Neap:

Trial Examination 2007

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

Question 1 B

This is a definition question. A chromatid is an entire compacted strand of DNA which carries many genes that code for a particular protein. These genes may have slight differences in the DNA along them and so code for a different protein. The different forms of a gene are termed alleles. The location of genes is the same and termed the locus.

Question 2 D

Each single strand in a double-stranded DNA molecule is anti-parallel to the other strand. This is important for replication and for protein synthesis along the template strand. The notation 3′ and 5′ represent this property of DNA. This refers to the direction the nucleotides are facing in each strand. As the DNA section in the question is in a 3′ to 5′ orientation, the strand complementary to it must be in the 5′ to 3′ orientation. **B** contains U and so cannot be correct.

Question 3 C

Meiosis involves two successive divisions, so **A** cannot be correct. At the very start of meiosis, chromosomes in the parent cell replicate themselves into pairs of chromatids. **B** is therefore incorrect. In the first division, each pair of homologous chromosomes is separated to reduce the chromosome number in the daughter nuclei by half. In the second division, the pairs of chromatids separate and enter the daughter cells. At no stage in the process are chromosomes destroyed.

Question 4 C

Mitosis is the form of nuclear division that maintains the same number of chromosomes from one generation to the next. A chromatid before mitosis is 'one half' of a chromosome. In nuclear division the pairs separate and each chromatid becomes a chromosome in its own right and passes into one of the two daughter cells. Since there are 40 chromatids, each daughter cell ends up with 20 chromosomes.

Question 5 C

The stem of the question gives enough information to determine that the man and the woman are both heterozygous, as they each have a parent who has blood type O. It is then a matter of determining the possible genotypes of the offspring.

	$\mathbf{I^B}$	**i**
$\mathbf{I^A}$	$\mathbf{I^AI^B}$ (type AB)	$\mathbf{I^Ai}$ (type A)
i	$\mathbf{I^Bi}$ (type B)	**ii** (type O)

Question 6 D

C = normal vision, **c** = red–green colour blindness

Since the woman had a colour-blind father ($\mathbf{X^cY}$), she must be a carrier of the colour-blindness allele ($\mathbf{X^CX^c}$).

The man is normal ($\mathbf{X^CY}$), so the predicted outcome of the cross would be as follows.

	$\mathbf{X^C}$	**Y**
$\mathbf{X^C}$	$\mathbf{X^CX^C}$ (normal female)	$\mathbf{X^CY}$ (normal male)
$\mathbf{X^c}$	$\mathbf{X^CX^c}$ (normal female, carrier)	$\mathbf{X^cY}$ (colour-blind male)

Question 7 A

The phenotype refers to the expressed appearance of the individual and, depending on the characteristic, can be a combination of genetics and environment. In this case, if a **W** allele is present, the individual must have a widow's peak. The individual also has the genotype **ss**, which means that the recessive phenotype, long fingers, is expressed.

Question 8 B

The mother having a continuous hairline must be **ww** and the long-fingered father must be **ss**. This eliminates **D**. The parents produce offspring that express both recessive characteristics. This means that the parents cannot be homozygous for any of the dominant characters. This eliminates **A** and **C**.

Question 9 A

D is incorrect because females cannot be affected by Y-linked traits and yet there are affected females in generations II and III. If the trait were X-linked dominant, all daughters of affected fathers would be affected. Individual II–3 is not affected, (mothers of affected sons should also express the trait: I–1 is not affected) so **B** is incorrect. If the trait were X-linked recessive, affected females must inherit two alleles for the trait, one from each parent. Individual III–1 is affected but cannot have inherited the allele from II–1, so **C** cannot be correct.

Question 10 A

Since the trait is autosomal recessive, each individual expressing the trait must be homozygous.

Question 11 B

Each amino acid is coded for by a codon (a set of three consecutive bases in an mRNA molecule). The codons do not overlap. This is a 30 base length of mRNA containing 10 codons. All of these will be translated since none of them is a STOP codon.

Question 12 D

A codon is a group of three mRNA nucleotides that codes for an amino acid that is added to the growing peptide. UGA codes for a stop and so no amino acid will be added at this point. The protein will stop being translated and a shorter protein will be produced.

Question 13 B

The easiest way to tackle this question is to divide the RNA sequence into codons.

