

# BIOLOGY

## Units 3 & 4 – Written examination



## 2016 Trial Examination

### SOLUTIONS

#### SECTION A: Multiple-choice questions (1 mark each)

##### Question 1

*Answer:* A

*Explanation:*

A nucleotide is the monomer or subunit of DNA. Each nucleotide consists of a phosphate group, a sugar (deoxyribose) and one of the four nitrogenous bases.

##### Question 2

*Answer:* B

*Explanation:*

The arrows are showing the folding that is occurring within the polypeptide chain and is therefore illustrating secondary structure.

##### Question 3

*Answer:* D

*Explanation:*

Compartmentalisation of a eukaryotic cell prevents the substances inside organelles from coming into contact with each other and also isolates chemical reactions occurring inside different organelles. Although it does increase surface area to volume ratio, this is not the most correct answer.

**Question 4**

*Answer: A*

*Explanation:*

The information provided states that the substances are “taken up in bulk”. Endocytosis is the only example of bulk transport provided.

**Question 5**

*Answer: A*

*Explanation:*

Cholesterol is attracted to part of the fatty acid chain on the nearest phospholipid. This helps to slightly immobilise the outer surface of the membrane, so without cholesterol, cell membranes would become too fluid. Cholesterol is found at a high concentration in plasma membranes and helps to separate the phospholipids so that the fatty acid chains can't come together and crystallise. As a result the presence of cholesterol prevents extremes (too fluid or too firm) from occurring.

**Question 6**

*Answer: D*

*Explanation:*

Process A represents diffusion and process B represents facilitated diffusion. Glucose enters cells by facilitated diffusion.

**Question 7**

*Answer: C*

*Explanation:*

At the end of the reaction the product/s will be different to the substrate, however, the enzyme is released unchanged. This is why an enzyme is able to sequentially bind to many substrate molecules.

**Question 8**

*Answer: D*

*Explanation:*

Diagram 2 is showing a non-competitive inhibitor. The shape of the enzyme changes when this type of inhibitor binds to the regulatory region of the enzyme. As a result the shape of the active site changes and the substrate will be unable to bind to the active site.

**Question 9**

*Answer: A*

*Explanation:*

Initially the reaction rate will increase, however, when a point of saturation is reached the reaction rate will become constant. This occurs because at any instant all active sites of the enzymes are occupied.

**Question 10**

*Answer: B*

*Explanation:*

The inputs for glycolysis include: glucose, ATP, ADP, Pi and NAD.

**Question 11**

*Answer: C*

*Explanation:*

Both NADH and FADH<sub>2</sub> are produced during the Krebs's cycle.

**Question 12**

*Answer: A*

*Explanation:*

ATP and NADPH are used in the light independent stage of photosynthesis.

**Question 13**

*Answer: B*

*Explanation:*

Water is an output of the electron transport chain, a series of reactions that occur in the mitochondria.

**Question 14**

*Answer: A*

*Explanation:*

As steroids are lipid soluble they are able to diffuse across the plasma membrane, therefore their receptors are located in the cytosol.

**Question 15**

*Answer: B*

*Explanation:*

After the action potential reaches the pre-synaptic terminal, calcium channels open and calcium ions move into the pre-synaptic terminal. This triggers vesicles to release neurotransmitters into the synapse.

**Question 16**

*Answer: A*

*Explanation:*

As stated in the information provided, the cells of people with type 2 diabetes are less able to detect insulin. Drugs such as metformin facilitate the ability of insulin to bind to the receptors of target cells.

**Question 17**

*Answer: C*

*Explanation:*

After phagocytosis occurs, antigenic fragments are combined with class 2 MHC markers and displayed on the surface of the phagocyte. Antigens are presented to T helper cells, which present the antigen to B cells. The B cells divide and differentiate into plasma and memory cells. The plasma cells produce antibodies, which bind to and neutralise antigens.

**Question 18**

*Answer: C*

*Explanation:*

Passive immunity occurs when an individual is provided with antibodies from another source. In all options, except C, the individual was exposed to an antigen.

**Question 19**

*Answer: D*

*Explanation:*

The secretion of histamine causes vasodilation. Antihistamine has the opposite effect and therefore limits the extent to which vasodilation occurs.

**Question 20**

*Answer: C*

*Explanation:*

Clonal selection is the theory that exposure to a specific antigen selectively stimulates the proliferation of the cell with the appropriate template to form a clone or colony of specific antibody producing cells.

**Question 21**

*Answer: A*

*Explanation:*

The G<sub>0</sub>, G<sub>1</sub>, S and G<sub>2</sub> stages all occur during Interphase.

**Question 22**

*Answer:* B

*Explanation:*

Transcription of genomic DNA occurs in the nucleus. A DNA template is read by RNA polymerase resulting in the production of the primary transcript.

