

BIOLOGY

Units 3 & 4 – Written examination



2018 Trial Examination

SOLUTIONS

SECTION A – MULTIPLE CHOICE QUESTIONS

Question 1

Answer: C

Explanation:

ATP is being broken down to produce ADP and inorganic phosphate (Pi). Energy is released as the phosphate group is removed from ATP.

Question 2

Answer: B

Explanation:

If ATP cannot be broken down, then energy will not be released. Active transport will not occur without an input of energy.

Question 3

Answer: A

Explanation:

Glucose and iodine are both able to diffuse across the membrane, but starch is unable to do so. Therefore, the iodine in the water outside of the tubing will remain yellow. Iodine diffuses across the membrane and changes colour to dark blue after it comes into contact with the starch.

Question 4

Answer: A

Explanation:

The fact that the RNA molecule has a poly A tail means that it is mRNA and therefore only contains coding regions (exons).

Question 5

Answer: B

Explanation:

Because mRNA is complementary to the coding regions of DNA, a given sequence of DNA is used to determine the sequence of mRNA.

Question 6

Answer: D

Explanation:

Regulatory genes are those that code for the production of a protein which controls the expression of one or more other genes. RNA polymerase is responsible for reading the template strand of DNA and assembling a complementary strand of RNA thereby playing a direct role in the regulation of other genes.

Question 7

Answer: C

Explanation:

The Krebs's cycle will not function if the electron transport chain is non-functional. As the electron transport requires an input of oxygen, the Krebs's cycle is also dependent upon the presence of oxygen, which is why it is classified as an aerobic process.

Question 8

Answer: B

Explanation:

Combining the data from the absorption and action spectra shows that the relative effectiveness of photosynthesis is highest when the absorption of light is the greatest.

Question 9

Answer: D

Explanation:

The leaves appear orange to us because the wavelengths of light associated with orange colouration are reflected. According to the second graph, this wavelength is approximately 625nm. As this wavelength is being reflected, this will be represented by the lowest point on the absorption spectrum.

Question 10

Answer: A

Explanation:

The graph shows that the peak absorption for each pigment differs from all of the others, so the ability to produce more than one type of pigment increases the amount of light which can be absorbed by the leaves of the plant increasing the efficiency of photosynthesis.

Question 11

Answer: D

Explanation:

Chlorophyll a and b molecules play similar roles. The structure of a protein determines its function; therefore, it would be expected that they have a similar shape. All of the other options are incorrect; different proteins are not produced by the same gene and proteins with different functions would not have the same primary structure as each other.

Question 12

Answer: A

Explanation:

This graph shows that the reaction rate increases as substrate concentration increases up to the point of saturation after which the reaction rate becomes constant.

Question 13

Answer: A

Explanation:

If Malonic acid acted as a coenzyme, then the reaction rate would be higher in the test tubes that contain malonic acid. Malonic acid does not cause SDA to denature, if this were the case there would be no reaction occurring in test tubes 2 and 3. Malonic acid must be acting as an inhibitor which is why the reaction rate is lower in tube 2 compared to tube 1.

Question 14

Answer: B

Explanation:

Protein based hormones are hydrophilic and unable to diffuse across the plasma membrane. Therefore, they bind to a receptor on the external surface of the plasma membrane of a target cell.

Question 15

Answer: A

Explanation:

Increasing the number of stages in a transduction pathway enables the effect of the signal to be amplified more efficiently.

Question 16

Answer: C

Explanation:

The p53 gene is also known as a tumour suppressant gene as it promotes apoptosis, preventing tumours from forming.

Question 17

Answer: A

Explanation:

T cells are produced in bone marrow and migrate to the thymus gland, where they mature.

Question 18

Answer: D

Explanation:

Macrophages and mast cells both secrete chemicals which cause vasodilation. A is incorrect as polymorphic neutrophils are phagocytic. B is incorrect because blood flow increases to the affected area. C is incorrect as platelets are responsible for sealing the wound, not attracting phagocytes.

Question 19

Answer: A

Explanation:

Passive immunity occurs when an individual obtains antibodies from another individual. In options C and D an individual is exposed to antigens, not provided with antibodies. Option B is an example of passive immunity, but this is artificially acquired, not naturally acquired.

