



Units 3 and 4 Biology

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Section A – Multiple-choice questions

Question 1

The correct answer is C. Enzymes are three dimensional tertiary proteins with globular structures.

Question 2

The correct answer is C. Diffusion, active transport and osmosis are the three processes involved in the mammalian kidney as waste products are filtered from the blood and urine is formed.

Question 3

The correct answer is D. Lysosomes are membrane bound organelles that contain enzymes involved in the destruction of cellular wastes and breakdown of unwanted molecules.

Question 4

The correct answer is A. Biological engineering is the synthesis of specifically shaped drugs to fit the active sites of enzymes, receptor proteins or regulatory proteins involved in curing or treating a particular disease.

Question 5

The correct answer is C.

Question 6

The correct answer is B. The high specific heat capacity of water means that heat energy is drawn from organisms onto water in their external environment such as sweat, or in their internal environment, such as water particles present in the lungs.

Question 7

The correct answer is A. At point X in the diagram, the amount of enzyme becomes the limiting factor and the amount of substrate added is irrelevant, and the graph levels off.

Question 8

The correct answer is C. The most powerful aspect of the study of the proteome is that it encompasses an understanding of the interactions between proteins, as proteins rarely function alone, but form part of biological pathways.

Question 9

The correct answer is C. If 31.5 per cent of a particular sample of DNA is thymine, it follows that 31.5 per cent is adenine according to base pairing rules. Thus, Cysteine and Guanine make up the remaining 37 per cent, and as they are present in equal proportions due to base pairing rules, 18.5 per cent of the DNA is cysteine.

Question 10

The correct answer is D. Steroid hormones are hydrophobic and are therefore able to diffuse across the plasma membrane to their receptors in the cytosol.

Question 11

The correct answer is A. Leaves with a large surface area means that more of the plant is subject to sunlight, and therefore it is not an effective mechanism for cooling in plants.

Question 12

The correct answer is B.

Question 13

The correct answer is C. This was a relatively easy question, and these should always be completed first in an exam to gain the maximum possible marks.

Question 14

The correct answer is A.

Question 15

The correct answer is A. Pain is our response to a strong stimulus.

Question 16

The correct answer is B.

Question 17

The correct answer is A. Fibrin, the protein involved in the binding or coagulation of blood cells in blood clotting is a secondary protein with a strong, symmetrical structure that works not unlike a spider web to bind together white blood cells and create a clot.

Question 18

The correct answer is B. The breaking down of large molecules to create smaller molecules (and thus, obtain energy through the energy stored in the bonds broken) is referred to as catabolic. Because a water molecule is used to split the molecule, the reaction can also be described as a hydrolysis reaction.

Question 19

The correct answer is C. Enzymes can withstand some temperature and pH fluctuations, it is only when they are beyond a certain range that the enzyme is denatured. NB: denaturing due to temperature fluctuations only occurs when the temperature becomes too hot.

Question 20

The correct answer is A. This question is very similar to question 18 of this exam. It is a necessary skill to be able to draw parallels between photosynthesis and cellular respiration. The Krebs cycle, which occurs in the enzyme rich mitochondrial matrix, can be thought of as the parallel process to the Calvin cycle in photosynthesis.

Question 21

The correct answer is A. Prokaryotic cells replicate by binary fission.

Question 22

The correct answer is C. Linked genes are written with such notation to indicate that they are not independent from one another

Question 23

The correct answer is B. The long way to solve this problem would be to write out a punnet square with 256 spaces to fill in. That would, however be ridiculous for a multiple choice question. Given the notation, the genes can be assumed to assort independently, so we can figure out the individual probability of each allelic combination and multiply them together. So, using monohybrid crosses, we know that the probability of the genotype pp is $\frac{1}{4}$, the genotype qq is $\frac{1}{2}$, the genotype rr is $\frac{1}{4}$, and the genotype ss is $\frac{1}{4}$. When these probabilities are multiplied, we get $\frac{1}{128}$.