**Question 23**

*Answer:* B

*Explanation:*

An anticodon is a sequence of three nucleotides forming a unit of genetic code in a transfer RNA molecule; generally this term is applied to the anticodon that corresponds to a complementary codon in messenger RNA.

**Question 24**

*Answer:* D

*Explanation:*

DNA helicase is responsible for breaking the hydrogen bonds between complementary bases during DNA replication. This creates structure D, the replication fork.

**Question 25**

*Answer:* C

*Explanation:*

Bacteria only have a single chromosome whilst humans have multiple chromosomes. DNA replication happens differently in humans, as there are many points of origin of DNA replication, compared to a single point of origin in bacterial DNA.

**Question 26**

*Answer:* D

*Explanation:*

As the restriction site has been removed from the “a” allele, a single fragment of DNA would be produced. There would be 2 fragments produced if the “A” allele were exposed to the same restriction enzyme. The lane containing a sample from an individual with the aa genotype would have a single band, the lane containing a sample from an individual with the AA genotype would have 2 bands and the lane containing a sample from an individual with the Aa genotype would have 3 bands.

**Question 27**

*Answer:* B

*Explanation:*

The role of DNA ligase is to facilitate the joining of DNA strands together by catalysing the formation of a phosphodiester bond between two or more fragments.

**Question 28**

*Answer: B*

*Explanation:*

The rabbit's fur was initially white but then grew back black only in the area exposed to the ice pack. This supports the hypothesis that skin temperature affects fur colour.

**Question 29**

*Answer: C*

*Explanation:*

Assuming A = purple and a = white then the genotypic ratio in the F2 generation would be 1AA:2Aa:1aa, therefore one third of the purple flowering offspring would be expected to be homozygous and the remainder would be heterozygous. Option B is incorrect as it refers to a gene for purple colouration, rather than an allele.

**Question 30**

*Answer: B*

*Explanation:*

As the genes are assorted independently they must be located on different chromosomes and will not be inherited together.

**Question 31**

*Answer: B*

*Explanation:*

The theory of evolution by natural selection is based on the assumption that genetic variation exists in a population.

**Question 32**

*Answer: A*

*Explanation:*

The data indicates that species I and J diverged the most recently, therefore their DNA would be expected to have a greater similarity than that of any other species, so the melting temperature of an I-J DNA hybrid would be expected to be the highest.

**Question 33**

*Answer: D*

*Explanation:*

In natural selection the organisms best suited to the environment are the most likely to survive and have offspring. In artificial selection humans choose which organisms reproduce based upon whether the organisms have a desirable trait or not.

**Question 34**

*Answer: A*

*Explanation:*

The information is describing an example of natural selection. In this case having larger beaks conferred biological fitness. The birds with larger beaks were more likely to survive and reproduce, which eventually lead to an increase in the trait of having a large beak.

**Question 35**

*Answer: C*

*Explanation:*

If the organisms that share a common ancestor have homologous features then the ancestral species should have had some form of the same feature.

**Question 36**

*Answer: B*

*Explanation:*

The only animals that colonised New Zealand were those that flew or floated there, so there was a complete absence of large predators. The birds are most likely to have lost the ability to fly, as they did not need to be able to do so.

**Question 37**

*Answer: C*

*Explanation:*

Genetic drift has a greater impact on small populations, particularly after the population has been reduced in size by a non-selective event such as a catastrophe.

**Question 38**

*Answer: A*

*Explanation:*

Stratigraphy is the only form of relative dating identified as an option. Fission tracking, carbon-14 dating and potassium to argon dating are all processes that are used for absolute dating.

**Question 39**

*Answer: B*

*Explanation:*

The cranial capacity of early hominins was much smaller than that of *Homo sapiens*.

**Question 40**

Answer: A

*Explanation:*

The fact that there is a large range of modern species of apple all related to a single ancestral species indicates that artificial selection most likely occurred.

**SECTION B: Short-answer questions**

**Question 1 (6 marks)**

a. The highest level of structure in the normal protein is a tertiary structure. 1 mark

AND

The highest level of structure in the alpha sheet is a secondary structure. 1 mark

b. Proteomics 1 mark

c. The ability of a protein to carry out a specific task is determined by its three dimensional shape. 1 mark

AND

Adding the alpha sheet to the toxic species changes the three-dimensional shape of the protein preventing it from being able to aggregate and form an amyloid fibril 1 mark

d. Changing the pH of the environment affects the bonds within the protein. The way in which the secondary structures are folded alters, changing the overall three dimensional shape of the protein. 1 mark

Total 6 marks

**Question 2 (9 marks)**

a. As follows

Substance	Glycolysis	Kreb's cycle	Electron Transport Chain
Pyruvate	2	0	0
ATP	Net 2	2	32-34
Water	0	0	6
Carbon Dioxide	0	6	0

1 mark for each column correctly completed.

b. The use of rotenone will decrease the rate at which the Kreb's cycle occurs. 1 mark

AND



If the action of NADH reductase is prevented then NADH molecules will not be able to unload high-energy electrons and H<sup>+</sup> ions. As a result NAD<sup>+</sup> will not be available to play a role in the Krebs's cycle.

