Neap:

Trial Examination 2008

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 **D**

These chromosomes are arranged together from a metaphase spread. The chromosomes form after DNA replication and condensation. Each chromosome comprises two identical chromatids connected to each other by one centromere.

Question 2 **D**

The cell cycle consists of four stages. The G1 phase is where the cell functions normally. Many cells remain in G1 phase forever. After the G1 phase is the S phase. This is when the DNA replicates. This is followed by the G2 phase where the DNA coils into visible chromosomes such as those seen in the karyotype. Division of the nucleus (mitosis or meiosis) can then occur.

Question 3 **B**

The autosomes are those chromosomes that are found as matching pairs in both males and females. As each chromosome carries two identical chromatids and has a matching pair, there are four genes present for a particular autosomal characteristic.

Question 4 **C**

As prokaryotes do not contain a nucleus they cannot divide by mitosis. Meiosis involves the generation of gametes as part of sexual reproduction. Apoptosis is the word used to describe various types of programmed cell death. Binary fission is how bacteria divide. The DNA replicates and the cell divides into two identical cells.

Question 5 **A**

The term homozygous means that the alleles present in an individual's genotype are the same. The flies are female (**XX**), homozygous red-eyed (**w+w+**) and yellow bodied (**yy**).

Question 6 **D**

A red-eyed male would have the genotype $\mathbf{X^{w+}Y}$. To produce daughters, this male can only provide red eye alleles in his gametes. Since red eye colour is the dominant characteristic, all the daughters will have red eyes, regardless of the mother's genotype. This means that, in this case, there is no chance of a daughter having yellow eyes.

Question 7 **C**

Recessive patterns of inheritance are clearly demonstrated when two parents produce a child expressing a characteristic that neither parent expresses (so **B** is incorrect). If the allele causing the disease was located on the Y chromosome, the father would have to express the characteristic (so **A** is incorrect). For PKU to be X-linked, the allele for the recessive phenotype could not be carried by the father, as he only has one X chromosome (so **D** is incorrect).

Question 8 **B**

The way in which the genotype is written tells us that the genes are inherited independently. Each chromosome pair behaves independently and the number of gamete genotypes can be calculated by multiplying the number of different types of gametes possible for each gene.

Aa can produce **A** and **a** gametes (two gamete genotypes)
BB can only produce **B** gametes (one gamete genotype)
cc can only produce **c** gametes (one gamete genotype)
Dd can produce **D** and **d** gametes (two gamete genotypes)
$2 \times 1 \times 1 \times 2 = 4$

Question 9 **D**

The way in which the genotype is written tells us that the genes are linked. Linked genes are located on the same chromosome and are inherited together. Linked alleles can sometimes switch chromatids due to crossover during meiosis, but there is no evidence that this has occurred in this individual.

Question 10 **C**

Male I–1 has the genotype **AB** and exhibits the disease. This is passed on to individual II–2 who also has the genotype **AB**. We can conclude that the **B** allele (inherited from individual I–1) must be linked to the disease allele. So if individual III–1's genotype is **BB** and no crossover occurred as II–2 is producing gametes, individual III–1 must have inherited the **B** allele from II–2, and must have the disease (so **C** is correct). For **B** to be correct, the probability should be 0%. If recombination occurs then some affected individuals will have the genotype **AB**, but not all (making **D** incorrect).

Question 11 **D**

A combination of three DNA nucleotides that carries the blueprint for an amino acid is called a triplet. The three-base mRNA sequence that is transcribed from a triplet is called a codon. Introns are cleaved out prior to the mRNA exons moving out of the nucleus. The tRNA carries an anticodon as well as a specific amino acid that is placed into the growing protein.

Question 12 **B**

All the snails in the population have one of three genotypes. Each genotype enables the snail to produce mucus (so **D** is incorrect). Allele **A2** is a less frequent allele (so **B** is correct and **C** is incorrect). As the heterozygote is quite rare in the population, it could be concluded that phenotype is not advantageous (so **A** is incorrect).