Question 24

The correct answer is A. To determine the genotype of an individual displaying a dominant phenotype, a test cross (to a homozygous recessive individual) is performed, and the ratio of the progeny determines the genotype of the dominant phenotypic individual.

Question 25

The correct answer is A. The phenotypes of the offspring of the test cross are in a 1:1 ratio, which means the individual with the dominant phenotype was heterozygous at only one of the gene loci.

Question 26

The correct answer is B. Complete karyotyping would be most useful in the situation because the syndrome is caused by an extra chromosome, and the karyotype would indicate abnormal chromosome numbers.

Question 27

The correct answer is D. When there is an extra chromosome (or a missing chromosome, for that matter) it is a result of non disjunction in anaphase II of meiosis.

Question 28

The correct answer is D. Helicase is only used in DNA replication, not transcription. In DNA replication, DNA is created in the 5' to 3' direction

Question 29

The correct answer is A. The man will pass his X linked dominant allele to all of his daughters, meaning they will all have the trait, whilst he passes his unaffected Y chromosome onto all of his sons. The X chromosome the sons receive will be the unaffected chromosome with the recessive allele for the trait from the mother, and thus they will be unaffected.

Question 30

The correct answer is C. (definition)

Question 31

The correct answer is D. Asexual reproduction such as mitosis, budding and vegetative propagation produce genetically identical clones of the parent which do not introduce variation to the population. Thus they do not contribute to evolutionary change.

Question 32

The correct answer is B. When a population is in genetic equilibrium, allele frequencies remain constant. However, like in any equilibrium, 'constant' means that the frequencies will fluctuate around a constant level, not remain static. As we are considering a population of living organisms for the allele frequencies to be truly constant, all individuals in the population would have to be clones.

Question 33

The correct answer is A. Smaller fragments move further (note: further, not faster) through the gel, than larger fragments, thus they are sorted according to their mass. Whilst their negative charge does play a role in their movement through the gel, all DNA molecules are negatively charged, so charge is not a defining factor when sorting DNA samples in a gel electrophoresis setup.

Question 34

The correct answer is D. Each individual has a unique variation in his or her DNA sequence, and DNA sampling uses this to identify individuals. Whilst alleles for genes differ, we all have the same genes on our chromosomes, so C is wrong, and A and B refer to proteins, when the question specifically asked about *DNA* sampling.

Question 35

The correct answer is B. An observation of 3 phenotypes is characteristic of codominancy at one gene locus. The variation within these phenotypes suggests environmental influences also play a role.

Question 36

The correct answer is A. For such a large phenotypic variation, the only explanation is the influence of polygenes. Environmental factors most likely also play a role.

Question 37

The correct answer is C. When a small isolated subset of a larger population has a high incidence of a particular genetic trait, this is usually due to genetic drift (also called the founder effect) where the small population had, by chance, a higher proportion of alleles coding for the genetic trait than the rest of the population at the time of isolation.

Question 38

The correct answer is C. The other pieces of evidence do indicate that the fossil was of a primate, but do not distinguish it as a hominid from an ape, as these are features shared by all primates.

Question 39

The correct answer is C. An organism with a gene of another organism implanted into the DNA sequence of some or all of its genes is called a transgenic organism.

Question 40

The correct answer is D. All other structures indicate divergent evolution.

Section B – Short-answer questions

Marks allocated are indicated by a number in square brackets, for example, [1] indicates that the line is worth one mark.

Question 1a i

Abscisic acid [1]

Question 1a ii

In plants, hormones travel either directly between cells or in the phloem, whereas in animals hormones travel in the bloodstream. [1]

Question 1b

- Hormones are specifically shaped molecules that only have effect on certain cells with the specific receptor molecules for them. [1]
- This means that the cell that did not respond to the hormone didn't have the appropriate receptor molecule for that hormone, and the other cell did [1].

Question 1c i, ii and iii

Various responses are acceptable, see your teacher or tutor if unsure. However, in part ii, it must be noted that the hormone has its effect due to the molecular pathway that is signal transduction, where each molecule present (such as enzymes and regulatory proteins) activates the next to eventually achieve a response.

