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YEAR 12 *Trial Exam Paper*

2016

BIOLOGY

Written examination

Sample answers

This book presents:

- high-level sample answers
- explanatory notes
- mark allocations
- tips on how to approach the exam

SECTION A – Multiple-choice questions

Question 1

Answer: D

Explanatory notes

A is incorrect – structure 1 is the nucleolus, which is responsible for making ribosomal subunits from proteins and ribosomal RNA.
B is incorrect – structure 2 is the nuclear membrane, which does not contain DNA.
C is incorrect – structure 5 is the rough endoplasmic reticulum, which the polypeptide is fed through after it has been assembled by a ribosome.
D is correct – structure 9 is a mitochondrion, which contains its own DNA that enables the mitochondrion to manufacture proteins that facilitate the process of aerobic respiration.

Note: both chloroplasts and mitochondria contain non-nuclear DNA.

Image source: https://commons.wikimedia.org/wiki/File:Biological_cell.svg

Question 2

Answer: C

Explanatory notes

A is incorrect – the diagram shows a substance that is only found in animal cells. ATP is not just found in animal cells. Additionally, the diagram shows a section of a polysaccharide. ATP is not a carbohydrate.
B is incorrect – starch is a polysaccharide, but it is found in plant cells, not in animal cells.
C is correct – glycogen is a polysaccharide that is only found in animal cells. Glycogen is produced and stored in the liver.
D is incorrect – glucagon is a polypeptide hormone, not a polysaccharide.

Image source: https://commons.wikimedia.org/wiki/File:Glycogen_bonds.png

Question 3

Answer: B

Explanatory notes

A is incorrect – Golgi bodies are responsible for the final modification and packaging of proteins before exocytosis. Cells that produce proteins are expected to contain Golgi bodies.
B is correct – ribosomes carry out translation, which is the synthesis of polypeptides. Cells that are specialised to produce proteins are expected to have large numbers of ribosomes.
C is incorrect – the number of chloroplasts in a cell has no bearing on the cell's ability to synthesise proteins.
D is incorrect – the smooth endoplasmic reticulum is responsible for the production and metabolism of lipids.

Image source: https://en.wiki2.org/wikipedia/commons/thumb/3/3d/1GZX_Haemoglobin.png/im344-480px-1GZX_Haemoglobin.png

Question 4

Answer: C

Explanatory notes

A is incorrect – a process that involves the assembly of a large molecule from smaller monomers is anabolic, not catabolic.
B is incorrect – anabolic reactions are also endergonic where an input of energy is required to form chemical bonds between monomers.
C is correct – biological macromolecules are produced as a result of condensation reactions.
D is incorrect – reactions that require an input of water are called hydrolysis reactions. Water is released when the bonds between monomers are broken.

Image source: https://upload.wikimedia.org/wikipedia/commons/2/2c/RNA_chemical_structure.GIF

Question 5

Answer: C

Explanatory notes

A is incorrect – osmosis is a passive process where water molecules diffuse down their concentration gradient and no energy is required.
B is incorrect – facilitated diffusion is the passive transport of substances across a biological membrane through trans-membrane proteins.
C is correct – active transport requires an input of energy because substances are pumped across a membrane against their concentration gradient. Bulk transport requires an input of energy because energy is required to move the membranes involved.
D is incorrect – facilitated diffusion is the passive transport of substances across a biological membrane through trans-membrane proteins.

Question 6

Answer: B

Explanatory notes

A is incorrect – the solution contains both glucose and water molecules. Glucose molecules are larger than water molecules, so the mass of the potato cylinder would be affected either by both glucose and water molecules or by just the water molecules.
B is correct – water molecules have kinetic energy and would have moved across the plasma membranes of the cells. If the solution surrounding the cylinder was isotonic then equal numbers of water molecules would have moved in both directions and there would be no net movement of water molecules.
C is incorrect – the cell walls of plant cells are permeable to a large range of substances, including water molecules.
D is incorrect – solute molecules have kinetic energy and will move whether or not there is a concentration gradient. However, the solute molecules, while moving, do not cross the plasma membrane.

Question 7

Answer: B

Explanatory notes

A is incorrect – cofactors are able to bind to the regulatory region of an enzyme but cofactors are inorganic.
B is correct – a coenzyme is an organic molecule that binds to the regulatory region of an enzyme. A coenzyme's role is to combine with inactive enzymes and activate them.
C is incorrect – competitive inhibitors bind to the active site of an enzyme, not to the regulatory region.
D is incorrect – non-competitive inhibitors bind to the regulatory regions of enzymes but their action prevents the enzyme from carrying out its function rather than enabling it to carry out its function.

Question 8

Answer: B

Explanatory notes

A is incorrect – lowering the temperature will decrease the rate of the reaction, but it will not prevent the spontaneous action of lipase.
B is correct – a catabolic reaction is one in which a larger molecule is broken down into two or more smaller products.
C is incorrect – enzymes speed up chemical reactions by lowering the activation energy required.
D is incorrect – the amount of products produced depends upon the amount of reactants available, not the speed at which the reaction occurs.

Question 9

Answer: D

Explanatory notes

A is incorrect – oxygen is not an input of photosynthesis, it is an output.
B is incorrect – light energy is absorbed by chlorophyll and used to facilitate the photolysis of water.
C is incorrect – carbon dioxide and water are not required to produce chlorophyll.
D is correct – chemical energy is used to produce ATP during the light-dependent stage. Some of this energy is used to combine hydrogen ions with the atoms from carbon dioxide during the light-independent stage, resulting in the production of glucose.