Question 13 **D**

There is no evidence in the question of the arrival in the population of new individuals with a cystic fibrosis allele, nor of the random elimination of such individuals from a small population by chance events, so **B** and **C** are unlikely. The cystic fibrosis allele arises from mutation, but its prevalence is best explained by selection for these individuals by the two named infectious diseases.

Question 14 **A**

The infant is homozygous for the sickle cell allele. This can be seen by comparing lane III of the reference data with lane III of the sample data.

Question 15 **D**

Historic records of recent extinctions (e.g. the Tasmanian tiger) and the extinction of large families other than dinosaurs (e.g. graptolites, trilobites, ammonites) make **A**, **B** and **C** incorrect. Extinctions can be caused by local events (e.g. habitat destruction, over-hunting) or global catastrophes.

Question 16 **A**

Mutation is a random process. Founder effects and genetic bottlenecks describe the genetic consequences following from the random sampling of an original population as a result of migration or natural catastrophe. Selection, however, is non-random. Reproductively successful individuals are selected by some natural or sexual selective pressure.

Question 17 **B**

Both species live in the same area and do not produce adult hybrid offspring, so **C** and **D** can be rejected. Zygotes (fertilised eggs) do form, develop and hatch into tadpoles, but these never become reproductively mature and no further offspring can be produced. Like the mule, this is an example of post-zygotic isolation.

Question 18 **C**

The biological fitness of individuals is measured by their ability to pass on their genes and alleles to the next generation. Individuals that are better able to survive are likely to produce more offspring.

Question 19 **C**

The bone positions in the forearm suggest all three had a common ancestor in the past. The reasons for the differences in size of the forelimb bones are related to the differences in the environments that each organism lives in. Natural selection favours successful adaptations in particular environments, and so as the ancestor moved into different environments, an accumulation of adaptations has occurred. This is called divergent evolution.

Question 20 **C**

Strata layers show older fossils in the deeper layers. This is due to these layers forming over the top of each other over time. Ichthyosaurs are in the top layer and so are the youngest fossils (so **A** is incorrect). Foraminifera are found in shale and limestone (so **B** is incorrect). Transition fossils show a structural link between two types of organisms and so more information would be needed for **D** to be correct. Sandstone is both the bottom (oldest) and top (youngest) layers, which makes **C** the correct answer.

Question 21 **B**

The age scale reads from top to bottom. 150 million years ago most dinosaurs were still alive (so **A** is incorrect). The common ancestor for the illustrated tree starts diverging from about 350 million years ago (so **D** is incorrect). Crocodiles have been living for a long time (about 250 million years) but the birds have more genera as their evolutionary line has a greater width (so **C** is incorrect). The bird line separates from the other evolutionary branches about 200 million years ago.

Question 22 **A**

Selection pressure would favour longer legs, and **A** depicts a population with a large number of individuals with longer legs.

Question 23 **C**

Current 'family trees' of hominins place *Homo erectus* as the most recent common ancestor of *H. neanderthalensis* and *H. sapiens*.

Question 24 **C**

A describes the learning of tool use by a group of organisms occupying a particular time and space. **B** describes natural selection and **D** is a process of organic evolution. **C** adequately describes a change over time in the technology humans use to solve problems and achieve their aims, which is an aspect of cultural evolution.

Question 25 **B**

The currently favoured 'Out of Africa' hypotheses postulate that *H. erectus* evolved in Africa and migrated elsewhere about 2 million years ago, and that *H. sapiens* did the same 60 000–100 000 years ago. **B** is the only answer consistent with these hypotheses.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. Phenotype refers to the observed characteristics. This can be as a result of an organism's genetic make-up, its environment or a combination of both. 1 mark

b. **i.** black – **B**
brown – **b**
light brown – $\mathbf{b^1}$
dense – **D**
dilute – **d**

2 marks
2 marks for all five correct responses
1 mark for three or four correct responses
0 marks for two or fewer correct responses

ii. $\mathbf{bb^1Dd}$ 1 mark

iii.