Question 20

Answer: C

Explanation:

A is incorrect because both T and B cells have a class II MHC marker on their external surface. B is incorrect as T helper cells have the ability to present antigens. D is incorrect as there are T memory and B memory cells.

Question 21

Answer: D

Explanation:

Biological fitness is used to compare an individual's ability to survive an environmental change to that of the rest of the population of the same species.

Question 22

Answer: A

Explanation:

The trait of having grey fur initially had the highest incidence, however, ten years later the incidence of this trait had substantially decreased. In order for this to occur, the trait of having grey fur must have become a disadvantage compared to having brown fur. Individuals with brown fur were selected for and individuals with grey fur were selected against.

Question 23

Answer: A

Explanation:

Speciation is a process which takes place over many generations, it will not begin to occur immediately.

Question 24

Answer: A

Explanation:

This is an example of the Founder Effect. All of the koalas on Phillip Island are the descendants of the koalas that were introduced. As a result, there would be less genetic variation in the smaller population on Phillip Island than in the original mainland population.

Question 25

Answer: C

Explanation:

The karyotype shows that the plant has four copies of each chromosome, therefore the plant is polyploid.

Question 26

Answer: A

Explanation:

Genetic drift occurs when the allele frequency of a population changes due to a chance event occurring. In this example, survival was due to chance rather than to biological fitness.

Question 27

Answer: A

Explanation: Adaptive radiation is the evolution of organisms of a single ancestral line to fill a range of ecological niches. As the ancestors of the finches colonised new islands, new niches became available, leading to the evolution of finches with novel phenotypes.

Question 28

Answer: C

Explanation:

Organisms are members of the same species if they can interbreed with each other and produce viable offspring.

Question 29

Answer: B

Explanation:

The term homologous structures refers to the structures present in different species which share a recent common ancestor.

Question 30

Answer: C

Explanation:

Chloroplasts and mitochondria both contain DNA which is different from nuclear DNA. This and the presence of ribosomes provides them with the ability to produce proteins which enable them to carry out specific purposes. Both mitochondria and chloroplasts are able to replicate by binary fission, independently of the replication of the cell in which they are located. The extensive membranous nature of both organelles is not considered to be proof of the endosymbiotic theory. However, had this option referred to the double membranes surrounding both organelles then the option would have been correct.

Question 31

Answer: D

Explanation:

If the fact that the four-chambered hearts are analogous structures was not known then the most plausible conclusion would be that the four-chambered heart is a homologous structure and that both types of organisms had inherited this trait from a recent shared ancestor.

Question 32

Answer: C

Explanation:

Although all of the statements provided are true, only option C has any bearing on the ability to use mtDNA as a molecular clock.

Question 33

Answer: D

Explanation:

This is an example of relative dating. The older fossils will be found at a lower level than the more recent fossils. The position occupied by a fossil does not provide any information about the number of fossils in that location or about the degree of relatedness between different fossilised organisms.

Question 34

Answer: C

Explanation:

Although this question refers to DNA amplification, the name of the process is Polymerase Chain Reaction.

Question 35

Answer: D

Explanation:

Endonucleases, also known as restriction enzymes are used to cut DNA into fragments. They recognise, bind to and cut specific sequences of DNA.

Question 36

Answer: D

Explanation:

The plasmid is recombinant as it contains DNA from two or more sources.

Question 37

Answer: A

Explanation:

Rational drug design is performed by identifying an appropriate target, determining the structure of the target and designing a molecule that will bind to that target. There is no need to sequence the DNA of the target as that will not provide useful information.

Question 38

Answer: C

Explanation:

A hybridoma is a cell that is formed as a result of fusing two cells together. The tumour cell is immortalised and the spleen cell provides the hybridoma with the ability to produce monoclonal antibodies.

Question 39

Answer: A

Explanation:

Herd immunity is the resistance to the spread of a contagious disease within a population that results if a sufficiently high proportion of individuals are immune to the disease, especially as a result of carrying out a vaccination programme.

Question 40

Answer: A

Explanation:

A master gene is one which is at the top of a gene regulation hierarchy and influences the expression of many other genes.

