BIOLOGY

Unit 4 – Written examination 2

2009 Trial Examination

SOLUTIONS

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

Question 1

Answer: B

Explanation:
A is wrong because chromatids are single armed chromosomes. C is wrong because amino acids are the sub units of polypeptides and D is wrong, because although chromosomes contain DNA, nucleotides do not contain histone proteins.

Question 2

Answer: D

Explanation:
The correct order of events is helicase breaks the hydrogen bonds, DNA polymerase produces daughter strands of DNA, Okazaki fragments are spliced together by DNA ligase and hydrogen bonds reform between the daughter strands.

Question 3

Answer: B

Explanation:
A is incorrect because the initial product contains introns and exons, the introns are removed, the exons are spliced together and the RNA is modified with a poly A tail and a methylated cap before it can be referred to as mRNA. Neither transfer RNA or ribosomal RNA are products of transcription.

Question 4

Answer: C

Explanation:
The number of nitrogenous bases, phosphate groups and sugar molecules are equal. The number of guanine bases equals the number of cytosine bases, and, although uracil can be complementary to adenine, it is only present in RNA, not DNA.

Question 5

Answer: D

Explanation:
In this example the origin is arbitrary; it is not a recognition point for the enzyme. The 3 fragments will be 1000 base pairs produced by cuts at 500bp and 1500bp, 900 base pairs produced by cuts at 1500bp and 2400bp and 1100base pairs produced by cuts at 2400bp and 500bp.

Question 6

Answer: C

Explanation:
Transcription is the process of using DNA as a template to make mRNA, so reverse transcriptase is an enzyme that is used to produce DNA from an RNA template.

Question 7

Answer: A

Explanation:
A gene probe is a short single strand of DNA that is complementary to a desired sequence. Electrophoresis is a separation technique, karyotyping is the process of obtaining an image of the complement of chromosomes in a cell and DNA sequencing is a process where the sequence of nucleotides in DNA is determined.

Question 8

Answer: B

Explanation:
The diagram shows a replicated chromosome consisting of 2 chromatids. Each chromatid is made up of a molecule of DNA so therefore there are 2 molecules of DNA present.

Question 9

Answer: B

Explanation:
A is correct as a bivalent chromosome is the structure formed after synapsis of a pair of homologous chromosomes up to the beginning of anaphase during meiosis I. Statement C is correct as the output of meiosis is a haploid gamete. Statement D is correct as cytokinesis is an essential last stage in the process of producing daughter cells. Statement B is wrong because the centromere splits during the second meiotic division, not the first.

Question 10

Answer: A

Explanation:
Since there are 3 different phenotypes this can only be an example of incomplete dominance or co dominance. The short tail phenotype is displayed by the heterozygous individual. Since this phenotype lies between the long tail phenotype and the no tail phenotype this must be an example of incomplete dominance, rather than codominance.

Question 11

Answer: C

Explanation:
Given that this is an example of incomplete dominance only options B and C show appropriate notation. The short tailed phenotype must be heterozygous because a cross between these 2 individuals produces kittens with 3 different phenotypes. Only option C shows both individuals being heterozygous.

Question 12

Answer: A

Explanation:
In a dihybrid test cross, one parent is heterozygous for both traits and the other is homozygous recessive for both traits, therefore the genotypes of the parents is BbCc and bbcc.

	BC	Bc	bC	bc
bc	BbCc	Bbcc	bbCc	bbcc

In thee offspring BbCc will be black with coarse fur. Bbcc will be black with smooth fur, bbCc will be white with coarse fur, bbcc will be white with smooth fur.
Therefore the theoretical phenotypic ratio is 1:1:1:1.

Question 13

Answer: D

Explanation:
In the previous question it was established that the expected phenotypic ratio is 1:1:1:1, but this will only occur if the genes are on different chromosomes and therefore they will be independently assorted. The results were not the expected 1:1:1:1, instead there were higher than expected offspring with the parental phenotypes and lower than expected offspring with the recombinant phenotypes. This divergence from the expected result can only have occurred if crossing over occurred, meaning that the genes must be on the same chromosome and are therefore linked.