5′ CGC UGU UCU AAG GGA UGC AUA AAG AGU AGU 3′

Look for the differences and use the table of codons to see if the protein will have a different amino acid sequence. Sequence **B** has three different codons, but they all code for the same amino acids. **B** is the correct answer.

Question 14 B

Lactose (when present) binds to the lac repressor. This results in the lac repressor detaching (inactive) from the promoter section of the gene. This allows RNA polymerase to bind to the promoter and transcribe the gene. This leads to the production of lactase which will reduce the level of lactose. Low levels of lactose will mean that the lac repressor will bind to the promoter preventing RNA polymerase from binding to the promoter (**A** is incorrect). **B** is the opposite to this, making it the correct response.

Question 15 C

A frameshift occurs when a base is removed from or added to DNA. Since the genetic code consists of triplets of bases, a frameshift changes the sequence triplets 'downstream' from the insertion or deletion. The frameshift may or may not introduce or remove a STOP codon, which means that the mutated polypeptide could potentially be shorter than, longer than, or the same length as the normal polypeptide, so **B** is incorrect. **A** is incorrect because the effect of a frameshift will not be detected unless it occurs in a region of DNA that is translated into a protein.

Question 16 B

A is incorrect because the question states that there is one species present. **C** may be true but does not explain why two size classes are found. Genetic drift is the variation over time of allele frequencies in small populations due to chance events and is an irrelevant distraction here. Size differences between the sexes is the most likely explanation.

Question 17 A

Homologous structures are anatomically similar but functionally different. The opposite is true of the wings of eagles and butterflies, which are **analogous** structures. Human and beetle eyes are also analogous structures, since they have similar functions but different structures.

Question 18 D

Homologous structures in different species, being anatomically similar, point to the divergent evolution of species from a common ancestor as a result of different selection pressures in different habitats. It is homologous **chromosomes** that occur in pairs and contain the same sequence of genes.

Question 19 A

Allopatric speciation results from the reproductive isolation of populations and their independent evolution in response to different selection pressures in different geographical locations. **D** is incorrect, since it is only upon reintroduction and failure to interbreed that the formation of new species is apparent. Post-zygotic isolation occurs **after** interbreeding. This cannot happen when populations are geographically isolated from each other. The isolation of populations on islands may indeed result in allopatric speciation, but it is not **essential**.

Question 20 C

A is a feature of Lamarck's idea of evolution through acquired characteristics. **B** and **D** are incorrect, since changes in genes (mutations) resulting from changes in the environment are more likely to be harmful than helpful. Variation between individuals is the basis for natural selection.

Question 21 D

Each point at which the cladogram branches represents a common ancestor. Species in a monophyletic group must, according to the definition, arise from a recent common ancestor. **A** and **B** are incorrect because they have evolved from ancestors that are not recent. Since VII is omitted, not all descendants of the common ancestor are included in answer **C**. The common ancestor of VI, VII and VIII lived closest to the present time.

Question 22 B

A is incorrect because there is evidence that the flies can still interbreed. **C** is unlikely because genetic drift is a random process affecting small populations and is not obviously linked to gamete viability. **D** is unlikely since no reasonable connection can be made between the selective pressure (diet) and its effect (different reproductive organs).

Question 23 A

Arm-to-leg ratio in man is smaller than the other apes. Therefore **B** is incorrect. **C** is incorrect as a larger brain may enable the human to solve problems, but will not affect his bone structure for walking. An omnivorous diet would not be a selective advantage for bipedalism so **D** is incorrect. Logic suggests the skull sitting vertically on the vertebrae will enable the eyes to look straight ahead if the human is upright.

Question 24 C

Mapping the human genome is a side-branch of what was originally termed 'genetic engineering'. The skills needed for success with the Human Genome Project have stemmed from other knowledge in the past and have been improved for the betterment of humanity. These skills are still changing and so fit the idea of technological evolution. Structural evolution and behavioural evolution are clearly incorrect. Cultural evolution is the keeping of customs within a particular group such as religion and language.

Question 25 C

This is a graph-interpretation question. *Ardipithecus ramidus* first appeared about 5.25 million years ago and ceased to exist about 4.25 million years ago. This shows an existence of about 1 million years.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. The trait is recessive as the trait is passed from unaffected to affected. For example, I–1 and I–2 are unaffected and produce II–4 who is affected. 1 mark

b. **i.** $\mathbf{X^D}$ = normal; $\mathbf{X^d}$ = DMD 1 mark

Both correct symbols and definitions are required

ii. $\mathbf{X^DY}$ 1 mark

iii.