Question 10

Answer: A

Explanatory notes

A is correct – the photolysis of water occurs in the grana after light energy is absorbed by chlorophyll.
B is incorrect – carbon fixation occurs in the stroma, photolysis of water does not.
C is incorrect – ATP energy is produced during the light-dependent stage. The outputs ADP and Pi are returned to the grana for phosphorylation to occur.
D is incorrect – the electron transport chain occurs during the light-dependent stage, but it occurs after the photolysis of water, not before.

Question 11

Answer: C

Explanatory notes

A is incorrect – prokaryotic organisms are also able to produce ATP by the phosphorylation of ADP.
B is incorrect – phosphorylation of ADP also occurs in the cytosol during glycolysis.
C is correct – small amounts of ATP are produced during glycolysis, which is anaerobic; however, the majority of ATP is produced under aerobic conditions.
D is incorrect – the production of ATP from ADP and Pi is catalysed by enzymes such as ATP synthase.

Question 12

Answer: A

Explanatory notes

A is correct – pyruvate is converted into lactic acid during anaerobic respiration in animal cells.
B is incorrect – ethanol is produced during fermentation, which only occurs in plant and yeast cells.
C is incorrect – pyruvate contains three carbon atoms. Lactic acid also contains three carbon atoms. Carbon dioxide is produced as a result of fermentation in plant and yeast cells.
D is incorrect – glycolysis produces net two ATP during the reactions that produce pyruvate. No further ATP is produced anaerobically.

Tip

- *It is important to know when to use the terms cellular respiration, aerobic respiration and anaerobic respiration. If a question implies that a process is occurring in the presence of oxygen then the answer should include the term aerobic respiration and should not use the term cellular respiration.*

Question 13

Answer: D

Explanatory notes

A is incorrect – peptide hormones are large molecules that are insoluble in lipids. They are unable to cross the plasma membrane.
B is incorrect – receptors for peptide hormones are located on the external surface of the plasma membrane. Most of the receptors for steroid hormones are located in the cytosol but there are a few receptors for steroid hormones located inside the nucleus.
C is incorrect – proteins are unable to cross the plasma membrane and are also unable to cross the mitochondrial membranes.
D is correct – peptide hormones are unable to cross the plasma membrane. Peptide hormones bind to receptors located on the external surface of the plasma membrane and this triggers the release of a second messenger inside the target cell.

Question 14

Answer: A

Explanatory notes

A is correct – there is resistance to the movement of ions across the axon membrane. Increasing the diameter of the axon decreases this resistance and increases the rate at which the action potential can be conducted.
B is incorrect – ions are only able to cross the membrane at the nodes of Ranvier, which are unmyelinated areas along the axon. If the entire exon were completely coated with myelin, an action potential would not be possible.
C is incorrect – decreasing the length of the axon would have no effect on the speed at which the action potential can be conducted.
D is incorrect – nervous responses are all or nothing. This means that a response will either occur or it won't. This depends upon the stimulus exceeding the threshold. Once this occurs, the response will be of the same magnitude, no matter how large the stimulus is.

Question 15

Answer: B

Explanatory notes

A is incorrect – sodium ions are involved in the transmission of the action potential along the axon, but calcium ions move into the presynaptic terminal causing vesicles to release neurotransmitters into the synapse.
B is correct – an action potential is transmitted along a synapse due to the sequential movement of sodium and potassium ions across the plasma membrane of the axon.
C is incorrect – potassium ions are involved in the transmission of the action potential along the axon, but calcium ions move into the presynaptic terminal causing vesicles to release neurotransmitters into the synapse.
D is incorrect – both sodium and potassium ions are involved in the transmission of the action potential along the axon, but calcium ions move into the presynaptic terminal causing vesicles to release neurotransmitters into the synapse.

Question 16

Answer: C

Explanatory notes

A is incorrect – the light chain of the antibody consists of both the constant and variable portions.
B is incorrect – the heavy chain determines the class and functional activity of the antibody, but does not govern its specificity.
C is correct – the variable portions of the antibody has been manufactured to be specific to a particular antigen.
D is incorrect – the constant region of an antibody would be identical in all antibodies of the same class. This prevents the constant portion from being specific.

Image source: https://commons.wikimedia.org/wiki/File:Antibody.JPG

Question 17

Answer: B

Explanatory notes

A is incorrect – mast cells are involved in the second line of defence and only act after physical and chemical barriers have been breached.
B is correct – the production of tears enables foreign objects to be flushed out of the eye. This prevents foreign materials from entering the body through the eye and is therefore a first line of defence.
C is incorrect – platelets are responsible for causing blood to clot and for the production of fibres that seal wounds. Platelets only act after intact skin has been breached.
D is incorrect – T helper cells stimulate other lymphocytes to take specific action against an antigen. T helper cells play a role in the third line of defence.

Question 18

Answer: A

Explanatory notes

A is correct – all nucleated cells have a class I major histocompatibility complex marker that identifies self cells. Cytotoxic T cells will act against cells that do not have the appropriate marker.
B is incorrect – immunosuppressive drugs suppress the ability of the immune system to attack the transplanted organ. They do not act against the transplant.
C is incorrect – if the surface antigens were identical then the immune system would identify the transplanted tissue as being self and would not act against it.
D is incorrect – the antigens on the kidney cells would not be foreign to those cells and therefore would not trigger apoptosis.

Question 19

Answer: B

Explanatory notes

A is incorrect – immunity has been acquired due to being exposed to a vaccine. This is an example of artificially, rather than naturally, acquired immunity.
B is correct – this is an example of artificially acquired immunity because it is the result of being exposed to a vaccine that contains antigens. The children produce their own antibodies to the antigen and this is therefore an example of active immunity.
C is incorrect – passive immunity only occurs when an individual obtains antibodies from another source. The vaccine is antigenic and therefore confers active immunity, not passive immunity.
D is incorrect – passive immunity only occurs when an individual obtains antibodies from another source. The vaccine is antigenic and therefore confers active immunity, not passive immunity.

