why rubisco is said to have quaternary structure. [1]

Ref to: more than one polypeptide

(a)(ii) Explain what makes a molecule such as rubisco soluble. [1]

1. Ref to: globular protein
2. Ref to: hydrophilic / polar / charged amino acid residues at the surface of the molecule
3. Ref to: hydrophobic / non-polar / non-charged amino acid residues at the inside of the molecule
4. Ref to: hydrogen bonds with water (molecules)

(b) Explain why rubisco does not need to be in an active form in the absence of light. [3]

1. Ref to: no light dependent reaction and no light independent reaction
2. Ref to: no ATP / reduced NADP
3. Ref to: no need to fix CO₂

(c) Explain the consequences to the plant of the reaction involving oxygen. [2]

1. Ref to: no CO₂ being fixed
2. Ref to: no (new) PGA / GP being made
3. Ref to: no (new) TP / glucose being made
4. Ref to: no (new) RuBP being (re)generated
5. Ref to: ATP used in making RuBP being wasted
6. Calvin cycle / light independent reaction / Photosynthesis decreased

(d) With reference to Fig. 1.2, predict whether C3 or C4 plants are favoured in the context of global warming in the tropics. Explain how these plants are better adapted physiologically. [4]

1. Ref to: C4 plants being favoured over C3 plants at high temperatures above 26 °C
2. Ref to: Plants closing their stomata, resulting in reduced CO₂ diffusion into the leaf
3. Ref to: risk of O₂ competing with CO₂ for rubisco in C3 plants / AW
4. Ref to: less CO₂ fixed, resulting in lower yield of C3 plants / AW

(e)(i) Describe how yeast converts glucose to ethanol. [2]

1. Ref to: anaerobic conditions
2. Ref to: pyruvate forming ethanal
3. Ref to: reduction of ethanal

(e)(ii) Explain why it may be better in the long term to use ethanol made from corn starch, rather than petrol, as a fuel for cars. [2]

1. Ref to: corn as renewable resource
2. Ref to: uptake of CO₂ by corn in photosynthesis
3. AVP

- (f)(i)** With reference to Table 1.1, suggest the source of biodiesel chosen by an oil company if reduction of greenhouse gas emissions were the sole criterion. [1]

palm oil from Malaysia

- (f)(ii)** Explain your answer to **(f)(i)**. [2]

1. Ref to: lowest emission due to change of land use and from cultivation, processing and distribution
2. Cite appropriate values

- (g)** Identify two criteria, apart from cost, that should also be considered in choosing a source of biodiesel. Explain the significance of each criterion. [4]

1. Ref to: impact on environment / wildlife / biodiversity
2. Ref to: impact on food supply
3. Ref to: loss of carbon sink / carbon dioxide emission
4. Ref to: ownership of land
5. AVP

[Total: 25]

Question 2

- (a)** Outline how gel electrophoresis separates DNA fragments. [4]

1. Gel electrophoresis separates a mixture of DNA fragments on the basis of size / molecular weight
2. Negatively-charged DNA fragments are loaded into wells at negatively-charged electrode, migrate towards the positively-charged electrode under application of an direct current
3. Size of the pores in the gel matrix act as a molecular "sieve" to resist / retard the movement of the molecules
4. Smaller / shorter DNA fragments are less impeded by the pores than longer ones and migrate faster and further forming a series of discrete size-fractionated bands

- (b)** With reference to Fig. 2.1 and 2.2, explain the DNA profile of Jane. [3]

1. Jane's is a heterozygous / carrier with 1 normal allele and 1 mutant allele on the homologous chromosomes
2. Restriction digestion of the normal allele generates 1 fragment that has moved least from the cathode and digestion of the mutant allele generates 2 fragments that have moved further from the cathode
3. Due to the presence of restriction site caused by gene mutation of *p53* in the mutant allele

- (c)** With reference to development of cancer as a multi-step process, describe how Jane might develop breast cancer. [3]

1. There is an accumulation of mutations in a single cell lineage, ref. to *BRCA 1 and BRCA* gene mutations
2. Activation of telomerase resulting in lengthening of telomeres, thus evading apoptosis / replicative cell senescence
3. Angiogenesis resulting in formation of new blood vessels, supplying nutrients and oxygen and removing toxic waste products
4. Cancer cells acquired ability to invade to directly migrate and penetrate into neighbouring tissues leading to metastasis

[Total: 10]