Question 2a

Threshold or threshold potential [1]

Question 2b

When there is no electrical impulse being transmitted in a neurone, the inside of the nerve cell has a negative charge in relation to the outside [1]. However, once an action potential is generated, the inside of the nerve cell momentarily becomes positively charged in relation to the outside, due to pumping of sodium and potassium ions against the concentration gradient (via active transport), which is how the electrical impulse is generated [1]. Once the action potential has passed the nerve cell again becomes negatively charged relative to the outside.

Question 2c

In a reflex arc neuron B [1] the interneuron would be missing, as the defining characteristic of a reflex arc is that it does not need to pass through the central nervous system as an innate response is in place [1]. However, it must be noted that the information of the stimulus and the response is still sent to the central nervous system, just after the reflex arc has occurred, and this allows the reflex arc to occur very rapidly.

Question 2d

- Stimulus – Internal temperature drops below the body's optimum range. [1]
- Receptors – Thermoreceptors on the skin [1] and then thermoreceptors in the hypothalamus of the brain [1] if enough of a response is not generated from the detection of the stimulus by thermoreceptors in the skin.

Question 2e

- When the electric potential comes to the synapse, the message is converted from electrical to chemical and neurotransmitters are released. [1]
- They travel via diffusion across the synaptic cleft to bind with specific receptor molecules on the dendrites of the post synaptic cells, which induces a new electric impulse. [1]

Question 3a i

- Cells involved in the specific immune response include the T_c cell, the memory cell and the plasma cell. [1 mark for one of these]
- The function of the cell needs to be a sentence such as: 'The memory cell (a B lymphocyte) stores information about the specific immune response needed to combat a particular pathogen that the organism has previously encountered, and is stored in the bone marrow.' [1]

Question 3a ii

- Cells involved in the non-specific immune response include the phagocyte, the neutrophil and the megakaryocyte. [1 for any of these]
- Explanation: The phagocyte engulfs and destroys unwanted materials and pathogens.

Question 3a iii

- T killer cell, or T helper cell [1]

Question 3b i

- An autoimmune disease is one in which the body detects 'self' cells as 'non-self' and destroys them. [1]

Question 3b ii

- Antibodies are present in the blood of a person with the autoimmune disease that bind to the antigens on the self-cell and cause a specific immune response. [1]

Question 3b iii

- The top two ends of the antigen should be circled. [1]

Question 3c i

- Active immunity is acquired through development of a specific response to a pathogen through exposure to that pathogen, whereas passive immunity is acquired through ingesting or being given the specific antibodies to a particular antigen from another organism that has formed them. [1]

Question 3c ii

- Passive, active, passive [1 each]

Question 4a

There are 64 possible combinations of nitrogenous bases coding for amino acids and only 20 amino acids [1].

Question 4b

RNA polymerase is an enzyme involved in transcription [1]. It catalyses the production of the messenger RNA strand. [1]

Question 4c

The process is called transcription [1]. RNA polymerase unzips the template strand of DNA from the coding strand [1] and complementary RNA nucleotides are added [1] to create messenger RNA, which undergoes post transcriptional modification and exits the nucleus via the nuclear pores.

Question 4d

The process is called translation [1]. Transfer RNA anticodons align with messenger RNA codons at the ribosome to align amino acids in a polypeptide sequence [1]. Peptide bonds form between these polypeptides until a STOP sequence is reached [1].

Question 4e

The codes represented in the table are for RNA [1]. The letter U (short for the nitrogenous base uracil, which only occurs in RNA, not DNA) is found in the table. [1]

Question 4f

Mutation A is a point mutation OR a substitution [1]

Mutation B is an addition or frameshift mutation [1]

Question 4g

An individual with mutation B. is more likely to suffer serious consequences [1], because the addition mutation shifts the whole sequence of amino acids after it, most likely changing every codon that follows with potentially disastrous effects including never reaching a stop codon or prematurely reaching one. [1]

Question 5a

The colour-blind man's mother must have given him a recessive allele on the X chromosome she donated. Thus if X^C indicates normal colour vision and X^c indicates colour blindness, the mother could have had the genotypes:

$X^C X^c$ or $X^c X^c$

[1] mark for determining allelic symbols, [1] mark for determining the two genotypes possible.

