Neap:

Trial Examination 2012

VCE Biology Unit 4

Written Examination

Suggested Solutions

SECTION A: MULTIPLE-CHOICE QUESTIONS

1	A	B	**C**	D
2	**A**	B	C	D
3	A	B	C	**D**
4	A	B	C	**D**
5	A	B	**C**	D
6	A	B	**C**	D
7	**A**	B	C	D
8	A	B	C	**D**
9	A	B	**C**	D
10	A	B	C	**D**
11	A	B	**C**	D
12	A	**B**	C	D

13	A	**B**	C	D
14	A	B	**C**	D
15	**A**	B	C	D
16	A	**B**	C	D
17	A	**B**	C	D
18	**A**	B	C	D
19	A	B	C	**D**
20	**A**	B	C	D
21	A	B	**C**	D
22	A	**B**	C	D
23	A	B	**C**	D
24	A	B	**C**	D
25	A	B	C	**D**

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Question 1 C

The G1 phase of cell division is a functional stage where the cell is performing the role it was programmed to do. Depending on a variety of factors this cell may remain in this phase indefinitely. In a human somatic (body) cell during this time there are 46 strands of DNA.

Question 2 A

The primary mRNA transcript contains introns that need to be removed, leaving only exons. On top of this, 5′-capping is needed, which allows the mRNA to attach to the ribosome. A 3′-poly(A) tail also needs to be added so the RNA is able to be detached from the ribosome.

Question 3 D

The diagram relates to gene expression. Option **B** therefore merely re-states the question. Option **A** is factually incorrect. The diagram does not relate to the regulation of genes (i.e. how genes are 'switched on and off') so Option **C** is not relevant. What is not illustrated in the diagram is how introns and exons are involved in gene expression.

Question 4 D

The deletion of a single nucleotide is a frameshift mutation where every codon after the mutation will be altered. This means every codon after the deletion will be different, which could leave:

1. a shorter protein due to a 'stop' codon being earlier than its original location.
2. a longer protein due to a 'stop' codon being later than its original location.
3. a different sequence of amino acids.

Question 5 C

B is incorrect because Down's syndrome is not sex-linked. Down's syndrome is caused by the inheritance of additional chromosome 21 genes and the translation of these genes into an excess of their products. The correct synthesis of these gene products is unlikely if all the genes are arranged in reverse order, so **A** is wrong. For a condition to run in a family, the genetic defect giving rise to it must be heritable from generation to generation. So for Down's syndrome to pass down through the generations, this additional material must be attached to a chromosome capable of behaving normally during meiosis. **D** is incorrect because the maternal age effect explains the increased frequency of non-disjunction, not the familial inheritance of the syndrome.

Question 6 C

The couple has a 50% chance of conceiving a son. The Y chromosome is inherited from the father and since the mother is heterozygous there are two possible genotypes for their sons. One would be X^NY (AID sufferer) and the other would be X^NY (normal).

Question 7 A

The key here is to look at I–2. She must be homozygous as there is no prior history of the disease in the family. If the normal phenotype was dominant, all of the generation 2 children would be normal as well. This means that the disorder is dominant. Individual II–6 would have to express the trait if the trait was sex-linked dominant and so this can also be eliminated.

Question 8 D

III-8's father (II-7) is unaffected and homozygous recessive (**hh**) and her mother (II-8) is heterozygous and affected (**Hh**) due to her having both an affected and unaffected parent.

A Punnet square would show a 50% chance of III-8 being heterozygous and a 50% chance of her being homozygous (see below), but as **Hh** is the only 'affected' genotype possible in this scenario, the counsellor would tell her that she has a 100% chance of being heterozygous.

	H	**h**
h	**Hh**	**hh**
h	**Hh**	**hh**

Question 9 C

The DNA moves through the gel from largest to smallest. This means the pattern of fragment size was 15, 12, 10, 8 and 5 moving down the gel. According to this information:

- Nancy would have a genotype of 15 and 10.
- Naomi would have a genotype of 12 and 10.
- Norman would have a genotype of 8 and 5.
- Neville would have a genotype of 12 and 12.