Question 20

Answer: C

Explanatory notes

A is incorrect – viruses contain nucleic acids as well as proteins.
B is incorrect – the amount of DNA in pathogens and pathogenic agents varies, so it cannot be said that pathogenic agents contain less DNA.
C is correct – pathogenic agents are not considered to be alive because they cannot replicate outside a host cell. This is why they are called pathogenic agents rather than pathogens.
D is incorrect – viruses are able to insert their DNA into a host cell.

Question 21

Answer: C

Explanatory notes

A is incorrect – the removal of introns and splicing of exons are not the only post-transcriptional modifications to the primary transcript.
B is incorrect – a spliceosome is a molecular construct that is responsible for the removal of introns from pre-mRNA. Material contained in the introns will be broken down and reused.
C is correct – a methylated cap needs to be added to the 5' end of the molecule. This allows for correct orientation as well as protection.
D is incorrect – the methylated cap and polyA tail both provide this type of protection, but the removal of introns and splicing of exons does not.

Image source: https://upload.wikimedia.org/wikipedia/commons/8/81/0326_Splicing.jpg

Question 22

Answer: C

Explanatory notes

A is incorrect – eukaryotic chromosomes are made up of introns and exons; prokaryotic chromosomes do not contain introns.
B is incorrect – only eukaryotic chromosomes are surrounded by a membrane.
C is correct – in eukaryotic cells, chromosomes are made up of chromatin, a fibre made up of DNA coiled around histone proteins. In prokaryotic organisms, DNA is packaged into chromosomes by DNA binding proteins. The DNA is bound to a protein core.
D is incorrect – prokaryotic cells have a single circular chromosome and it is impossible for homologous pairs of chromosomes to form.

Question 23

Answer: B

Explanatory notes

A is incorrect – this process cannot be mitosis because there is no spindle fibre involved and there are no clear stages shown.
B is correct – this process is binary fission because it shows the cellular division of prokaryotic cells.
C is incorrect – this process cannot be mitosis because there is no spindle fibre involved and there are no clear stages shown.
D is incorrect – this diagram does not show anything relating to the cell cycle. Mitosis is one of the stages that occur during the cell cycle, but binary fission is not part of the cell cycle.

Tip

- *Binary fission is different from mitosis because many of the events that occur during mitosis do not occur during binary fission. During binary fission, no spindle fibre is involved and there are no specific phases (e.g. metaphase). Bacterial chromosomes do not have a centromere so the chromosomes do not separate at the centromere and the chromosomes do not align at the equator of the cell at any point during the process.*

Iamge source: https://commons.wikimedia.org/wiki/File:Binary_Fission_2.svg

Question 24

Answer: B

Explanatory notes

A is incorrect – a cell that contains one complete set of chromosomes is haploid, not diploid.
B is correct – a diploid cell contains two copies of each chromosome.
C is incorrect – although the chromosomes align in homologous pairs, the pairs of chromosomes do not have to have the same DNA sequence. If an individual is heterozygous, even at a single locus, then the sequences will not be the same.
D is incorrect – haploid cells also contain DNA arranged into discrete chromosomes.

Question 25

Answer: C

Explanatory notes

A is incorrect – the removal of a codon from an mRNA sequence will not prevent the ribosome from reading that sequence and carrying out the process of translation.
B is incorrect – the mRNA sequence will be shorter by one codon and the stop codon will still be the final codon in the mRNA sequence. A stop codon will not be produced just after the mutation point.
C is correct – the reading frame of codons will be unchanged after the mutation.
D is incorrect – as the codon codes for a single amino acid, the primary sequence of the protein will differ by a single amino acid. This is not an extensive change.

Question 26

Answer: A

Explanatory notes

A is correct – this option correctly identifies the first of the events that occur during gene expression.
B is incorrect – individual genes are not replicated. Replication of DNA is essential before cell division, but it is entirely irrelevant to gene expression.
C is incorrect – the reading of the leading strand (transcription) does occur first, however, the leading strand is read by RNA polymerase, not DNA polymerase.
D is incorrect – tRNA is responsible for transferring amino acids from the cytosol to the ribosome, but mRNA has to be read by the ribosome before this occurs.

Tip

- *It is important to be aware of the difference between enzymes associated with DNA replication and those that play a role in protein synthesis. In both cases there are enzymes with similar sounding names (e.g. DNA polymerase and RNA polymerase). The correct naming of these enzymes is imperative if such a question occurs in the short-answer section of the paper.*

Question 27

Answer: D

Explanatory notes

A is incorrect – a deletion is the loss of a sequence of DNA (from a single base to a section of a chromosome), which hasn't happened in this case.
B is incorrect – if a frameshift mutation had occurred then the DNA sequence would be either shorter or longer (by a number of bases that is not divisible by three) than the original sequence.
C is incorrect – a duplication mutation occurs as a result of an error during crossing over. One of a pair of sister chromatids retains two copies of a section of DNA and the other member of the pairs is missing this section.
D is correct – a substitution mutation occurs when one base replaces another. In this case, guanine has been substituted for adenine.

Question 28

Answer: C

Explanatory notes

A is incorrect – although recognition sites for Alu1 surround the gene of interest, this enzyme causes the production of fragments that have blunt ends that are unsuitable for manipulation.
B is incorrect – there are no restriction recognition sites for this enzyme surrounding the gene of interest.
C is correct – recognition sites for this enzyme are located in the regions flanking the gene of interest. This enzyme causes the production of fragments with sticky ends.
D is incorrect – there is a restriction site for BamHI, but this cuts through the gene of interest and is therefore an unsuitable choice.