SECTION B - Short-answer questions

Question 1 (9 marks)

- a. Test tube 1 contains the experimental control group. The reason for setting up this test tube is to establish a baseline of comparison so that the impact of the independent variable can be determined (the effect of the presence of living organisms can be determined).

1 mark

- b. Ammonia is added to each of the test tubes, so that the solution in all test tubes begins as being basic. This will enable a colour change to be observed if the solution becomes acidic.

1 mark

- c. The colour change of the indicator, which indicates the change in pH.

1 mark

- d. Photosynthesis would be occurring in the conditions in test tubes 2 and 4.

1 mark

AND

Aerobic cellular respiration would be occurring in the conditions in test tubes 2,3 and 4.

1 mark

- e. In test tubes 1, 2 and 4 the indicator would be expected to remain blue.

1 mark

AND

In test tube 3, the indicator would be expected to have turned yellow.

1 mark

OR

In test tubes 1 and 2 the indicator would be expected to remain blue.

1 mark

AND

In test tubes 3 and 4 the indicator would be expected to have turned yellow.

1 mark

Note: Two slightly different answers are acceptable as the colour of the indicator will depend on the amount of excess carbon dioxide present. In test tube 2 the elodea use up the carbon dioxide produced causing the indicator to remain blue. In test tube 4 the indicator would remain blue if the elodea took up and used all of the carbon dioxide produced by the snails. However, if the elodea did not take up and use all of the carbon dioxide produced by the snails then the excess carbon dioxide in the water would dissolve, producing carbonic acid which would cause the indicator to turn yellow.

- f. Measuring the inputs or outputs of the processes of photosynthesis and aerobic cellular respiration are used to establish the rate of these reactions. This experiment is used to establish information regarding carbon dioxide production.

1 mark

AND

Carbon dioxide is an output of aerobic cellular respiration and is an input of photosynthesis. The colour of the indicator is used to determine whether carbon dioxide production by the snails exceeds carbon dioxide uptake by the plants, thereby establishing a relationship between these two processes.

1 mark

Total 9 marks

Question 2 (9 marks)

- a. The repressor protein would be expected to bind to the operator gene when the surrounding concentration of tryptophan is high.

1 mark

AND

The trp operon is responsible for enabling the production of tryptophan. If the concentration of tryptophan is already high then there would be no need for additional tryptophan to be produced. If the repressor protein is bound to the operator gene, then the trp operon will not be expressed and additional tryptophan will not be produced.

1 mark

- b. A regulatory gene codes for the production of a repressor protein.

1 mark

AND

Regulatory genes regulate the expression of other genes. A gene which produces a repressor protein produces a product which regulates the expression of a gene.

1 mark

- c. Protein synthesis is an endergonic process (requires an input of energy).

1 mark

AND

The bacterium benefits from being able to regulate the expression of this gene as the protein product is not produced when it is not required. Therefore, energy is conserved.

1 mark

- d. Transcription occurs when the repressor protein is not bound to the operator gene.

1 mark

AND

RNA polymerase binds to the promoter region.

1 mark

AND

RNA polymerase reads the template strand of DNA and assembles a complementary strand of RNA.

1 mark

Total 9 marks

Question 3 (6 marks)

- a. The DNA template contains more nucleotides than the mRNA as it contains both introns and exons.

1 mark

AND

Introns are removed during post transcriptional modification of the primary transcript. So the mRNA molecule only contains exons, and therefore contains less nucleotides than the DNA template.

1 mark

- b. 91 amino acids.

1 mark

AND

The mRNA molecule is made up of 276 molecules, which is 92 codons. However, the final codon is a stop codon, which codes for a release factor instead of an amino acid.

1 mark

- c. Any two of:

DNA is double stranded, mRNA is single stranded.

DNA contains adenine, thymine, guanine and cytosine. mRNA contains adenine, guanine, cytosine and uracil.

DNA contains the pentose, deoxyribose. mRNA contains the pentose, ribose.

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

Total 6 marks

Question 4 (7 marks)

- a. Ribosome.

1 mark

- b. Condensation reaction.

1 mark

- c. DNA is exposed to restriction enzymes in order to cut it into fragments.

1 mark

AND

The DNA is placed into an agarose gel in order to separate the fragments using electrophoresis. This generates a profile, which can be compared to other profiles.