P. phenotypes:	chocolate	×	fawn
P. genotypes:	$\mathbf{bb^1Dd}$		$\mathbf{b^1b^1dd}$
gametes:	$\frac{1}{4}\mathbf{bD} + \frac{1}{4}\mathbf{bd} + \frac{1}{4}\mathbf{b^1D} + \frac{1}{4}\mathbf{b^1d}$		all $\mathbf{b^1d}$

Gametes	bD	bd	$\mathbf{b^1D}$	$\mathbf{b^1d}$
$\mathbf{b^1d}$	$\mathbf{bb^1Dd}$	$\mathbf{bb^1dd}$	$\mathbf{b^1b^1Dd}$	$\mathbf{b^1b^1dd}$

F_1 genotypes – $1\mathbf{bb^1Dd} : 1\mathbf{bb^1dd} : 1\mathbf{b^1b^1Dd} : 1\mathbf{b^1b^1dd}$ 1 mark

F_1 phenotypes – 1 chocolate : 1 lilac : 1 cinnamon : 1 fawn 1 mark

c. **i.** II–3 with either II–2 or II–4 1 mark
The lilac individuals (III–1 and III–2) are not appropriate, as they carry the light brown allele. Breeding from these may result in lilac cats, but they couldn't be guaranteed of being pure-breeding.

ii.

P. phenotypes:	black	×	black
P. genotypes:	**BbDd**		**BbDd**
gametes:	$\frac{1}{4}\mathbf{BD} + \frac{1}{4}\mathbf{Bd} + \frac{1}{4}\mathbf{bD} + \frac{1}{4}\mathbf{bd}$		$\frac{1}{4}\mathbf{BD} + \frac{1}{4}\mathbf{Bd} + \frac{1}{4}\mathbf{bD} + \frac{1}{4}\mathbf{bd}$

$\frac{1}{16}$ of the offspring would be expected to be **bbdd** – pure-breeding lilac. 1 mark

Total 8 marks

Question 2

a. **i.** The promoter region is where RNA polymerase binds to the DNA, and transcription of the gene commences. 1 mark

ii. In mode 1, a repressor protein binds to the promoter to block transcription. When the gene is to be transcribed, an activator protein binds to the repressor, causing it to detach from the promoter. This allows RNA polymerase to bind to the promoter and initiate transcription.

In mode 2, RNA polymerase cannot bind to the promoter alone. When the gene is to be transcribed, an activator protein bonds with another protein. This protein complex then binds to the promoter region of the gene. This allows RNA polymerase to bind to the promoter and to initiate transcription. 1 mark

b. If a gene is repressed at the translational level, transcription occurs needlessly, using up valuable energy for no purpose. Transcriptional control therefore conserves energy. 1 mark

c. mRNA moves along the template strand of the DNA 1 mark
collecting RNA nucleotides complementary to the template and placing them in position. 1 mark