Question 10 D

Neville produces one band only, while the others produce two. Each individual has two loci for each gene. In Neville's case, the number of repeats he possesses at each locus is the same (12 repeats), making him homozygous. The others are heterozygous.

Question 11 C

Each individual inherits one copy of each autosomal allele from each parent. The region is autosomal as it is located on chromosome 6. Norman could not be Naomi's father because she has no bands in common with him. Nancy could be the mother as one of her bands is in common with Naomi. Neville has a common band with Naomi, making him the probable father. In the context of the question, Nancy and Neville are equally genetically similar to Naomi because they both have one fragment in common with her.

Question 12 B

Gene therapy is a technology aiming to insert specific forms of genes into particular cell types. Many textbooks incorrectly suggest the faulty allele is being replaced; however, a more accurate term would be overridden. Once the allele is introduced into the cell the gene is expressed and the subsequent protein produced enables the cell to function normally. Faulty genes are not individually removed from cells, repaired and replaced.

Question 13 B

A bacterial plasmid is a convenient vector into which a particular gene (or genes) can be inserted using restriction enzymes and ligase enzymes. Once this task is completed, the recombinant plasmid is inserted into a bacterium so the gene can be expressed into the required protein.

Question 14 C

After 100 generations there are more individuals that have the genotype rr and fewer individuals who express the dominant phenotype (**Rr**, **RR**). This means there has been an increase in allele r within the population because it was favoured by the selective advantage offered by the red phenotype. The data contains no information on population size, but it is clear that only two alleles control fur colour and that no new fur colour mutations are occurring.

Question 15 A

Selective pressure has been placed on the smaller stick insects by Boyd's forest dragon. This means that over time the longer stick insects are more likely to survive to reproductive age and pass their larger alleles onto the next generation. This also means an increase in the average length of the stick insects over time. However, the selective pressure on Boyd's forest dragon is much less intense because stick insects are but one small part of their varied diet.

Question 16 B

In an outcrop, lower rock layers were laid down earlier than higher rock layers. This is the basis of relative dating. The age of the rock layers increases in the order X3, X2 = Z3, X1 = Z2, Y2 = Z1, Y1, so options **A**, **C** and **D** are all incorrect. Rock layers X1 and X2 contain a type of fossil missing from outcrops Y and Z, which could very well mean this organism never lived in localities Y and Z.

Question 17 B

The half life of an isotope is defined as how long it takes for one half of the given mass of a particular isotope to decay. In this case, it has taken 15 000 years for this isotope to decay from 100 grams to 50 grams.

Question 18 A

Structural homology could be defined as 'the same anatomical structure modified by evolution/natural selection for different functions in different organisms'. For example, structures as different as a bat's wing, a seal's flipper, a cat's paw and a human hand have a common underlying structure of bones and muscles. Homologous structures are due to sharing a common ancestor and as a result of divergent evolution; the structure is also seen in the modern day descendants.

Question 19 D

The more closely related two animals are, the greater the similarity in their genetic codes, and consequently the greater the similarity in the amino acid sequences of their proteins. The monkey (II) is most closely related to the human and hence has the least difference in cytochrome c, while the fish (I) has the amino acid sequence most dissimilar to a human's.

Question 20 A

All the birds, whatever their colour, are Antarctic skuas. No new species has evolved, so **B** is wrong. Genetically speaking, populations are likely to evolve if new alleles emerge (mutation) and individuals can immigrate and emigrate freely, so **D** is unlikely to be correct in this scenario. A population of 100 individuals is probably large enough to resist the effects of genetic drift (random but significant changes to allele frequencies), but **C** is still a poor choice because there is no suggestion that any allele combination of the colour gene is deleterious (harmful).

Question 21 C

The genotype of a white skua is **mm**. No alleles for dark coloration (**M**) are present in the population, so the frequency of the **m** allele is 100% ($q = 1.00$).

Question 22 B

Although the white colour is ultimately due to a mutation, the new population consists solely of white individuals because the ancestors from which the population has descended were all white. There is no information concerning any selective pressure or selective advantage in relation to the birds' colour, and no new species has formed, so **A** and **D** are incorrect.