1 mark

- c. The effect of rotenone is not immediate as the fish are still able to produce some ATP via aerobic respiration. The pathway associated with the release of energy from FADH<sub>2</sub> is not affected. However, this energy is not sufficient to sustain life for long, resulting in the death of the fish.

1 mark

- d. The ability of the Krebs's cycle to function is dependent upon the ability of the electron transport chain to function. As the electron transport chain is dependent upon the presence of oxygen as a final acceptor, so is the Krebs's cycle.

1 mark

- e. There are several possible answers. These include:

- The electron transport chain is unable to produce the theoretical maximum amount of ATP.
- There is insufficient energy provided to sustain life indefinitely.
- NADH is unable to unload H<sup>+</sup> ions and NAD<sup>+</sup>, therefore no energy will be produced by this pathway.
- Any other reasonable suggestion.

1 mark for each correct response to a maximum of 2 marks

Total 9 marks

**Question 3 (8 marks)**

- a. Neurohormones.

1 mark

- b. Similarity: neurohormones and neurotransmitters are both signalling molecules involved in cellular communication. They are both released by one cell and act upon a different cell.

1 mark

AND

Difference: neurohormones are released into the circulatory system and act upon a target cell that is at a distance from the point of release. Neurotransmitters are released into a synapse between two cells and can only act on the next cell in the pathway.

1 mark

c. Protein.

1 mark

AND

The signaling molecule has bound to a receptor located on the external surface of the plasma membrane of the target cell. Had the signaling molecule been a steroid then the receptor would have been in the cytosol or in the nucleus.

1 mark

d. Reception: The signaling molecule binds to the receptor on the external surface of the target cell.

1 mark

AND

Transduction: a series of relay proteins activate transcriptional factors.

1 mark

AND

Induction: The cell carries out transcription and translation, resulting in the production of a new protein.

1 mark

Total 8 marks

**Question 4 (7 marks)**

a. The primary and secondary levels of defence.

1 mark

AND

The presence of lysozyme in secretions acts to prevent the entry of pathogens into the body and is therefore part of the primary response. The presence of lysozyme in the macrophages assists them to carry out phagocytosis, which is a secondary defence.

1 mark

b. The first stage of the experiment was performed in order to ascertain that inserting a gene for the mutated protein would confer lysozyme resistance on a lysozyme sensitive bacterium.

1 mark

AND

The second stage was performed to determine that the loss of the mutated sequence and insertion of the normal sequence removed the trait of lysozyme resistance. This showed that lysozyme resistance was conferred by the action of a single gene.

1 mark

- c. Lysozyme is generally secreted onto skin and mucosal surfaces. The bacteria that have this mutation are resistant to lysozyme and are able to colonise these surfaces rather than being killed.

1 mark

- d. Lysozyme enables the break down of bacterial cell walls enabling the bacterial cells to be broken down.

1 mark

AND

Antigenic fragments are then combined with the class II MHC marker and displayed on the surface of the macrophage. The antigenic fragment is then presented to T helper cells, which activate cytotoxic T cells and also trigger clonal expansion.

1 mark

Total 7 marks

**Question 5 (10 marks)**

- a. The founder effect.

1 mark

- b. The trait for having blue coloured skin increased in incidence during this period, as the size of the population was very small and the three families present all intermarried, thus the allele was frequently passed on.

1 mark

- c. The presence of the new roads allowed additional people to move into the area. As a result gene flow occurred between the existing population and the new arrivals. As the number of people having or carrying the trait decreased, so did the incidence of children being born with the trait.

1 mark

- d. The mode of inheritance is autosomal recessive.

1 mark

The trait is recessive because individuals II-1 and II-2 are unaffected, but they have a child, III-2 who has the trait.

1 mark

AND

If the trait were X linked as well as being recessive then the father of an affected female must also be affected, however the father of affected individual III-2 is unaffected, therefore the trait cannot be X linked, so must be autosomal. (The same reasoning applies to III-7 and II-4)

OR

If the trait were X linked as well as being recessive then all sons of an affected female must also be affected. As affected female I-1 is affected, but her son II-2 is not, this trait cannot be X linked, so must be autosomal.

1 mark

e. 1/3.

Note: Both parents are heterozygous e.g. Aa x Aa. The genotypic ratio of their offspring would be 1AA:2Aa:1aa. The table shows that the individual does not have the trait and so cannot have the aa genotype leaving the ratio of 1AA:2Aa.

1 mark

f. Let N = normally coloured skin and n = blue skin.