Question 29

Answer: B

Explanatory notes

A is incorrect – the fragment in Lane 2 is approximately 5.3 kb and represents the plasmid.
B is correct – the fragment in Lane 3 is approximately 8.2 kb and represents the gene annealed to the plasmid (5.3 kb + 2.9 kb = 8.2 kb).
C is incorrect – the fragment in Lane 4 is approximately 2.9 kb and represents the gene of interest.
D is incorrect – the fragment in Lane 5 is approximately 5.8 kb, which doesn't correspond to any of the expected results, but is most likely to be two copies of the gene annealed to each other.

Question 30

Answer: A

	$\mathbf{I^B}$	**i**
$\mathbf{I^A}$	$I^A I^B$	I^A i
i	I^B i	i i

Explanatory notes

A is correct – as shown in the Punnett square, the only way for parents with these phenotypes to have one child with type A blood and another with type B blood is for both parents to be heterozygous.
B is incorrect – if the child with type A blood were heterozygous then the father could not have type B blood. If the child with type B blood were heterozygous then the mother cannot have had type A blood.
C is incorrect – the phenotypic ratio for the offspring is 1 type A : 1 type AB : 1 type B : 1 type O. Four phenotypes are possible, not three.
D is incorrect – this would only be possible if both parents were homozygous.

Tip

- *It is important to remember that there are two types of inheritance in this case. The alleles for types A and B blood are codominant with respect to each other and both are dominant with respect to the allele for type O blood. Therefore, there are two possible genotypes for the type A and type B phenotypes.*

Question 31

Answer: D

Explanatory notes

A is incorrect – cells of this individual are not diploid because they are lacking a chromosome.
B is incorrect – euploid means that the cells have a chromosome number that is an exact multiple of the haploid number. Because this individual has 45 chromosomes, the cells are aneuploid, not euploid.
C is incorrect – polyploid cells are those containing more than two paired sets of chromosomes.
D is correct – aneuploidy refers to the condition of having an abnormal number of chromosomes that is not an exact multiple of the haploid number.

Image source: https://upload.wikimedia.org/wikipedia/commons/1/1b/45,X.jpg

Question 32

Answer: C

Explanatory notes

A is incorrect – the phenotypic ratio is 2 normal vision female : 1 normal vision male : 1 colour blind male. There are three possible phenotypes in the offspring, not one.
B is incorrect – the phenotypic ratio is 2 normal vision female : 1 normal vision male : 1 colour blind male. There are three possible phenotypes in the offspring, not two.
C is correct – the phenotypic ratio is 2 normal vision female : 1 normal vision male : 1 colour blind male. There are three possible phenotypes in the offspring.
D is incorrect – the phenotypic ratio is 2 normal vision female : 1 normal vision male : 1 colour blind male. There are three possible phenotypes in the offspring, not four.

Note: The following punnet square contains information relating to the solutions for questions 32 and 33.

	$\mathbf{X^B}$	**Y**
$\mathbf{X^B}$	$X^B X^B$	$X^B Y$
$\mathbf{X^b}$	$X^B X^b$	$X^b Y$

Tip

- *If a condition is X-linked then gender is also part of the phenotype. In this example, it is incorrect to state that the phenotypic ratio is 3 normal vision : 1 colour blind.*

Question 33

Answer: B

Explanatory notes

A is incorrect – as shown in the Punnett square the phenotypic ratio for males is 1 normal vision : 1 colour blind. Therefore any of her sons will have a 50 per cent chance of being colour blind.
B is correct – as shown in the Punnett square the phenotypic ratio for males is 1 normal vision : 1 colour blind. Therefore her sons will have a 50 per cent chance of being colour blind.
C is incorrect – none of her daughters will be colour blind, but they do have a 50 per cent chance of being a carrier.
D is incorrect – males are more likely to inherit X-linked recessive traits than females because males only require one copy of the allele for the trait whereas females require two copies. None of the female offspring of this woman will be colour blind.

Question 34

Answer: A

Explanatory notes

A is correct – the founder effect is a type of genetic drift that occurs when a population descends from a small number of colonising individuals. As a result, some traits will occur at a higher rate in their descendants than would be expected in other populations.
B is incorrect – variegate porphyria is a genetic disease and does not confer any reproductive advantages.
C is incorrect – no information has been supplied relating to the number of offspring.
D is incorrect – the allele for variegate porphyria is dominant. It is very unlikely that an environmental factor would have had such an extensive effect.

Question 35

Answer: A

Explanatory notes

A is correct – allopatric speciation requires reproductive isolation to occur between members of the same species. These iguanas have been geographically and reproductively isolated from the rest of their species. The separated populations may be exposed to different selection pressures and any accumulation of genetic changes may lead to speciation.
B is incorrect – a genetic bottleneck requires a substantial decrease in the population. There is still a large number of iguanas in North America.
C is incorrect – genetic drift refers to the change in allele frequency over a period of time. It does not refer to the physical movement of organisms that occurred in this example.
D is incorrect – iguanas dying out would not give biologists the opportunity to observe the processes of natural selection and evolution, and while this event would be regretted, it would not be of interest.

Question 36

Answer: D

Explanatory notes

A is incorrect – speciation occurs when a single population is split into two isolated groups and each group then experiences different selection pressures.
B is incorrect – natural selection refers to changes that occur in a single species over a period of time. Individuals that are more biologically fit are more likely to survive and have offspring than those that are less biologically fit.
C is incorrect – divergent evolution occurs when two or more species descend from a common ancestor.
D is correct – the features of these species are analogous. The features resemble each other in some ways and they carry out similar functions, but their roles in flight have evolved separately. These features were developed due to adapting to similar environmental conditions, not as a result of sharing a common ancestor.