Question 5b

Parents	X^C	X^c
X^c	$X^C X^c$	$X^c X^c$
Y	$X^C Y$	$X^c Y$

Thus there is a $\frac{1}{4}$ probability that the child will be a colour-blind boy (genotype $X^c Y$)

[1] mark for the punnet square, [1] mark for explaining what this means for the probability that the child is a colour-blind boy.

Question 5c

$\frac{1}{2}$ [1]

Question 5d

$\frac{1}{2}$ [1]

Question 6a

This question is asking for an explanation of recombinant DNA technology.

DNA is cut from chromosomes using restriction enzymes, or it can be produced from mRNA using the enzyme reverse transcriptase. [1] The DNA is copied via the Polymerase Chain reaction to provide a large enough sample to work with, or it may be cloned in microbial cells. [1] DNA is added to a vector, bacteria, virus or other smaller particle which invades the organism. The aim is that that it becomes integrated into the DNA of the host. [1]

[1] mark for a suitable diagram, does not need to be detailed but basically needs to show the gene being 'cut and pasted' and inserted into a host cell.

Question 6b i

Many answers are suitable to gain the one mark. An example is amplifying a DNA fragment from a crime scene to obtain a quantity large enough for gel electrophoresis.

Question 6b ii

DNA is heated to 95 degrees Celsius, to denature the DNA by splitting the two strands [1]. DNA is allowed to cool slightly to allow primers to anneal to it, which promotes replication. [1] The enzyme Taq polymerase and free nucleotides are added. The enzyme extends the complementary strand beyond the primer. Two double stranded DNA molecules result. [1]

A suitable labelled diagram could also be used to gain the three marks.

Question 7a

The term bottleneck effect refers to the loss of genetic variability when a population size is severely reduced [1]. For example, consider a population of lions in the African savannah. If a large proportion of the population were killed, then, when the population got dangerously low and the risk of extinction was evident, a captive breeding program was initiated; the population numbers would rise again. However, much of the genetic variability would have been killed, and the new, captive population would have been propagated from a much smaller gene pool, resulting in a lower overall genetic variability in the population, known as a genetic bottle neck. [1]

Question 7b

Chimpanzees and humans diverged due to natural selection favouring the most fit for their respective environments. [1] For example, as early humans began to walk through savannah grasses, being upright became a selective advantage, as they could see across the grasses for potential predators or prey, and thus those with a more upright stature had more reproductive success, and the allele frequency of alleles coding for a more upright stance increased in the early human population. Similarly, as chimpanzees remained predominantly tree dwellers, an upright stance did not infer any selective advantage, so this was not a characteristic selected for. [1] As these different requirements of their respective environments caused different selecting pressures and different traits that were deemed 'fit', the allele frequencies of the two groups slowly diverged until speciation occurred, that is, two members of each group could not reproduce and create viable (able to reproduce) offspring. [1]

Question 7c

Convergent evolution is the development of analogous structures and physiological processes of two unrelated species due to similar selecting pressures, such as the wings developed by Australian sugar gliders and bats. [1]

Divergent evolution is the development of differing structures or physiological processes in two species from a common ancestor. An example are the homologous underlying bone structures of whales, humans, horses, bats and many other animals' forearms, indicating the presence of a common ancestor to all these species. [1]

Question 7d

Name any three of the following: [1] mark each, and give a brief outline of each: [1] mark each.

- Homologous structures
- Comparative embryology
- Analogous structures
- Vestigial structures
- Biogeography (plate tectonics)
- The fossil record (fossil dating)
- Radiometric dating
- If you are unfamiliar with any of the means for evidence of evolution mentioned above, ask your teacher or tutor for more information.