Parents phenotypes: Normal coloured skin x Normal coloured skin

Parents genotypes: Nn x Nn

Gametes: N, n x N, n

1 mark

	N	N
N	NN	Nn
n	Nn	nn

1 mark

Genotypic ratio 1NN : 2Nn : 1nn

Phenotypic ratio 3 normally coloured skin : 1 blue skin

1 mark

Total 10 marks

**Question 6 (4 marks)**

a. This is an example of natural selection due to the forest environment being replaced by the sand dunes.

1 mark

AND

The mice with the lighter coloured fur became better camouflaged against the lighter coloured background. These mice became more biologically fit than their darker counterparts because they were less likely to be eaten by predators.

1 mark

AND

The lighter coloured mice were more likely to survive (selected for) and reproduce leading to an increase in the incidence of lighter coloured mice in subsequent generations.

1 mark

b. These mice are more likely to eaten by predators as they will be less able to camouflage themselves against the darker background.

1 mark

Total 4 marks

**Question 7 (4 marks)**

- a. Conditions that promote fossilization include rapid coverage, lack of oxygen and a lack of disturbance by weather or scavengers. Organisms falling into the tar pits would be rapidly covered, preventing disturbance and the thick, sticky tar contains little, if any oxygen.  
1 mark
- b. Radiocarbon dating.  
1 mark
- c. Organisms with a thicker cuticle would be better able to defend themselves against predators.  
1 mark
- d. Members of the Fallotaspioidea were less able to adapt to changing environments than the other species, which is why they became extinct a lot earlier than any other species.  
1 mark

Total 4 marks

**Question 8 (5 marks)**

- a. When the repressor protein binds to the operator gene, transcription cannot occur and the enzymes will not be produced. When the repressor protein releases the operator gene, transcription occurs and the enzymes will be produced.  
1 mark
- b. Protein synthesis is an endergonic process. The bacterium conserves energy by only producing enzymes when they are required.  
1 mark
- c. Transcription  
1 mark
- d. Answers may include:
- Introns are removed and exons are spliced together.
  - A methylated cap is added to the 5' end of the molecule.
  - A poly A tail is added to the 3' end of the molecule.

1 mark for each correct response to a maximum of 2 marks

Total 5 marks

**Question 9 (6 marks)**

- a. Suspect 2, as the banding pattern for this individual is the same as the pattern that was obtained from the DNA from the crime scene.  
1 mark
- b. Polymerase chain reaction.

1 mark

- c. Denaturation stage: the DNA template is heated to a temperature of approximately 90 °C. Annealing stage: the mixture is cooled to approximately 55°C in order to allow the primers to anneal to the template strands. Extension stage: the temperature is raised to approximately 72°C. Taq polymerase reads the template strands and assembles complementary copies. These stages are repeated many times.

2 marks: all stages correctly identified and described.

1 mark: 2 stages correctly identified and described.

0 marks: 1 or less stages correctly identified and described

- d. The extent to which a DNA fragment migrates through a gel is determined by the size of the fragment, with larger fragments staying closer to the origin than smaller fragments.

1 mark

AND

The alleles that cause these conditions all contain more repeat sequences than the allele for normal functioning, therefore the DNA representing these alleles will remain closer to the origin enabling diagnosis to occur.

1 mark

Total 6 marks

**Question 10 (5 marks)**

- a. The actual existence of a cabbit.

1 mark

- b. This statement is not correct.

1 mark

AND

Although in most cases both of the parent species have the same diploid number the parents of zonkies, mules and geep have different diploid numbers.

1 mark

- c. Closely related species, such as horses and donkeys can hybridise, but cats and rabbits are too distantly related.

1 mark

AND

Rabbits are herbivores and cats are carnivores, so their genes would code for very different structures. For example, the digestive systems of the two organisms are extremely different.

1 mark

Total 5 marks

**Question 11 (6 marks)**

- a. *Homo sapiens* have a much larger cranial capacity compared to their size than *Homo floresiensis* have.

1 mark

AND

This would enable *Homo sapiens* individuals to engage in comprehensive cognitive thought allowing them to solve problems associated with survival, such as making complex tools.

1 mark

- b. The significance of the similarities is that it indicates that *Homo sapiens* and *Homo floresiensis* share are both hominins and share a common ancestor.

1 mark

AND

The significance of the differences is that the most recent common ancestor of the two species separated more than 800, 000 years ago. As the two species were exposed to different selection pressures, they developed different adaptations.

1 mark

- c. This information suggests that *Homo floresiensis* were capable of using weapons in order to hunt *Stegodon*.

1 mark

- d. Possible answers include:

- Crossing over does not occur in mtDNA.
- mtDNA mutates at a known rate.
- mtDNA is inherited through the maternal line.
- Any other reasonable answer.

1 mark

Total 6 marks