Neap:

Trial Examination 2009

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 B

As this trait is X-linked dominant, the only heterozygous individuals could be affected women. There are only two affected women on the pedigree. Individual I-2 is heterozygous and has passed an X chromosome with the faulty allele to the affected son and an X chromosome with the normal allele to the unaffected son. Individual II-4 is also heterozygous and has passed an X chromosome with the faulty allele to III-1 and an X chromosome with the normal allele to III-2.

Question 2 C

As the father is unaffected he has a genotype of XY. The mother is affected and is heterozygous X^HX. The punnet square in this situation shows the mother has a 50% chance of passing her faulty X chromosome to any of her children.

Question 3 A

As I-2 and II-4 are heterozygous, they have a chance to pass the faulty allele to either a son or daughter regardless of the location of the gene. On the other hand if the trait was X-linked dominant and I-3 expressed the trait, all of his daughters would also have to express the trait.

Question 4 D

Chromosomes are only visible during the mitotic or meiotic phases of the cell cycle, which eliminates **B**. When viewing a karyotype, the chromosomes can be classified due to their shape and size, so **A** is incorrect. A micrograph will not be able to 'see' nucleotides because they are far too small. Organisms can be classified due to their diploid number, so it follows suit that all members of a particular species have a specific diploid number.

Question 5 A

Replication of DNA occurs during interphase and then the DNA coils to form the chromosomes. Each chromosome is comprised of two identical chromatids. Meiosis consists of two divisions. The first separates the chromosome pairs and the second division separates the chromatids.

Question 6 B

For Skip to have type O blood he must inherit an O allele from each parent. This means Barbie would have to carry the O allele and have a genotype of AO (**A** is incorrect). Ken could be type O or heterozygous B to be able to pass an O allele to Skip, so **C** is incorrect. Response **D** is incorrect as blood type is set from the moment blood develops in the embryo. **B** is correct, but OO is not necessarily the only genotype Ken could have.

Question 7 A

Both parents must be heterozygous for the sickle cell trait. This means they have a one in four chance of conceiving a child with the autosomal recessive trait. Each child is independently conceived and so the probability of non identical twins both expressing the trait is $\frac{1}{4}$ multiplied by $\frac{1}{4}$.

Question 8 D

The answer cannot be **A** as all offspring would be yellow *ee*. It cannot be **B** as all offspring will be coloured *Ee* (brown or black). Some of the offspring of response **C** would be brown which makes it incorrect. The only two genotypes possible in the offspring with the parents in response **D** are *BbEe* (black) and *Bbee* (yellow).

Question 9 **C**

Gel electrophoresis pushes the negatively charged DNA from the wells through the gel away from the negative electrode towards the positive electrode. The smaller fragments travel faster and so over time will be arranged with the smallest fragments closest to the + and the largest nearest the –.

Question 10 **D**

The question tells us we are investigating two linked genes. Each gene has two alternative forms making four alleles in total.

Question 11 **C**

The genotype *AaBb* illustrates independent inheritance and so is incorrect. *Aa/Bb* is incorrect as it suggests both *A* and *a* alleles are on the same chromatid (the same applies for alleles *B* and *b*). Response **D** shows the individual is not heterozygous for both genes. The annotation illustrated in response **C** is appropriate. It should be noted that an equally acceptable response would be *Ab/aB*.

Question 12 **C**

Complementary base pairing occurs during transcription of DNA into mRNA. The adenine (A), guanine (G), uracil (U) and cytosine (C) in mRNA were encoded respectively from a template of single-stranded DNA containing 15% T, 20% C, 30% A and 35% G. There is no thymine (T) in mRNA. The non-template strand of DNA consequently contains 15% A, 20% G, 30% T and 35% C. Overall, therefore, the double-stranded DNA that the mRNA was transcribed from has the composition:

$$T = \frac{15 + 30}{2} = 22.5\% \qquad A = \frac{30 + 15}{2} = 22.5\%$$

$$C = \frac{20 + 35}{2} = 27.5\% \qquad G = \frac{35 + 20}{2} = 27.5\%$$

Question 13 **C**

Due to the non-overlapping, triplet nature of the genetic code, the 27 bases in this mRNA could be expected to code for a sequence of nine amino acids. However, the final three bases form a *stop* codon that does not code for an amino acid, terminating translation instead.

Question 14 **C**

Addition or deletion of a nucleotide in a DNA or mRNA sequence causes a frameshift that usually leads to a missense mutation.

Question 15 **A**

Response **D** specifically refers to one extra chromosome added to the diploid number. The general term for additional chromosomes, not forming complete sets, is aneuploidy.

Question 16 **D**

Better fed beetles might well grow larger and would live longer and be more likely to become fully grown if predators were scarce. Larger beetles might have a selective advantage, if their larger size made them better able to compete for food or mates. All these factors could, therefore, account for the increase in average body size.