Question 3

- (a) With reference to Fig. 3.1, explain how somatic recombination during B cell development results in the formation of millions of different antibody molecules. [4]
1. Ref to process by which different segments of V, D, J ligated to form gene encoding different variable regions in heavy chain of the antibody
 2. Ref to idea that only 1 segment from each is chosen
 3. Ref to idea that remaining gene segments removed
 4. Ref to number of gene segments in context of question
 5. Ref to different mRNA sequences leading to different amino acid sequences, and subsequently different specific 3D conformation of variable region
- (b)(i) Compare the increase in mean level of anti-X antibodies after vaccination and after infection with *B. pertussis*. [2]
Any two:
1. Ref to levels of antibody rise earlier after infection
 2. Ref to levels of antibody rise faster after infection
 3. Ref to levels of antibody rise higher after infection
 4. credit comparative manipulation of data
- (b)(ii) Explain the changes in mean level of anti-X antibodies after infection with *B. pertussis*. [2]
1. Ref to secondary immune response
 2. Ref to memory cells / immunological memory
 3. Ref to idea that (on infection / second exposure) memory cells are activated / stimulated
- (c)(i) Suggest why anti-Y antibodies were not present in the blood of these rats until after infection with *B. pertussis*. [1]
Any one:
1. Ref to idea that antibodies will only be present if antigen present
 2. Ref to idea that antigen Y is not present in vaccine
 3. Ref to vaccination failed to stimulate immune response
- (c)(ii) Place a tick in the box next to the term that describes the type of immunity that results in the production of anti-Y antibodies. [1]
- Natural active
- (d) Explain how class switching allows for formation of IgG. [3]
1. Ref to one constant region gene segment from IgM is replaced with another of a different segment from IgG
 2. Ref to gene segment coding for constant region of IgG is ligated with other exons
 3. Ref to somatic recombination in activated B cells
- (e) Comment on the reliability of the data shown in Fig. 3.2. [2]
Any two:
1. Ref to no indication of number of rats used
 2. Ref to no data points indicated
 3. Ref to no error bars (on graph) / no indication of variability
 4. Ref to idea that no indication of experimental details / control group
 5. Ref to idea that mean has been used therefore there must have been some repeats carried out

[Total: 15]

SECTION B

Question 4

- (a) Describe and explain gene mutation and chromosomal aberration. Using a suitable named example, explain how chromosomal aberration can result in a diseased phenotype in humans. [13]

1. Ref. to gene mutation as a change in one or a few bases in the DNA sequence of one gene
2. Ref. to base substitution
3. and effects
4. Ref. to base addition or deletion
5. and effects
6. Ref. to chromosomal aberration as a change in the structure of a chromosome
7. Ref. to chromosomal deletion, duplication, inversion, translocation
8. and effects
9. Ref. to chromosomal aberration as a change in the number of chromosomes
10. Ref. to aneuploidy and polyploidy
11. and effects
12. Ref. to relevant named example, e.g. Down syndrome
13. and link to chromosomal aberration

- (b) Discuss how the genotype of an organism is linked to its phenotype and using suitable named examples, explain how the environment may affect the phenotype of an organism.[12]

1. Ref. to genotype as the genetic makeup
2. Ref. to phenotype as a measurable or distinctive character
3. Ref. to how genotype dictates phenotype
4. Ref. to dominant and recessive alleles
5. and their effects in phenotypes
6. Ref. to role of environment on phenotype
7. Ref. to relevant named example 1
8. e.g. temperature on coat / fur colour in Himalayan rabbits
9. and how phenotype is affected
10. Ref. to relevant named example 2
11. e.g. diet on differentiation in honey bees
12. and how phenotype is affected

[Total: 25]

Question 5

- (a) Using a named example each, describe and explain directional and disruptive selection. Suggest, with reasons, which of these two forms of natural selection might contribute to the emergence and subsequent development of a new species. [13]

Directional selection

1. Ref to a correct named example
2. Ref to idea of this form of selection favouring one extreme phenotype and eliminating the other extreme phenotype in the population
3. Correct identification of selection pressure
4. Correct sketch of distribution graph with appropriate labelled axes

Disruptive selection

5. Ref to any correct named example
6. Ref to idea of this form of selection eliminating intermediate phenotypes and favouring extreme phenotypes
7. Correct identification of selection pressure

8. Correct sketch of distribution graph with appropriately labelled axes

Emergence and development of new species (speciation)

9. Disruptive selection

10. The possibility that the gene pool of one population may become split into two distinct gene pools over time / disruptive selection would result in two distinct populations

11. Ref to presence of geographical barrier / isolation

12. Ref to generation of reproductive isolating mechanisms

- (b) The fossil record reveals that the evolutionary history of life on Earth has been episodic, with long, relatively stable periods punctuated by brief, cataclysmic ones. During these upheavals, macroevolutionary events occur where new species form through adaptive radiation and others died out in great numbers through mass extinctions.

Discuss mechanisms that trigger adaptive radiation and mass extinctions, and explain how microevolution can be linked to these macroevolutionary events. [12]

Mechanisms that trigger adaptive radiation

1. Ref to availability of new resources through ecological opportunities

2. Ref to an original colonizing group encountered no competitor and diversified

3. Ref to adaptations that can make the organisms better adapted for the habitat they occupy

4. Ref to succeeding generations diversify into new species

Mechanisms that trigger mass extinctions

5. Major changes in climate could have adversely affected those plants and animals

6. Ref to changes in the environment due to catastrophes

7. Ref to natural / biological factors

8. Ref to some animals / plants unable to adapt

Linking microevolution to the macroevolutionary events

9. Ref to defining microevolution

10. Ref to defining macroevolution

11. Ref to mechanisms / processes that bring about microevolution like natural selection, mutation, genetic drift and gene flow

12. Ref to mass extinctions create new ecological opportunities that can be exploited by surviving organisms to evolve

13. Ref to difference in scale for microevolution and macroevolution

14. Ref to macroevolution occurring as a result of microevolution

[Total: 25]