Question 14

Answer: B

Explanation:
The stem of the question indicates that height is governed by the expression of a series of genes at multiple loci. There is insufficient information to determine if these genes are linked or not. This is very clearly an example of polygenic inheritance (by definition inheritance governed by the expression of multiple genes) and the range of phenotypes caused by polygenic inheritance is continuous rather than discontinuous.

Question 15

Answer: D

Explanation:
The mode of inheritance has to be recessive as individuals I-1 and I-2 are both unaffected while 2 of their children are affected. It must also be autosomal as individual II-4 is affected, and if this were an X linked trait all of her sons would be affected, since in X linked recessive inheritance males only need 1 copy of the allele. As individual III-2 is unaffected this trait cannot be X linked, so must be autosomal.

Question 16

Answer: A

Explanation:
The mode of inheritance has been shown to be autosomal recessive; therefore an affected individual has to be homozygous for the recessive trait. A is correct as although they are unaffected, they have an affected child and therefore must be heterozygous. B is incorrect for the same reason that A is correct. C is incorrect as this individual has the condition and therefore is homozygous, not heterozygous. D is incorrect as individual II -3 could be heterozygous.

Question 17

Answer: B

Explanation:
The founder effect involves a small unrepresentative sample of a large population leaving and establishing a new population, this has not happened in this case. Genetic drift is a change in allele frequencies caused by a chance event, which also has not occurred here. This is a classic example of a bottleneck; where the population is dramatically reduced and slowly rebuilds with the new population having a different allele frequency to the original population.

Question 18

Answer: A

Explanation:
In cases such as this where there is a dramatic loss in population there is also a loss in genetic diversity of the remaining population and their descendents. This means that there would be a lack of variation. Although it is possible that all modern bison are descended from 1 bull, there is insufficient information to determine this, and since 750 survived, it is unlikely there was only 1 bull amongst them. Population bottlenecks can lead to inbreeding and health issues, but this is not determined by analysing DNA samples.

Question 19

Answer: B

Explanation:
Since there are no snails with cream or light brown shells, they have been selected against and the phenotype is shifting in one direction.

Question 20

Answer: D

Explanation:
The eye structure of both organisms is similar, but since one organism is a mammal and the other is a mollusc they do not share a recent common ancestor. Both structures fulfil the same purpose but have a different evolutionary origin therefore they are analogous structures.

Question 21

Answer: C

Explanation:
Similarity in nucleotide sequence and protein function indicates these species must have a similar evolutionary background. Their DNA will not be identical because it is uncommon for even individuals of the same species to have identical DNA. Different species do not evolve into the same species although they may have some similarities usually caused by exposure to similar environmental conditions.

Question 22

Answer: C

Explanation:
A is incorrect, as although mtDNA mutates at a known rate it does not recombine as the mitochondria in sperm are located in the tail. The amount of each type of DNA is irrelevant to establishing evolutionary relationships and sperm contains large numbers of mitochondria in order to produce the energy required to swim, so mtDNA is not only present in female gametes.

Question 23

Answer: B

Explanation:
Selection pressures are factors that influence the survival of a species and include competition for limited resources. In this case there would be competition for mates. The males with the brighter bills are generally healthier so the chicks produced should also be healthier.

Question 24

Answer: A

Explanation:
Unless there have been some disturbances the fossils in the top layer will always have been formed later than those in deeper layers. Without further information no inferences can be made about the relationships between fossils of organisms in different layers or the relative complexity of these organisms.

Question 25

Answer: C

Explanation:
The features of skeleton 1 are all associated with bipedal individuals such as modern humans. The features of skeleton 2 are those of a gorilla.

If the foreman magnum is central it indicates the organism is bipedal.

SECTION B: Short-answer questions

Question 1

a. Product 1 is the primary transcript or pre mRNA. Product 2 is mRNA

1 mark

Note: both products must be correctly identified in order to obtain this mark.
AND
Product 1 is longer than product 2 because it contains both introns and exons, whereas the introns have been removed and the exons spliced together to form product 2.

1 mark

b. RNA ligase
Note: it is essential to specify RNA ligase as DNA ligase has the role of annealing Okazaki fragments during DNA replication.