	$\mathbf{X^D}$	$\mathbf{Y}$
$\mathbf{X^D}$	$\mathbf{X^DX^D}$	$\mathbf{X^DY}$
$\mathbf{X^d}$	$\mathbf{X^DX^d}$	$\mathbf{X^dY}$

1 in 4 1 mark

Note: If the question stated the gender of the child, then the correct answer would be different. Males would have a 50% risk and females would have a 0% risk.

c. Individual II–3 has a 50% chance of being $\mathbf{X^DX^d}$ and a 50% chance of being $\mathbf{X^DX^D}$. 1 mark

The normal male has the genotype $\mathbf{X^DY}$ and so has no chance of passing a DMD allele to a child. However, the female would have a $\frac{1}{4}$ chance of passing a DMD allele to a child. The child would need to be a male express the trait, and there is a $\frac{1}{2}$ chance of this occurring. The counsellor would suggest there is a $\frac{1}{8}$ chance of a DMD son. 1 mark

Some sense of the chance plus the gender of the child should be included.

d. **i.** A part of the coding region of a gene that is transcribed and translated. 1 mark

ii. Removal of an exon results in fewer nucleotides than normal to be translated. 1 mark

If fewer nucleotides are present in the mRNA, then there will be fewer amino acids (2500) in the resulting protein.
OR

When the remaining exons are spliced together, a stop signal may interrupt the synthesis of the protein, leaving a smaller, dysfunctional protein.

1 mark

Total 9 marks

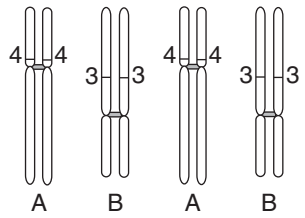
Question 2

a. **i.** Genes 2, 5 and 6 are linked 1 mark
as they are found on the same chromosome.

ii. Genes 2 and 6 1 mark
as they are linked and very close together.

iii. 4 1 mark
as each chromosome is one compacted strand of DNA.

b.



2 marks

Note: Since the plant is diploid, there are two copies of each chromosome. As the cell is in prophase I, the chromosomes should be drawn with two chromatids connected by a centromere.

1 mark for the diagram
1 mark for labels

c. **i.** 16 1 mark
Note: If there are initially four chromosome pairs in the cell, and genes 1–6 are spread across all of them, independent assortment will mean that there are 2^4 different allele combinations (2^1 one pair, 2^2 two pairs, 2^3 three pairs ... 2^n n pairs). This means that there would potentially be 16 different allele combinations.

ii. Crossing over between the highlighted genes could occur on chromosome D.
If this happened, there would be an exchange of alleles between homologous chromosomes. This would give rise to new allelic combinations. 1 mark
These new combinations could not be achieved in any other way.

Total 7 marks

Question 3

a. five 1 mark

b. **i.** two fragments, each 80 kbp in length 1 mark

ii. one 80 kbp fragment, one 60 kbp fragment and one 20 kbp fragment 1 mark

c. **i.** Fragments of DNA are negatively charged. Therefore in an electric current, fragments move through the gel towards the positive terminal. 1 mark
Smaller fragments of DNA move further through the gel. 1 mark

ii. A gene probe is a length of single-stranded DNA (or sometimes RNA) that binds to a specific sequence of bases. It also contains a fluorescent or radioactive label or marker. Gene probes can be used to locate a specific locus (gene or allele) in a DNA fragment. 1 mark

iii. Standard DNA, when digested, produces fragments of known sizes against which the size of fragments of sample DNA can be compared.
OR
Standard DNA, when digested, produces a known number of fragments. When the standard fragments appear on the gel, they show that the gel electrophoresis has occurred correctly.

1 mark

d. Janet, John and Jerome all carry the mutant allele 1 mark
since their DNA for this locus has been digested into three fragments, i.e. 20, 60 and 80 kbp fragments which are characteristic of the digested mutant allele. 1 mark

Total 9 marks

Question 4

a. *Any two of*

- hunting of tigers;
- over-hunting of tigers' prey;
- habitat destruction.

1 mark

b. White individuals are better camouflaged against snow.
OR
White individuals are larger.