Image source: https://upload.wikimedia.org/wikipedia/commons/3/38/Homology.jpg

Question 37

Answer: B

Explanatory notes

A is incorrect – indicator fossils are used for relative dating.
B is correct – transitional forms are considered to be evidence for the theory of evolution because these organisms have traits in common with ancestral and descendent species.
C is incorrect – there is no such term as 'hybrid fossil', and there is no indication that this organism was a hybrid.
D is incorrect – many fossils are used as evidence to support the theory of evolution, but they are not referred to as evidentiary fossils.

Image source:
https://commons.wikimedia.org/wiki/File:Archaeopteryx_lithographica,_replica_of_London_specimen,_Staatliches_Museum_f%C3%BCr_Naturkunde_Karlsruhe,_Germany_-_20100925.jpg

Question 38

Answer: B

Explanatory notes

A is incorrect – different sections of mitochondrial DNA mutate at different rates. The rate of mutation cannot be compared with that of genomic DNA.
B is correct – mitochondrial DNA only comes from the maternal line and recombination cannot occur.
C is incorrect – all children inherit mitochondrial DNA from their mother. Not all members of a family will have the same mitochondrial DNA because children do not have any mitochondrial DNA in common with their father.
D is incorrect – this statement is true, but it has nothing to do with the question.

Question 39

Answer: C

Explanatory notes

A is incorrect – this is an example of somatic gene therapy. The inserted gene is only taken up by some somatic cells. It will not be incorporated in the gametes to be inherited by offspring.
B is incorrect – the action of a viral vector inserting a gene into a cell does not cause that cell to immediately commit apoptosis.
C is correct – as in this case, specific tissues may be targeted. However, there is currently no method of programming the virus to insert the gene at a specific location.
D is incorrect – viral vectors are able to insert DNA into a cell, but they are not able to remove DNA.

Question 40

Answer: A

Explanatory notes

A is correct – the fact that all of the oldest discovered hominin fossils were found in Africa supports the Out of Africa theory.
B is incorrect – this statement is untrue. Even among modern humans there are many differences in mitochondrial DNA sequences.
C is incorrect – this information does not state where these individuals originated and therefore does not support the Out of Africa theory.
D is incorrect – this information supports the multiregional theory, not the Out of Africa theory.

SECTION B – Short-answer questions

Question 1a.

Sample answer

primary transcript

OR

pre-mRNA

Mark allocation: 1 mark

- 1 mark for either of the answers provided or any other comparable term

Tip

- *DNA is made up of introns and exons. RNA polymerase will copy the entire leading strand. The introns will be removed and the exons spliced together during post-transcriptional modification.*

Image source: https://commons.wikimedia.org/wiki/File:Simple_transcription_initiation1.svg

Question 1b.

Sample answer

Protein synthesis is an endergonic process requiring an input of energy. *E. coli* benefits because energy is only expended on the production of these enzymes when they are required.

Mark allocation: 1 mark

- 1 mark for referring to both the energy requirements AND the bacteria benefits by conserving energy

Tip

- *All responses have to completely answer the question because there are no half marks available. This question asks for a benefit to be identified. An answer that only refers to the fact that protein synthesis requires an input of energy would be incomplete. A reference to conservation of energy is essential.*

Image source: https://upload.wikimedia.org/wikipedia/commons/thumb/2/22/Lac_Operon.svg/2000px-Lac_Operon.svg.png

Question 1c.

Sample answer

Structure 2 is a repressor protein and Structure 4 is an operator gene.

Mark allocation: 1 mark

- 1 mark for identifying Structures 2 and 4 correctly

Question 1d.

Sample answer

When the repressor protein binds to the operator gene, RNA polymerase is unable to bind to the promoter sequence. As a result, transcription cannot occur and the enzymes will not be produced.

Mark allocation: 1 mark

- 1 mark for explaining that transcription cannot occur while the repressor protein is bound to the operator gene

Question 1e.

Sample answer

Proteins are specific, so the shape of a protein determines its ability to carry out its function. In this case, the repressor protein has to be complementary to the operator gene to bind to it. Repressor proteins have to be able to bind to and release the operator gene as conditions change. Therefore it is essential that repressor proteins have the ability to change shape.

Mark allocation: 1 mark

- 1 mark for any answer that identifies the importance of the complementary structure of proteins and explains that a repressor protein must be able to change shape to bind to and release the operator gene.

SECTION B

Question 2a.

Sample answer

metabolic pathway

OR

biochemical pathway

Mark allocation: 1 mark

- 1 mark for the correct answer

Question 2b.

Sample answer

Individuals who have this condition are unable to produce sufficient dihydrotestosterone and therefore do not develop male characteristics (this is generally due to a defect in 5-α-reductase). Individuals produce a large amount of testosterone with the onset of puberty. Some of this is converted into dihydrotestosterone, which causes the individual to develop male characteristics.

Mark allocation: 2 marks

- 1 mark for stating that the individual does not produce sufficient dihydrotestosterone to develop male characteristics
- 1 mark for stating that the production of high levels of testosterone at the start of puberty triggers the production of dihydrotestosterone, causing the development of a male appearance

Question 2c.

Sample answer

This child has a female appearance because the child did not produce sufficient dihydrotestosterone before birth. The child will develop male characteristics at the onset of puberty. The karyotype shows their 23rd pair of chromosomes is XY, which means that the child is genetically male.