Question 17 B

Mere survival of better adapted individuals is not enough for natural selection to lead to the change over time of a population. Successful genotypes must be passed on to subsequent generations, so 'fit' individuals not only survive but are more successful in reproducing and passing on their alleles.

Question 18 B

The surviving bacteria have a selective advantage arising from their antibiotic-resistance genes or alleles. These genes or alleles were the product of genetic mutation occurring before the antibiotic was applied.

Question 19 D

Genetic drift is the effect of random, non-biological processes on the frequencies of alleles in a population. Genetic drift is normally significant only in small populations, where the frequency of any given allele will fluctuate randomly until the allele is either eliminated or fixed. 'Fixed' means that it becomes the only allele of that gene in the population. An allele with a low initial frequency is more likely to be eliminated. One with high initial frequency is more likely to become fixed.

Question 20 A

Although members of the same species are likely to be similar in appearance, behaviour, geographical range and evolutionary ancestry and relationships, their defining feature is their inability to produce viable, fertile offspring with members of another species.

Question 21 B

The reproductive isolation of these two species is revealed in their inability to produce fertile offspring. Mating occurs and zygotes form, but the resulting offspring cannot reproduce.

Question 22 C

The similarity in phenotype of these two groups of mice is a product of similar selective pressures. They do not share a recent common ancestor but have evolved convergently.

Question 23 A

The earliest branch in the evolutionary tree was a tetrapod that would have been a land-dwelling animal using its four legs as support. This animal however, is not the common ancestor to modern whales (so **C** is incorrect) and there are only ten branches in the evolutionary tree leading to modern whales, not twelve (so **D** is incorrect).

Question 24 D

Reading directly from the time line, modern whales and Ambulocetus branched 52 million years ago. This is during the early Eocene era.

Question 25 B

An emu-like bird would be expected to have DNA in common with all other animals. However, due to the evolutionary divergence of birds, it would not be expected to have any DNA regions that are specific to mammals.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. process 2 – translation 1 mark

0 marks for writing process 2*; the process must be named*

b. Structure *P* is transfer RNA/tRNA 1 mark

Structure *N* is messenger RNA/mRNA 1 mark

c. Transfer RNA brings amino acids to the ribosome where they are bonded together into a sequence corresponding to the sequence of codons in the mRNA 1 mark

d. Not all the mRNA initially transcribed (from DNA) is translated
OR
only exons are translated 1 mark

mRNA transcribed from intron DNA is removed/spliced/cut out from the mRNA before it is translated 1 mark

Total 6 marks

Question 2

a. *Any one of:*

- Genetic testing: rapid diagnosis leading to faster treatment
- Genetic fingerprinting: quantitative DNA comparisons for accurate incriminations
- Genome mapping: providing large amounts of DNA for more accurate sequencing

2 marks

1 mark for the technology
1 mark for its importance

b. Within the PCR mix needs to be added primers. 1 mark

Primers are sections of single-stranded DNA, usually around 10–20 nucleotides long. They bind in a complementary fashion with DNA at either end of the section of the DNA strand scientists wish to examine. 1 mark

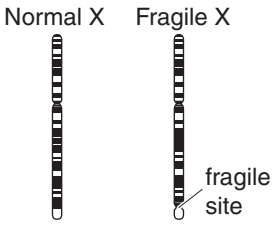
c. **i.** PCR uses a heat resistant *taq* polymerase enzyme.
OR
The temperature is raised, the H-bonds between DNA strands break so that templates for replication are formed. 1 mark

ii. 512 1 mark

Total 6 marks

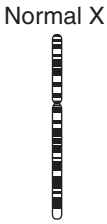
Question 3

a. A carrier female would have a chromosome arrangement like this:

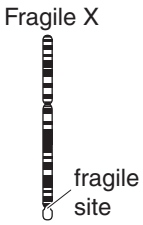


1 mark

After meiosis, each ovum would contain either a fragile X chromosome



or a normal X chromosome.



Any son conceived would have a 50% chance of inheriting the fragile X chromosome. A boy will inherit a Y chromosome from the father, and so will express fragile X syndrome. 1 mark

Note: This question could be attempted with labelled diagrams alone.

b. **i.** 0% 1 mark

ii. As the fragile X syndrome is X-linked, fathers cannot pass the mutation onto their sons. The mother II-2 carries the pre-mutation which developed into the full mutation in the egg which, in this case, is combined with the Y chromosome from II-1. 1 mark

c. 9 1 mark

(The genotypes are XY, X^FY, X^fY, XX, XX^F, XX^f, X^FX^F, X^fX^f, X^FX^f)

d. **i.** 50% 1 mark

ii. There is 100% chance the father will pass an X^f chromosome to his daughters as he suffers fragile X syndrome and has a genotype of X^fY. 1 mark