1 mark

- d. The purpose of extracting DNA from a sample of pure beef is to enable the production of a profile of beef which is not contaminated by proteins from other sources.

1 mark

AND

The genetic profile from a sample of pure beef could be compared to samples taken from meat shipments.

1 mark

AND

If the meat in the shipments is pure beef then the profile of DNA taken from this meat should be the same as the profile produced from the sample known to be pure beef. If the meat contained protein from other sources then there will be substantial differences between this DNA profile and the profile from the sample known to be pure beef.

1 mark

Total 7 marks

Question 5 (7 marks)

- a. The flies' choice of habitat acted as a barrier to gene flow between different populations of flies.

1 mark

AND

This enables the populations of different flies to be isolated, increasing the probability that they will be subjected to different selection pressures, which facilitates the development of genetic differences between the two different types of fly.

1 mark

- b. Divergence occurred rapidly.

1 mark

AND

The flies diverged to take advantage of the new niche in 239 years. This is a comparatively short period of time in evolutionary terms.

1 mark

- c. The habitat preference of the two types of flies tends to keep them reproductively isolated, however, there is an overlap in the time period of the ripening of apples and hawthorn fruits. This enables some mating to occur between members of the two types of fly.

1 mark

- d. The term "races" is more accurate than the term "species".

1 mark

AND

The information provided states that mating occurs between the two types of flies and results in the production of viable offspring. If speciation had occurred then the offspring would not be viable. That the offspring of an apple maggot fly and a hawthorn maggot fly is viable.

1 mark

Total 7 marks

Question 6 (8 marks)

- a. Point mutation or substitution mutation.

1 mark

AND

The primary structure of the protein from organisms 1 and 2 is the same length and differs by a single amino acid. The only way this could have occurred is if a point mutation occurred changing a codon that coded from Val to a codon that coded for Arg.

1 mark

- b. The table should contain the following information

PREDICTED EFFECT	JUSTIFICATION
The protein structure and function are unaffected.	The change of a single amino acid in the primary structure was insufficient to alter the three-dimensional shape of the protein and therefore the function of the protein was unaffected.
The protein may have a different structure but retain the same function.	The change of a single amino acid in the primary structure altered the three-dimensional shape of the protein. However, the change in shape was not sufficient, or occurred at the wrong location to affect the function of the protein.
The protein may have a different structure and a slightly different function.	The change to the primary structure of the protein occurred at a position which affected the overall three-dimensional shape of the protein to the extent where it could not perform its original function.

1 mark for each correct reason provided

- c. This statement is most likely to be accurate.

1 mark

AND

The first six amino acids in the protein expressed by the translation of both alleles is the same. However, each of the following four amino acids are different. An addition or deletion of a single nucleotide alters the codons after the point of the mutation, resulting in the assembly of different amino acids.

1 mark

- d. Organisms that are closely related will have similar DNA sequences, which will lead to the production of similar proteins. Therefore organisms that are closely related will produce proteins with a greater degree of similarity of amino acid sequence than those that are not as related.

1 mark

Total 8 marks

Question 7 (8 marks)

- a. After an organism dies, the remains are rapidly covered by sediments. Over a long period of time minerals are exchanged between the remains and the environment and the sediment becomes a rock.

1 mark

AND

The Naracoote caves are appropriate for fossilisation to occur as many animals became trapped in the caves and the caves are set up in such a way that sediments become washed into the cave and cover the remains. Rapid coverage of the remains and the low oxygen content in the sediment would have promoted fossilisation of the remains.

1 mark

- b. Potassium to argon dating.

OR

Any other reasonable answer.

1 mark

- c. Body fossils are the fossilised remnants of body structures of dead organisms. These will usually be the hard sections of the body, such as bones and teeth. Trace fossils are remnants that were produced by organisms, but were not part of their structure.

1 mark

AND

Body fossils provide information about the structure of the organism and are used to establish what the organism may have looked like.

1 mark

AND

Trace fossils provide evidence about the activities or diet of the organism rather than its appearance.

1 mark

- d. Transitional fossil.

1 mark

AND

Transitional fossils are useful in providing information about evolution as they have features in common with the ancestral and descendant species.