Mark allocation: 2 marks

- 1 mark for stating that the child will develop male characteristics at the onset of puberty, or for speculating that there may be a defect in their 5-α-reductase enzyme
- 1 mark for referring to the presence of the X and Y chromosomes in the karyotype, which proves the individual is genetically male

Image source: https://commons.wikimedia.org/wiki/File:NHGRI_human_male_karyotype.png

SECTION B

Question 3a.

Sample answer

light

Mark allocation: 1 mark

- 1 mark for the correct answer

Image modified from: https://commons.wikimedia.org/wiki/File:Calvin_cycle_overall.svg

Question 3b.

Sample answer

light-independent stage

Mark allocation: 1 mark

- 1 mark for the correct answer

Tip

- *Students are required to be able to identify the inputs and outputs of both stages of photosynthesis.*

Question 3c.

Sample answer

NADPH is responsible for carrying hydrogen ions from the grana to the stroma. NADPH provides the ability (reducing power) to fix carbon dioxide into organic sugar molecules.

Mark allocation: 1 mark

- 1 mark for providing an explanation rather than just stating that the NADPH is a carrier molecule

SECTION B

Question 3d.

Sample answer
The diagram shows an input of carbon dioxide, ATP and NADPH. These substances are inputs for the light-independent stage, which occurs in the stroma.

Mark allocation: 2 marks

- 1 mark for identifying that this stage of the process occurs in the stroma
- 1 mark for identifying the substances shown as being inputs for the light-independent stage

Tip

- *Make sure that instructional words such as identify are interpreted correctly. Part b of this question asks for an identification. This means that an explanation as to what occurs during that stage of the reaction is not required. Nor is it necessary to explain why the answer is correct. Writing additional, but irrelevant information on an examination paper uses up time but does not allow additional marks to be obtained. Writing concise answers is a valuable skill for all students.*

Question 4a.

Sample answer

fermentation

Mark allocation: 1 mark

- 1 mark for the correct answer

Question 4b.

Sample answer

Glucose is an input for the process of fermentation. At the ten-hour mark, the glucose molecules have been completely used up and no further ethanol molecules are produced. Therefore, the concentration of ethanol remains constant.

Mark allocation: 2 marks

- 1 mark for stating that glucose is an input in the process of fermentation
- 1 mark for stating that ethanol production ceases once all of the glucose molecules have been used

Question 4c.

Sample answer

Initially, the yeast cells increase in number as they have been provided with sufficient glucose to carry out cellular respiration and produce the ATP that is necessary to survive. The number of yeast cells then decreases because ethanol is cytotoxic and causes the cells to die off.

Mark allocation: 2 marks

- 1 mark for identifying that the initial increase is due to the amount of glucose provided
- 1 mark for explaining that the yeast cells die because of the increase in ethanol

Question 4d.

Sample answer

Ethanol is only produced by the anaerobic process of fermentation. As the yeast cells were supplied with oxygen, they would not produce any ethanol, so the second graph would not include a reference to ethanol.

Mark allocation:

- 1 mark for identifying that ethanol would not be shown on the second graph
- 1 mark for explaining why the yeast cells would not be producing ethanol in the presence of oxygen

SECTION B

Question 5a.

Sample answer

Reception occurs when the peptide hormone binds to the receptor located on the external surface of the plasma membrane of the target cell. Transduction occurs when a second messenger is activated inside the cell and triggers a metabolic cascade that amplifies the effect of the signal. Induction occurs when the cell carries out a response such as taking up glucose.

Mark allocation: 3 marks

- 1 mark for identifying reception as the first stage and describing how a peptide hormone binds to a receptor
- 1 mark for identifying transduction as the second stage and describing the release of a second messenger
- 1 mark for identifying induction as the third stage and identifying a cellular response that occurs as a result of insulin binding to the target cell

Question 5b.

Sample answer

Liver cells and muscle cells differ in their responses to insulin because different second messengers are triggered inside the two cell types and, therefore, the transduction pathways will also be different.

Mark allocation: 1 mark

- 1 mark for discussing the fact that the release of different second messengers will initiate different transduction pathways and cause different cellular responses to occur

Question 5c.

Sample answer

Glucose enters cells by the process of facilitated diffusion, a passive process in which glucose moves from an area of high glucose concentration to an area of low glucose concentration, down its concentration gradient. Glucose molecules bind to a glucose transporting protein (carrier protein), which then changes shape and releases the glucose molecule on the other side of the plasma membrane.

Mark allocation: 1 mark

- 1 mark for describing the process of facilitated diffusion

Tip

- *The instructional word explain is often used in examination papers. One of the common mistakes that occurs is that students will provide a statement instead of an explanation. As an example, 'glucose enters a cell by the process of facilitated diffusion' is a statement, not an explanation. In an examination, it is unlikely that marks would be awarded for that answer because, although the information is correct, nothing has been explained. In the sample answer provided, an identification of the process was supplied, and was followed by an explanation of that process, resulting in an answer that meets the requirements.*

Question 6a.

Sample answer

An antigen is any foreign substance that induces a specific immune response, in particular the production of antibodies in an individual.

Mark allocation: 1 mark

- 1 mark for providing an appropriate definition of an antigen

Question 6b.

Sample answer

If the T cell receptor is specific for that antigen, then it will bind to the complex of the class I major histocompatibility complex molecule and the antigen on the external surface of the cell. The cytotoxic T cell will produce perforins that cause the infected cell to undergo apoptosis.

Mark allocation: 1 mark

- 1 mark for writing an answer shows an understanding that the cytotoxic T cell will bind to the complex and release chemicals that result in cellular apoptosis

Question 6c.