1 mark

c. Protein synthesis is an endergonic (requires energy) process. Producing proteins only when they are required is a means of conserving energy.

1 mark

d. AUG AAC GGU CGA CUG UCA.

1 mark

e. A point mutation
OR
A base substitution mutation
Note: this type of mutation should always be identified as a point or substitution mutation, although students will know of missense, nonsense and silent mutations these should not be presented as a complete answer.

1 mark

AND
The original codon codes for Arg and the altered codon codes for a stop codon

1 mark

AND
As a result a truncated (shortened) protein will be produced.

1 mark

f. The genetic code is **universal**. A codon will always code for the same amino acid.

1 mark

g. Both are capable of providing an individual with the ability to make proteins they were previously unable to make.

1 mark

AND

In gene therapy the vector used to insert the DNA is an adenovirus, a liposome, a retrovirus or naked DNA. In gene splicing the plasmid is the vector that is used to insert the desired gene into the bacterial cell.

1 mark

Total 11 marks

Question 2

a. Homologous X chromosomes fail to separate properly in anaphase I
OR
Sister X chromatids fail to separate during meiosis II
OR
Non disjunction during meiosis I or meiosis II

1 mark

AND

As a result a gamete is produced with an abnormal number of chromosomes. If an abnormal gamete combines with a normal gamete during fertilisation it will result in an individual with an abnormal chromosome number.

1 mark

b. Aneuploid
Note: Polyploid would not be correct as this refers to copies of whole sets of chromosomes, rather than of individual chromosomes.

1 mark

Total 3 marks

Question 3

a. Let C^B = chestnut brown and C^W = cremello
Note that this is an example of incomplete dominance so symbols such as B and b or B and W would not be appropriate.

1 mark

b. Incomplete dominance OR Intermediate inheritance

1 mark

c.

Parents phenotypes	Palomino x Palomino
Parents genotypes	$C^B C^W$ x $C^B C^W$
Gametes	C^B, C^W x C^B, C^W

1 mark

AND

	C^B	C^W
C^B	$C^B I^B$	$C^B C^W$
C^W	$C^B C^W$	$C^W C^W$

1 mark

Note: consequential marking may be required here. If students did not identify appropriate symbols in part a, they may obtain full marks, if they utilise correct reasoning and use their symbols appropriately.

AND

Genotypic ratio: 1 C^BC^B : 2 C^BC^W: 1 C^WC^W
Phenotypic ratio: 1 Chestnut: 2 Palomino: 1 White
Note: It is essential to identify each of the ratios in order to obtain this mark.

1 mark

d. The stallion is palomino.

1 mark

AND

	C^B	C^B
C^B	C^BC^B	C^BC^B
C^W	C^BC^W	C^BC^W

1 mark
Total 7 marks

Question 4

a. If the condition is X linked dominant then all daughters of an affected male must also be affected.

1 mark

AND
Individual I-2 is an affected male, however, one of his daughters, individual II-3 is unaffected, therefore the mode of inheritance cannot be X linked dominant.

1 mark

b. Individual II-4 must be heterozygous as she is unaffected, but has an affected father.

	X^D	Y
X^D	X^DX^D	X^DY
X^d	X^DX^d	X^dY

1 mark

She has reason for concern and there is a 25% chance she will have an affected child.
OR
She has reason for concern as her sons have a 50% chance of being affected.

1 mark
Total 4 marks

Question 5

a. It is necessary as DNA has a negative charge and DNA fragments will be attracted towards the positive end of the gel allowing separation of fragments.
Note: it is insufficient to limit an answer to the fact that DNA has a negative charge, as this is a statement, not an explanation.

1 mark

b. The 10kb fragment is at the top of the gel (closest to the negative terminal) and the 1 kb fragment is at the bottom of the gel (closest to the positive terminal).

1 mark

c. The DNA fragment containing the gene annealed to the plasmid is 9kb.

1 mark

AND
Therefore the gene + plasmid fragment is in lane 4.

1 mark

d. Insert a gene for antimicrobial resistance into the recombinant plasmid at the same time as the desired gene.