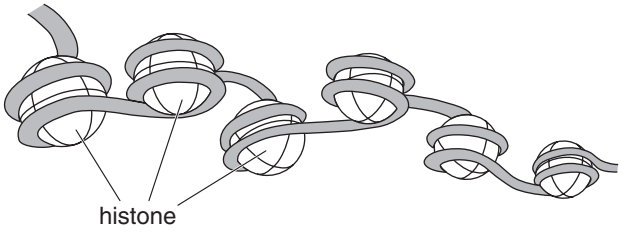
The mother has the genotype XX^F and has a 50% chance of passing the pre-mutation to a daughter. 1 mark

However, this pre-mutation would need to develop into the full mutation in the mother if a daughter was to inherit fragile X syndrome. The chance of this occurring (if there was a daughter) would be somewhere between 0% and 50%). 1 mark

Total 9 marks

Question 4

a. **i.**



1 mark

ii. Removal of histone protein which 'exposes' the gene. 1 mark

Controlling sections as well as the gene are then accessible for expression. 1 mark

b. **i.** RNA polymerase 1 mark

The RNA polymerase moves along the template strand of the DNA 'collecting' RNA nucleotides complementary to this strand. 1 mark

Note: genes such as helicase and ligase could also be discussed.

ii. Different combinations of genes are switched on in different types of cells. 1 mark

c. **i.** At this stage the stem cells are 'younger' and have the potential to differentiate into a larger range of cell types. 1 mark

This is in comparison to adult stem cells, which are in the body for a more specific purpose and may not be able to differentiate into as many different types of cells. 1 mark

ii. To prevent the exploitation of the use of embryos, governments can introduce laws that:

- only allow embryos to be kept for a certain length of time.

OR

- mean the use of each embryo must be justified. 1 mark

Total 9 marks

Question 5

a. **i.** The Bt resistance allele has been preferentially passed on, so its frequency has increased (in the gene pool of the diamondback moth). 1 mark

ii. Genetic variation exists among diamondback moths, some individuals having the allele(s) conferring Bt resistance. 1 mark

These Bt-resistant individuals survive insecticide spraying (the selective pressure) while other moths do not. Resistant moths reproduce and pass on the Bt resistance allele(s) to the next generation. 1 mark

This selective process is repeated over many generations so that the proportion of Bt-resistant moths (and therefore the frequency of the Bt resistance allele(s)) increases in the population. 1 mark

b. Homozygous recessive moths with the Bt resistant phenotype survive the spraying but mate with homozygous or heterozygous sensitive moths living in the adjacent untreated field. 1 mark

The majority of the offspring of these matings will be heterozygous, sensitive moths that will be eliminated by the next spraying, so the frequency of the Bt resistance allele does not increase. 1 mark

Total 6 marks

Question 6

a. **i.** Rapid burial of the gogo fish under sediment (on the sea floor) followed by compression of the sediment over geological time to form rock. 1 mark

ii. The half-life of radiocarbon is so short that this isotope can only be used to date fossils that are less than 50 000 years old. This fossil is 380 million years old. 1 mark

b. homologous structures

OR

pentadactyl limbs 1 mark

c. Falling sea levels or extended periods of drought might have subjected *Gogonasus* to prolonged exposure to the air. 1 mark

Fins would evolve into limbs to support the body when out of the water and the need to breathe air would lead to the evolution of internal gas exchange surfaces (lungs) instead of gills. 1 mark

d. **i.** The organisms that produced the remains all lived at the same time. 1 mark

ii. During the Ice Age, no organisms lived in the area from which fossils could form.

OR

During the Ice Age there was no lake so conditions were not suitable for the preservation of fossils by rapid burial. 1 mark

Total 7 marks

Question 7

a. **i.** *A. africanus* and gorilla both have brain cases that are about 500 cc. Whereas *A. africanus* has a smaller body size (about 30 kg) compared to gorilla (about 100 kg). The ratio of brain case to body size is much higher in *A. africanus* than in gorilla. 1 mark

ii. With a bigger brain to body ratio, *A. africanus* would have higher intelligence and be able to manipulate the environment to suit their needs. 1 mark

b. **i.** Mitochondrial DNA is passed through the maternal line and only shows differences due to mutation. 1 mark

Mutations accumulate over time and occur at a set rate. Those organisms that have more differences in their mitochondrial DNA are more distantly related. 1 mark

ii. 6 600 000 years ago 1 mark

c. Hominins are bipedal. 1 mark

The savannah provides long distances between trees and those hominins that were able to balance on their back legs for longer would be more able to survive, i.e. to carry food; to look for predators over the grass. 1 mark

Total 7 marks