Question 23 C

The first evidence of the use of fire is the evidence associated with *Homo erectus* fossils. The earliest definitive evidence of human control of fire was found at Swartkrans, South Africa. Several burnt bones were found among bone tools, and bones with hominid-inflicted cut marks. The Cave of Hearths in South Africa has burnt deposits dated from 200 000 to 700 000 BC. This predates *H.sapiens* and post dates *H.habilis* as well as *A.afarensis.*

Question 24 C

The 'Out of Africa' hypothesis claims that *Homo sapiens* appeared in Africa and then migrated elsewhere. If this is the case then one would expect more variation in the mtDNA of Africans when compared to any other group. Mitochondrial DNA mutates at a constant rate and so a group which is together for longer would be expected to show more differences. The line of migration from Africa would be

Africa...Middle East...North Europe/India...East Asia...America

This would mean the American mtDNA should be more homogeneous but the Middle Eastern mtDNA would be most similar to the African mtDNA, as the migrating humans would have to pass through there first.

Question 25 D

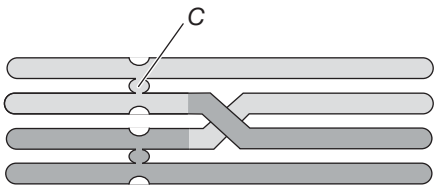
Classification is a constantly changing science. The Neanderthal coexisted with humans until quite recently. So, the Neanderthal fits along the evolutionary line leading to humans and the chimpanzee fits along a different evolutionary line. Hominins include humans and all their bipedal ancestors. (The chimpanzees fit into tribe Panina.) Hominids include the hominins as well as chimpanzees, gorillas and orang-utans. Hominoids include gibbons as well as hominids. Anthropoids refer to monkeys as well as hominoids.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. The shuffling of (maternal and paternal) chromosomes/random alignment of chromosomes/bivalents produces new/different combinations of alleles. 1 mark

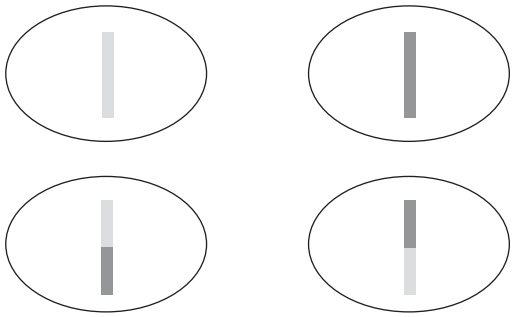
b. **i.**



1 mark

ii. Homologous chromosomes are identical in size, shape, centromere position, gene loci and banding pattern. 1 mark

c.



2 marks
1 mark for each two correct nuclei

Question 2

a. **i.** 8 1 mark

ii. Males have an XY and females have an XX. 1 mark

Males provide a Y chromosome 50% of the time in gametes and an X the other 50% of the time. This explains why half the population would be male (XY). 1 mark

b. **i.** All crosses 1 mark

ii. 50% 1 mark

	$\mathbf{X^w}$	**Y**
$\mathbf{X^W}$	X^W	X^WY
$\mathbf{X^w}$	X^WX^w	X^wY

c. If independent, the expected phenotypic ratio would be 1:1:1:1. 1 mark

If linked, the ratio would either be 1:1 or the presence of recombinants would give four phenotypes, but in a high low low high ratio. 1 mark

Question 3

a. 1089, because a triplet of bases codes for each amino acid $(363 \times 3 = 1089)$. 1 mark

Note: The triplet coding for methionine must be excluded in this instance. It is not permissible to include a STOP triplet, since this does not code for an amino acid.

b. *Any one of:*

- high energy radiation
- X-rays
- ultraviolet light
- ionising radiation
- gamma rays
- alpha particles
- beta particles
- (named) chemical mutagens e.g. benzene
- caffeine
- pesticide
- mustard gas
- tobacco tar
- free radicals

1 mark

c. Only mutations or genetic modifications occurring in germ cells (sperm or egg cells) can be inherited by the next generation. 1 mark