1 mark

AND
Grow all of the bacteria exposed to the plasmid on agar containing the antibiotic. Only those bacteria which have taken up the plasmid will have the resistance gene that enables them to grow in the presence of the antibiotic.

1 mark

e. Any reasonable answer in the fields of forensic science, molecular biology, genetics, microbiology and biochemistry.
Note: it is not acceptable for a student to limit their answer to separating DNA or other substances as this information is provided and the question clearly states identify another example.

1 mark
Total 7 marks

Question 6

a. Initially some of the insect population is sensitive to the pesticide while others are resistant. This is not important until a selection pressure, the use of the pesticide occurs.

1 mark

AND
The insects that are resistant are more biologically fit than those that are sensitive and these are more likely to survive and reproduce.

1 mark

AND
Subsequent generations will resemble those that survive and the incidence of the resistant phenotype will increase, with the percentage of insects being affected decreasing from 90% to 20% over a period of 10 years. *Note it is essential to refer directly to the data provided.*

1 mark

b. The term selection implies there are traits to be selected for or against. If all individuals are genetically identical then all would be equally sensitive or resistant.

1 mark

c. Any 2 of the following
- Crossing over during meiosis
- Mutations to germ line cells
- Independent assortment of chromosomes
- The combination of parents. In a varied population different parents may have different allele combinations.
- Any other reasonable suggestion

1 mark

d. In natural selection environmental factors impact on the phenotypes of the individuals, with some being more biologically fit than others.

AND
In artificial selection, humans select organisms with the trait that they see as desirable.

1 mark
Total 6 marks

Question 7

a. The multiregional hypothesis.

1 mark

AND
Homo erectus, Neanderthals, Homo sapiens and other humans were a single species. This species arose in Africa two million years ago as Homo erectus and then spread out over the world, developing adaptations to regional conditions but with gene flow still occurring between populations.

1 mark

OR
The replacement hypothesis (also called the out of Africa hypothesis).

1 mark

AND
Homo sapiens is a separate species, which evolved in Africa and then migrated out of Africa replacing any other populations they came into contact with. 1 mark

b. If a species evolves from a pre-existing species then you would expect to find transitional forms with aspects of both.

1 mark

AND

Therefore the existence of transitional form fossils can be used to show how one species of organisms has evolved into another.

1 mark

c. Cultural evolution

1 mark

d. One of the following reasons:
- Remains are rapidly covered by silt
- Remains are undisturbed by weather
- Remains are undisturbed by scavengers

1 mark

e. One of the following
- Radiocarbon dating
- Radio isotopic dating measuring decay of U-235 to Th-230 or U-238 to U-234
- Electron spin resonance
- Any other reasonable suggestion

1 mark

f. Homo sapiens and Neanderthals co-existed for thousands of years.
OR
Homo sapiens are not descended from Neanderthals.

1 mark

g. Homologous features

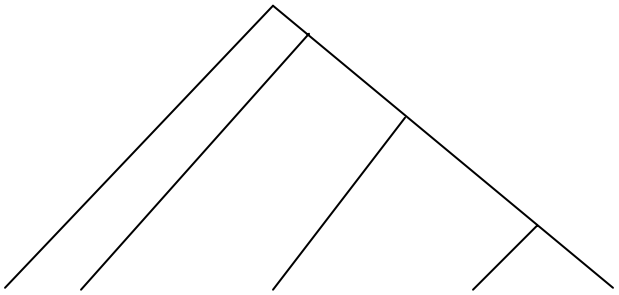
1 mark

AND

The information shows that Homo sapiens and Homo neanderthalensis are both descended from Homo heidelbergensis, so this is an example of divergent evolution where organisms share a recent common ancestor and have homologous features.

1 mark

h. The cladogram should look like this



From left to right the labels should read Squirrel Monkey, Rhesus Monkey, Gibbon, Gorilla, and Chimpanzee.

1 mark

Any one of the following:

- Chimpanzees are the most closely related to humans
- Gorillas and chimpanzees are more closely related to humans than monkeys
- Any other reasonable answer

1 mark

Total 12 marks