Sample answer

Macrophages engulf the antigenic substance, combine antigenic fragments with their class II major histocompatibility complex marker and display this complex on their external surface. The antigen is then presented to T helper cells, which produce cytokines that stimulate the production of B cells. T helper cells then present the antigen to B cells which rapidly divide, producing large numbers of antibody secreting B plasma cells and a few B memory cells.

Mark allocation: 2 marks

- 1 mark for describing phagocytosis and antigen presentation to T helper cells
- 1 mark for describing the T helper cells presenting the antigen to B cells and the results of clonal expansion

SECTION B

Question 6d.

Sample answer

The health professional is describing herd immunity. If a large percentage of the population is immune to a specific pathogen or pathogenic agent then the chances of being exposed to, and passing on, the pathogen to those who are not immune will be very low.

Mark allocation: 2 marks

- 1 mark for identifying the term 'herd immunity'
- 1 mark for explaining how a population benefits from herd immunity

Question 6e.

Sample answer

The purpose of carrying out booster shots is to cause individuals to produce additional B memory cells that will remain in their lymphatic systems. The presence of these B memory cells increases the ability of individuals to produce higher levels of antibodies at a greater rate if they are challenged with the antigen in the future.

Mark allocation: 2 marks

- 1 mark for stating that the purpose is to ensure the production of additional B memory cells
- 1 mark for demonstrating an understanding that the presence of B memory cells enables a stronger response if repeated exposure to an antigen occurs, thus demonstrating that long-term immunity has been achieved

Question 7a.

Sample answer

hypersensitivity

Mark allocation: 1 mark

- 1 mark for the correct answer

Image source: https://commons.wikimedia.org/wiki/File:Skin_prick_testing_for_allergies.jpg

Question 7b.

Sample answer

allergen

Mark allocation: 1 mark

- 1 mark for the correct answer

Note: in this example, allergen is the most appropriate answer because not all antigens are also allergenic.

Question 7c.

Sample answer

The parents should change the brand of washing powder that they use. The weal size of 16 mm surrounding the point of exposure to the washing powder indicates that the child is very sensitive to a component of the washing powder.

Mark allocation: 2 marks

- 1 mark for identifying that the washing powder is the allergen, including using the data that proves that the child is very sensitive to the washing powder
- 1 mark for stating that the parents should cease using this brand of washing powder

Question 7d.

Sample answer

Histamine naturally promotes swelling and is used as a positive control. The application of histamine provides a baseline for comparison.

Mark allocation: 1 mark

- 1 mark for demonstrating an understanding that the response to histamine is normal and the extent of response can be used to compare the effects of exposure of allergens to a normal response

SECTION B

Question 8a.

Sample answer

Crossing over (or recombination) is the exchange of genetic material between two sister chromatids, resulting in the production of recombinant chromatids.

Mark allocation: 2 marks

- 1 mark for using the term 'crossing over'
- 1 mark for discussing the exchange of DNA between sister chromatids

Image source: https://upload.wikimedia.org/wikipedia/commons/b/be/Crossing-over_scheme_PL.svg

Question 8b.

Sample answer

Crossing over enables a sexually reproducing organism to produce greater genetic variation in its gametes. A species with a larger range of genetic variation is more likely to survive environmental changes than a species with less variation because it is more likely that at least some individuals will have adaptations that confer biological fitness.

Mark allocation: 2 marks

- 1 mark for identifying that there will be greater variation in the gametes
- 1 mark for writing an answer that demonstrates a link between variation and natural selection

Question 8c.

Sample answer

There will be no effect on the phenotype of the individual. The individual has a full complement of DNA and will be phenotypically normal. All seven genes from A to G will be inherited.

Mark allocation: 2 marks

- 1 mark for stating there will be no effect on the phenotype
- 1 mark for stating that the individual has the normal complement of DNA and all genes will still be expressed

Question 9a.

Sample answer

This trait is recessive because parents III-2 and III-3 do not have the trait, but they have two children (IV-2 and IV-4) who do.
This trait is autosomal because if the trait were X-linked and recessive then the father of an affected female must also be affected. Because individual IV-2 is affected and her father is not, this trait cannot be X-linked and must be autosomal.

This trait is autosomal because it is caused by a mutation located on chromosome 1. The trait is recessive because two unaffected parents have a child with the trait.

Mark allocation: 3 marks

- 1 mark for identifying the mode of inheritance as being autosomal recessive
- 1 mark for explaining why the inheritance of the trait is recessive
- 1 mark for explaining why the inheritance of the trait is not X-linked

Question 9b.

Sample answer

Let A = unaffected by MCADD and a = affected by MCADD.

Mark allocation: 1 mark

- 1 mark for using appropriate notation where being unaffected is the dominant trait and having the condition is the recessive trait. A capital letter must be used for the dominant trait and a lower case version of the same letter must be used for the recessive trait.

Question 9c.

Sample answer

The chance of this child being homozygous is 1 in 3.

	A	**a**
A	AA	Aa
a	Aa	aa

Mark allocation: 2 marks

- 1 mark for correctly identifying the probability
- 1 mark for drawing a correct Punnett square

Tip

- *Sometimes genetics problems will refer to conditional outcomes. In this case the child is unaffected and therefore cannot have the aa genotype. Therefore, the genotypic ratio is 1AA : 2Aa, so the chance of the child being homozygous is 1 out of 3. Similar conditional outcomes can also be based on the analysis of pedigree charts.*

Question 9d.

Sample answer

If 1 in 40 individuals are carriers then there would be a 1 in 1600 chance that two carriers will have offspring. There is then a 1 in 4 chance that their offspring will have the trait reducing the probability of inheriting MCADD to 1 in 6400. It is expensive to undertake genetic screening, particularly if a small number of people are likely to be affected.