Total 5 marks

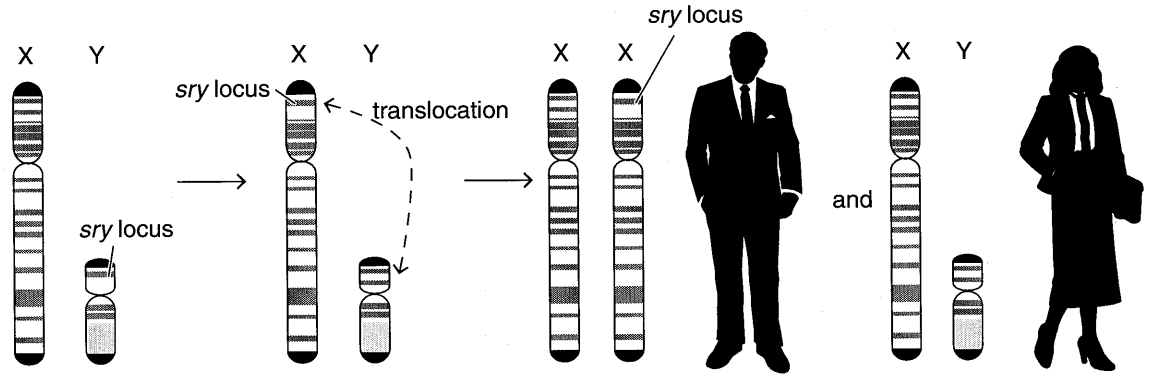
Question 3

a. Males only have one copy of most Y chromosome genes. However some Y chromosome genes have homologues on the X chromosome, meaning that males have two copies (similar to autosomal genes). 1 mark

b. **i.** Introns (derived from the term 'intragenic regions') are non-coding sections of genes. Once a DNA sequence is transcribed as an RNA strand, the introns are spliced out. The resulting mRNA sequence is then translated into a protein. 1 mark

ii. $204 \times 3 = 612$ base pairs 1 mark

c. **i.**



2 marks

1 mark for correctly showing a correct translocation of sry from Y to X chomosome
1 mark for clearly showing the genders of the resulting individuals
If a good written explanation is provided with no diagram, a maximum of 1 mark can be scored

ii. Destructive point mutations in the *sry* gene can give rise to XY females because the *sry* gene's protein product is not produced and male anatomical characteristics cannot develop (gonadal dysgenesis, a.k.a. Swyer syndrome).

OR

Individuals with XY genotype and functional *sry* gene can have a female **phenotype**, where the underlying cause is a mutation in a gene encoding receptor proteins for male sex hormones. Cells lack these receptors and do not respond to testosterone so maleness does not develop (this is called **androgen insensitivity syndrome** or AIS). 1 mark

d. **i.** A fragment of single stranded DNA or RNA of variable length (usually 100–1000 bases long), which is used to detect in DNA or RNA samples the presence of nucleotide sequences (the DNA target) that are complementary to the sequence in the probe. 1 mark

ii. In all anatomical females with an *sry* gene, the gene product is not produced so testes do not develop and significantly enhanced levels of testosterone are not secreted. Secondary male characteristics such as enhanced musculature do not develop and these athletes have no significant competitive advantage. 1 mark

e. **i.** The genetically active regions must be conserved in a functional state from generation to generation. Heterochromatin is not transcribed/does not code for proteins/enzymes so it can accumulate mutations without deleterious effects on survival and reproduction. 1 mark

ii. Y chromosomes pass down generations only from father to son and therefore track patrilineal descent (often used in combination with studies of surnames).

OR

Heterochromatin occurs in the non-homologous region of the Y chromosome and therefore escapes from crossing over and recombination with the X chromosome. 1 mark

Total 10 marks

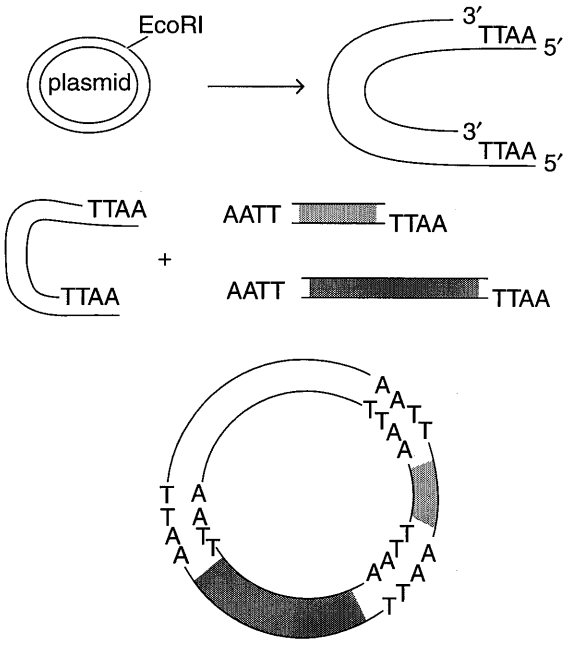
Question 4

a. **i.** GM salmon reach a market size of 4 kg after two years, compared with three years for standard salmon. This means that the fish can be brought to market more quickly and with less feed cost. 1 mark

ii. Foods prepared from GM fish may contain high levels of antifreeze chemicals, which may, when eaten, harm humans OR have enhanced allergenic properties. 1 mark

b. **i.** A circular strand of extra-chromosomal DNA in a bacterial cell. 1 mark

ii.