1 mark

Total 8 marks

Question 8 (11 marks)

- a. The 2008 finding meant that the theories relating to human evolution had to be altered to take this new information into account. Analysis of the human fossil record is always open to reinterpretation whenever new evidence is found.

1 mark

- b. The term “X-woman” may not be accurate as the individual may have been male or female.

1 mark

AND

A female passes mitochondrial DNA onto all of her offspring regardless of their gender. Nuclear DNA is required in order to prove whether an individual is male or female.

1 mark

- c. According to the information in the cladogram, Denisovans and Neanderthals shared a common ancestor which diverged from that of modern humans.

1 mark

AND

As Neanderthals and Denisovans shared a more recent common ancestor than either had in common with modern humans, this would have led to these two hominins having a greater degree of similarity with each other than either had with the less related modern human species.

1 mark

- d. Modern Asians have some Denisovan DNA.

1 mark

AND

The information provided shows that interbreeding took place between the Denisovans and the ancestors of modern Asians. This took place after the ancestors of modern Asians separated from other modern human populations.

1 mark

- e. In comparison with *Homo sapiens*, a skull from *Homo erectus* would be expected to show any two of the following:

- Have larger brow ridges.
- Have a jaw that is more square and less parabolic
- Have a less definite chin
- Have a foramen magnum which is further towards the back of the skull, rather than centralised.
- Any other reasonable response.

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

- f. These findings show that members of *Homo erectus* had the cognitive ability to construct tools to open shells and also to carve designs into them.

1 mark

AND

Indications of cultural evolution in *Homo erectus* include the production of decorative items which are not directly associated with survival as well as the ability to make use of fire.

1 mark

Total 11 marks

Question 9 (5 marks)

- a. Autoimmune disease.

1 mark

AND

These conditions should not occur as all nucleated cells have a class I MHC marker which identifies the cells as being “self”. The immune system should be able to recognise these markers and not act against self cells.

1 mark

- b. Macrophages engulf fragments of myelin which they combine with the class II MHC markers and display on their external surface.

1 mark

AND

These are presented to T helper cells in the same way as a foreign antigen is presented to T helper cells. In turn, the T helper cells present the myelin antigen to immature B cells and activate cytotoxic T cells.

1 mark

AND

Cytotoxic T cells act directly against the myelin sheath. Antibodies produced by B plasma cells bind to the myelin sheath, attracting more macrophages which continue to break down the myelin, resulting in demyelination.

1 mark

Total 5 marks

Question 10 (5 marks)

- a. The gene pool of 100 colonists is much smaller than that of the entire human population, leading to decreased diversity in the population that descended from these individuals.

1 mark

- b. This is an example of the founder effect

OR

The initial population is a founding population.

1 mark

AND

Some traits or alleles present in the entire human population may be over-represented and others may disappear from the descendants of the colonising population.

1 mark

- c. It is beneficial for a founding population to be as diverse as possible in order for the gene pool of that population to be as fully representative of the larger population as possible.

1 mark

AND

A colonising population would experience different selection pressures compared to the large originating population. Having a diverse population would increase the chance that some individuals will be better able to survive these new pressures and the incidence of the most favourable traits will increase in subsequent generations.

1 mark

Total 5 marks

Question 11 (5 marks)

- a. Chikungunya disease was classified as a pandemic as although it naturally occurs in tropical regions, cases of the disease subsequently occurred in a large range of geographical areas across the planet.

1 mark

- b. Viruses are pathogenic agents and cannot reproduce outside of a host organism. Viruses can only be grown in living cells. Agar in a Petri dish is not alive and therefore does not provide the required conditions.

1 mark

- c. Possible answers include:

- People travel much further distances on a more frequent basis than has occurred in the past.
- Population density has increased in many countries; therefore, people live in closer proximity with each other.
- Urban expansion continues to occur, displacing wild animals. In some countries people are more likely to come into contact with these animals and zoonosis is more likely to occur.
- Pathogens or pathogenic agents may be deliberately spread.
- Any other reasonable response

1 mark for each correct answer to a maximum of two marks

- d. The purpose of these strategies is to identify the cause of emerging diseases as soon as possible in order to limit the spread of the pathogens which cause the disease. Additionally, if information is known about the pathogens then the cause of outbreaks can be identified and more rapid treatment can be provided.

1 mark

Total 5 marks