Mark allocation:

- 1 mark for an answer that discusses the probability of being affected
- 1 mark for an answer that refers to the cost of screening an entire population

Question 9e.

Sample answer

MCADD is a serious condition and these siblings may have the condition and be unaware of it. There is a much higher chance that these individuals will have the trait compared with the risk for the average person (the chance is 25 per cent rather than 0.015 per cent). There is also a 50 per cent chance that the siblings of an affected child will be heterozygous and have the potential to pass the allele for the trait onto their offspring.

Mark allocation: 1 mark

- 1 mark for an answer that refers to the increased risk to the sibling of an affected child also developing the trait OR for discussing the increased chance of being heterozygous and passing an allele for the trait onto their offspring.

Question 10a.

Sample answer

gene flow

Mark allocation: 1 mark

- 1 mark for the correct answer

Question 10b.

Sample answer

There would be low genetic diversity in the Kangaroo Island koala population. These koalas may not be able to be used for conservation efforts due to inbreeding, or the lack of variation may prevent them from being able to withstand selection pressures.

Mark allocation: 2 marks

- 1 mark for identifying that genetic diversity will be low
- 1 mark for identifying inbreeding or lack of variation as being potential problems in using these koalas for conservation efforts

Question 10c.

Sample answer

Small populations are more vulnerable to these events because they decrease the size and genetic variation of the population. The smaller the population, the greater the contribution each individual makes to the gene pool. The loss or gain of a single individual may have a substantial effect upon the genetic variation of that population.

Mark allocation: 1 mark

- 1 mark for explaining why small populations are more vulnerable to these events

Question 10d.

Sample answer

A population that has genetic diversity will also display phenotypic variation. Because selection pressures are the impact of the environment on phenotype, a species having a greater range of phenotypes increases the chance that at least some of the population will survive if environmental changes occur.

Mark allocation: 1 mark

- 1 mark for writing an answer that demonstrates an understanding that some members of a genetically varied population are likely to survive environmental changes, decreasing the risk that extinction will occur

SECTION B

Question 10e.

Sample answer

A greater degree of genetic variation would have been expected in the samples from the museum specimens compared with the modern koalas.

Mark allocation: 1 mark

- 1 mark for an answer that shows a correct interpretation of the information provided

Tip

- *When a question requires a comparison to be made, then both factors must be mentioned in the answer. A comparison must be made to receive the mark for this question. This type of question may include the word compare, but it is more likely to be implied rather than stated.*

Question 10f.

Sample answer

The low genetic diversity of the mtDNA hypervariable region in the modern population of koalas may not indicate recent inbreeding or founder events, but may instead reflect an older event that occurred to the population of koalas.

Mark allocation: 1 mark

- 1 mark for an answer showing that the low genetic diversity in the populations of modern koalas is not due to events that have occurred after the late 1700s and must have had an earlier cause

Tip

- *Sometimes it may be tempting to rewrite the information provided and present that as an answer. To be awarded a mark, additional information must be provided. For example, writing 'modern koala's have a low degree of diversity due to inbreeding, hunting and disease' as an answer is not adding any new information and would not be awarded a mark.*

Question 11a.

Sample answer

As new hominin fossils are discovered, our ideas regarding human evolution and ancestry also have to change to accommodate those new finds.

Mark allocation: 1 mark

- 1 mark for any answer that provides a valid discussion of the link between fossils and our understanding of human evolution

Question 11b.

Sample answer

The curved fingers demonstrate that the species were well adapted for climbing ability, as they would be needed to hold on to branches.

Mark allocation: 1 mark

- 1 mark for any answer that provides a correct interpretation of the information provided

Question 11c.

Sample answer

Ritualised behaviours directed towards the dead indicate a belief system and cognitive thought.

Mark allocation: 1 mark

- 1 mark for any answer that provides a correct interpretation of the information provided

Question 11d.

Sample answer

This is not completely correct. If *H. naledi* is considered to be a direct human ancestor then the species should be classified as a hominin, not a hominid.

Mark allocation: 1 mark

- 1 mark for any answer that indicates an understanding of the difference between hominins and hominids

SECTION B

Question 12a.

Sample answer

The donor cell had to be a somatic cell rather than a gamete because the cloned individual needed to be diploid, not haploid.

Mark allocation: 1 mark

- 1 mark for any answer that indicates that the individual needed to be diploid and that the genetic information was coming from a single parent

Question 12b.

Sample answer

The cloned frog would be genetically identical to frog 1 because the genetic material inserted into the empty egg came from a diploid cell taken from frog 1.

Mark allocation:

- 1 mark for an appropriate explanation that includes an identification of frog 1

Question 12c.

Sample answer

nuclear transfer cloning

Mark allocation: 1 mark

- 1 mark for the correct answer

Question 12d.

Sample answer

As cells age they become more specialised and the potency of the cells decreases (from totipotent to pluripotent to multipotent).

Note: At the time of this experiment it was concluded that genetic potential diminishes as cells differentiate, and that it is impossible to produce a clone from the nucleus of an adult cell. This is no longer accurate.

Mark allocation: 1 mark

- 1 mark for an answer that demonstrates the understanding that it is harder to produce a clone from a specialised cell than from an undifferentiated cell

SECTION B

Question 12e.

Sample answer

Cloning could be used for the following:

- to reliably reproduce animals genetically engineered to produce drugs
- to produce organisms with organs that can be transplanted into humans
- to produce clones of endangered or extinct animals
- to produce cells that could be used to treat degenerative diseases.

Mark allocation: 1 mark

- 1 mark for identifying one current or potential application of cloning

END OF SAMPLE ANSWERS