In this example of gene therapy, only the targeted somatic (body) cells are genetically modified. 1 mark

d. Viruses bind specifically to target cells and introduce their own DNA into them, thereby introducing the modified gene into the affected white blood cells that require it. 1 mark

e. A mutation involving a deletion causes frame shift/alters the entire base sequence ('downstream' from deletion), thereby changing the sequence of amino acids ('downstream' from deletion) encoded by the DNA. 1 mark

Substitution alters one triplet/codon only, so only one amino acid is altered. (Since the genetic code is degenerate, this may have no effect on the encoded amino acid). 1 mark

Question 4

a. **i.** phenotype = genotype + environment 1 mark

Note: It is not good enough for students to say the expressed characteristic.

ii. *One of:*

- large sample of twins (non-identical and identical) and non-twins for rapid comparison
- large spread of age, gender, location and general health so no bias
- accurate testing for ASD for quantification

1 mark

b. **i.** 46% 1 mark

ii. 38% is genetic 1 mark

environmental factor other than diet may be the reason 1 mark

c. **i.** on chromosome 6 1 mark

ii. Crossing over between the coeliac gene and the autism gene, forming recombinants that carry only one of the alleles rather than both. 1 mark

d. Advantage: Early warning signs could result in modification of diet as a precaution. 1 mark

AND

Disadvantage: One may not carry allele for ADS, yet could be diagnosed as a sufferer due to the positive testing for coeliac disease. 1 mark

Question 5

a. **i.** continuous variation 1 mark

ii. The median/modal/average/mean height of Marquis plants is shorter/smaller than for Red Fife plants *(or converse statement).* 1 mark

The range of heights is smaller for Marquis than Red Fife (only 4 height classes versus 9 for Red Fife) *(or converse statement).* 1 mark

iii. Marquis is easier to harvest OR less stalk is collected by the combine/harvesting machine OR none of the grain is missed during harvesting. 1 mark

b. Grow a large number of Marquis wheat plants (minimum 50) in a greenhouse. Infect them with the fungus, collect the survivors and cross-pollinate them/allow them to reproduce. 1 mark

Plant the seeds and grow them in a new greenhouse to produce a second generation of plants. Infect them with the fungus. Collect the survivors and cross-pollinate them/allow them to reproduce. 1 mark

Repeat the process over many generations until all individuals show resistance/breed true for resistance to the black rust fungus. 1 mark

Question 6

a. the permanent disappearance (of every individual member) of a species 1 mark

b. hunting by humans OR competition from introduced species OR loss of habitat due to forest clearance 1 mark

c. **i.** Primers enable replication/sequencing to start from a short length of double-stranded DNA necessary for DNA polymerase to bind to OR primers allow the formation of a replication fork at which DNA polymerase can add new nucleotides OR primers define the start and end of the length of DNA selected for replication. 1 mark

ii. *Taq* polymerase catalyses the joining together of nucleotides in the new (daughter) strand while resisting denaturation by the high temperatures reached during the PCR process. 1 mark

d. **i.** The fragments have different lengths/sizes/mass and the smallest fragments move furthest through the gel. 1 mark

ii. A possible structure of the double-stranded DNA molecule would look like this. (5′ and 3′ ends can be opposite to those shown).

3′ GCCATGTCCATGGCA 5′ **complementary strand**

5′ CGGTACAGGTACCGT 3′ **template strand**

OR

5′ GCCATGTCCATGGCA 3′ **complementary strand**

3′ CGGTACAGGTACCGT 5′ **template strand**

2 marks

1 mark for correct sequences

1 mark for correct identification of complementary and template strands

Question 7

a. **i.** koala and wombat 1 mark

ii. 60 million years ago 1 mark

iii. compare the mitochondrial DNA from each group of marsupials 1 mark

As this DNA mutates at a predicted rate and all the marsupials have an original common ancestor, a date of divergence of each group could be estimated. 1 mark

b. Disagree. They are all marsupials and so would have evolved from a common ancestor and diverged. 1 mark

The continents would have separated after marsupials evolved in Gondwanaland. 1 mark

c. The death of the dinosaurs made more niches available. 1 mark

Greater diversity of available environments for natural selection and evolution, which leads to more types of marsupial. 1 mark