Plasmid cut into linear form by restriction enzyme, producing "sticky ends".

Transgenes from Chinook salmon and ocean pout prepared using same restriction enzyme to give complementary "sticky ends". Transgenes mixed with plasmid *in vitro*.

DNA Ligase covalently joins the two DNA molecules by reforming phosphate bonds

2 marks

1 mark for showing how genes are excised and plasmids are cut with restriction enzymes
1 mark for showing how DNA ligase is used to form the recombinant plasmid

iii. So that bacteria containing the recombinant plasmid could be selected by growing them on a medium containing this antibiotic. The selected bacteria could then be cloned to make many copies of the recombinant plasmid. 1 mark

Total 6 marks

Question 5

a. i. jackals — 1 mark

ii. Sea lions and ferrets, — 1 mark
because they diverged longer ago than weasels and striped skunks. — 1 mark

b. i. The number of chromosomes found in normal body cells. They are generally found as homologous pairs. — 1 mark

ii. The grey wolf and arctic fox belong to different genera and so would be unable to reproduce.
OR
The grey wolf has diploid number of 78 and the arctic fox has a diploid number of 50 and so the gametes would be unviable. — 1 mark

c. i. mtDNA only shows variation due to mutation and is passed along the maternal line. — 1 mark

Mutations accumulate over time and so those that have been isolated for longer from each other will have more different sequences. This means that domestic dogs diverged from grey wolves more recently than the divergence of grey wolves and coyotes. — 1 mark

ii. The scientist would need to establish whether they are able to reproduce to produce fertile offspring. — 1 mark

d. Artificial selection (AS) differences from natural selection (NS).

- no environmental change with AS
- no selective advantage with AS because humans choose the characteristics
- the human only allows certain individuals to breed with AS — 2 marks

2 marks for any two of the above points
1 mark for one of the above points
Total 10 marks

Question 6

a. i.
- rapid burial (evades scavengers)
- low oxygen (reduced decomposition)
- low temperature (reduced decomposition) — 2 marks

2 marks for any two of the above points
1 mark for one of the above points

ii. radioisotopic dating such as K/Ar dating *(not carbon dating)* — 1 mark

Measure the amount of K isotope in the fossil or the rock around the fossil and compare this to the amount found naturally in new rock. Using a known half life for K, the age of the fossil can be determined. — 1 mark

iii. *P. catalaunicus* lived 13 million years ago and *P. africanus* lived 5–23 million years ago. According to this evidence, *P. catalaunicus* could only be ancestral to *P. africanus*, not the other way round. — 1 mark

b. The lesser apes were probably divided into two groups and were isolated from each other. — 1 mark

One area probably had an environment that suited evolution via natural selection down the great ape line. — 1 mark

c. **i.** You can reconstruct whole bone structure from small bone fragments. The anatomy of a bone is logical to deduce. If enough bone fragments are present from enough different bones it would then be reasonable to reconstruct a skeleton. 1 mark

ii. If modern day organisms use a particular structure for a type of lifestyle, it is appropriate to use as evidence of a particular use of a fossilised structure. 1 mark

d. *Any one of:*

- Finding more fossils. This could lead to more conclusive links between primates at different time periods.
- The position of the foramen magnum. This would allow the scientists to determine whether the species was bipedal.
- Any other appropriate piece of evidence and explanation. 2 marks

1 mark for identifying an appropriate piece of evidence
1 mark for appropriate explanation
Total 11 marks