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Unit 4 Biology - Solutions

Practice Exam Solutions

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Section A – Multiple-Choice questions

Question 1

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

Question 2

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

Question 3

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 ¼, the genotype qq is ½, the genotype rr is ¼, and the genotype ss is ¼. When these probabilities are multiplied, we get 1/128.

Question 4

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 5

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 6

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 7

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 8

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 9

The correct answer is C. If 23% of the DNA is cytosine this means that 23% is also guanine. Thus, 46% of the DNA is cytosine and guanine, and 54% of the DNA is adenine and thymine. This means that, as proportions of adenine and thymine are equal, 27% of the DNA is adenine.

Question 10

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 11

The correct answer is C. (definition)

Question 12

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

Question 13

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 and for the allele frequencies to be truly constant, all individuals in the population would have to be clones

Question 14

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 15

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 16

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 influcences also play a role.

Question 17

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 18

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 19

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 20

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 21

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

Question 22

The correct answer is A. Whilst there are four amino acid differences in the DNA sequence, these could be due to more than 4 base differences due to the redundancy in the genetic code.

Question 23

The correct answer is B. Recombination (or crossing over) occurs during prophase I of meiosis, where homologous chromosomes line up next to each other and overlap, causing a chiasma to occur, thus resulting in recombination.

Question 24

The correct answer is B. Usually in a cross between two heterozygotes, the chance that the progeny are also heterozygotic is ½. However, as this allele is lethal when recessive homozygous, we can eliminate the chance of that genotype from our punnet square, leaving us with three genotypes possible, two of which are heterozygotes.

Question 25

The correct answer is C. Meiosis is an example of sexual reproduction, whereas all other examples given were of asexual reproduction.

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. It must be noted that many of these answers do not provide the only possible acceptable wording to obtain full marks, and if you are unsure as to whether or not your answer has obtained full marks, you are advised to ask your teacher or tutor.

Question 1a

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^CX^c or X^cX^c

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

Question 1b

Parents	X^C	X^c
X^c	X^CX^c	X^cX^c
Y	X^CY	X^cY

Thus there is a ¼ probability that the child will be a colourblind boy (genotype X^cY)
[1] mark for the punnet square, [1] mark for explaining what this means for the probability that the child is a colourblind boy.

Question 1c

½ [1]

Question 1d

½ [1]

Total : 6 marks

Question 2a
The term redundant means that more than one codon can code for the same amino acid. [1]

Question 2b

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

Question 2c

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 2d

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

Mutation B is an addition or frameshift mutation [1]

Question 2e

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]

Total: 9 marks

Question 3a

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 3b

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 3c

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 3d

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.

Total: 13 marks

Question 4a

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 4bi

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 4bii

DNA is heated to 95 degrees Celsius, to split the two stands. DNA is allowed to cool slightly to allow primers to anneal to it, which promote 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 two marks.

Total: 7 marks

Question 5a

Non spotted [1]

Question 5b

Ss [1]

Question 5c

S and s [1]

Question 5d

	S	s
S	SS	Ss
S	Ss	ss

[1]

Question 5e

¼ [1]

Question 5f

½ [1]

Question 5g

He will do a test cross between the mouse and a homozygous recessive individual. [1]]

Question 5h

This hypothesis is more detailed than required for clarification.

Spot colours show codominance, meaning that the black and brown spotted individuals are heterozygous for spot colour. However, no matter what the spot colour genes, individuals who are non-spotted will not show any spot phenotypes. This has one gene blocking the expression of another, which shows co dominance. [1] Let the allele Bl code for black spots, and the allele Br code for Brown spots, in the following punnet square, which has phenotypes added to clarify the above explanation:

	SBl	SBr	sBl	sBr
SBl	SSBlBl non-spotted	SSBrBl non-spotted	SsBlBl non spotted	SsBlBr non-spotted
SBr	SSBlBr non-spotted	SSBrBr non-spotted	SsBlBr non-spotted	SsBrBr non-spotted
sBl	SsBlBl non-spotted	SsBlBr non-spotted	ssBlBl – black spotted	ssBlBr – Black and brown spotted
sBr	SsBlBr non-spotted	SsBrBr non-spotted	ssBlBr – brown spotted	ssBrBr – Brown spotted

[1]

Question 5i

Phenotype	
Non-spotted	SSBrBr, SSBrBl, SSBlBl, SsBrBr, SsBrBl, SsBlBl
Brown-spotted	ssBrBr
Brown and Black-spotted	ssBlBr
Black-spotted	ssBlBl

[1/2] mark for each genotype in first box (you only gain the mark if two are right however, as per VCAA regulations) and [1] mark for all other genotypes. [6]

Total: 15 marks