These traits are genetically determined. 1 mark

Being less visible to prey, they are better hunters and more successful in surviving and raising young.
OR
Being larger, they lose less heat in cold winters. 1 mark

The allele(s) for white fur
OR
large size

have been passed on to the next generation and have become more frequent in the tiger population. 1 mark

c. Sumatra was once connected by land to the mainland, so tigers travelled across a 'land bridge'. 1 mark
(Rising sea level due to melting ice following the last ice age or due to plate tectonics/ volcanic activity isolated them on Sumatra.)

d. The South China sub-species. 1 mark

This sub-species has the least genetic diversity, indicated by the lowest total number of alleles (66). A genetic bottleneck occurs when a population is reduced to such small numbers of individuals that the diversity of alleles is also severely reduced. 1 mark

*Note: The number of **unique** alleles is an indicator of evolutionary divergence. The number of **different** alleles is an indicator of genetic diversity.*

e. The Malayan population has less genetic diversity (108 alleles) than the Northern population (130 alleles). 1 mark
The Northern population has undergone a greater mutation rate/greater divergence from the common ancestor of the two populations (14.6% of its alleles are unique, compared with 2.8% for the Malayan population). 1 mark

f. Habitat differences and intense and different selection pressures amplify phenotypic differences between populations.
OR
Small and isolated populations are affected by high levels of genetic drift and low levels of gene flow which amplify phenotypic differences between populations.

1 mark

g. Mitochondrial DNA mutates more rapidly than chromosomal DNA, so genetic differences between tiger populations will accumulate quickly and be more easily detected.

OR

mtDNA is only inherited through the maternal line and is not affected by recombination during meiosis, so mutations can easily be traced over time. 1 mark

Total 11 marks

Question 5

a. The remains of a living organism (its body parts or traces of its activities) preserved in a rock or other geological deposit. 1 mark

b. **i.** The hard parts of organisms (e.g. bones) resist destruction by scavengers and detritivores. 1 mark
The remains of organisms rapidly buried in underwater sediments are protected from scattering by scavengers and decay by decomposers. 1 mark
Fish are therefore more likely than most animals to be preserved as fossils.

ii. The ages of different sedimentary rocks in different locations are the same if they both contain the same index fossils. 1 mark

Note: Good index fossils should be abundant, geographically widespread, easily identifiable and relatively short-lived in evolutionary terms.

c. By radiometric dating, 1 mark
using the ratio of a suitable radioisotope to its stable daughter atom. 1 mark
Note: Carbon-14 or radiocarbon dating is incorrect here in view of the age of the fossils.

d. Lobefins could have evolved into basic legs that could be used for locomotion on land, 1 mark
and a swim bladder capable of absorbing oxygen and excreting carbon dioxide could have evolved into lungs capable of allowing continuous breathing of air on land. 1 mark

Total 8 marks

Question 6

a. **i.** genetically inaccurate 1 mark
The 'normal' allele is inserted into the genome but this does not mean the faulty gene is removed. It just means that the cell will be able to express the normal form of the gene (good for recessive disorders). 1 mark
Note: The allele could disrupt other genes, or more than one copy could be inserted. Hence, various side-effects could occur.

ii. genetically accurate 1 mark
The genome will be identical because an entire nucleus has been transferred. The nucleus is taken from a 'parent' clone and so that nucleus has descended from many others via mitosis. Each cell division impacts on structures at the ends of chromosomes called telomeres. Over several mitotic events, telomeres wear a little like rope does at the ends after several uses. This is thought to 'age' the cell. The new clone, even though it is a new individual, will have the same age as the parent clone. 1 mark

b. gene therapy
For: It provides a prospect of a cure for genetic disease.
Against: It could lead to a change in the gene pool. The frequency of genes in humanity is as a result of natural selection and so an artificial change could place humans at a selective disadvantage.
*Note: Germ-line therapy **and** somatic gene therapy could both change the gene pool, depending on the survival success of the individuals treated.*
OR
cloning
For: Improved milk production/yield of wheat/wool quality etc.
Against: The genetic variation between individuals would be reduced. This is against the laws needed for survival.

Note: There are many biological reasons for and against these technologies. Use your discretion with assessment. The key is for the students to discuss biologically, as well as giving a point for and a point against.

2 marks
1 mark for point for the technology
1 mark for point against the technology
Total 6 marks