Trial Examination 2006

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 **C**

Light bay horses do not have to have light parents as both parents could be sooty dark bay (**Ee**).
The offspring of a sooty dark bay stallion need not be sooty dark bay if the offspring is heterozygous (**Ee**). A medium bay colour would result from a situation of incomplete dominance or co-dominance.

Question 2 **D**

The graph depicts meiosis, since the final products are haploid (n). Options **A** and **B** require mitosis. Bacteria, having no nucleus, do not undergo nuclear division.

Question 3 **A**

Only one chromosome from each homologous pair will enter a gamete as a result of independent segregation. Each homologue has an equal (1/2) chance of doing so. So the likelihood of only the paternal chromosomes from each of the four homologous pairs entering the same sperm cell is
$\frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} = \mathbf{\frac{1}{16}}$.

Question 4 **B**

The expected results of the cross will be

	cr
CR	**CcRr** – red
Cr	**Ccrr** – yellow
cR	**ccRr** – white
cr	**ccrr** – white

*Note: If the genotype is **cc**, the genotype in respect of gene R is immaterial, as no colour can form.*

Question 5 **D**

In mammals, 'sex-linked' generally means 'X-linked' and the chromosome does not carry an allele of the gene in question. Tortoiseshell fur requires both $\mathbf{X^b}$ and $\mathbf{X^g}$ alleles to be present. In a male cat, this is only possible if the animal inherits two X chromosomes (i.e. the feline equivalent of Klinefelter's syndrome).

Question 6 **A**

Mutation of the Y chromosome is unlikely to be the cause, since the Y chromosome lacks a locus for the fur colour gene. The female parent has the genotype $\mathbf{X^gX^g}$. If translocation between these X chromosomes duplicated the $\mathbf{X^g}$ allele on one of them ($\mathbf{X^{gg}}$), this would presumably produce male offspring that were ginger. Likewise, non-disjunction of the X chromosomes in the female cat would mean the male kitten would inherit the genotype $\mathbf{X^gX^gY}$ and have ginger fur.

Question 7 **B**

No new species has formed. A genetic bottleneck would produce abnormally low genetic diversity rather than favour a particular phenotype. While islands may be geographically remote, they do not necessarily 'geographically isolate' populations of marine animals from gene flow. The higher frequency of silver seals is most likely due to an unusually high frequency of silver seals in the original breeding population that colonised the island.

Question 8 A

All surviving foxes must have one of the three non-lethal genotypes $\mathbf{W^+W^+}$, $\mathbf{W^+W}$ or $\mathbf{W^+W^P}$. Two of these are heterozygous and all three contain the $\mathbf{W^+}$ allele. Nothing is said in the question about the frequencies of the alleles.

Question 9 C

mtDNA is a circular molecule of double-stranded DNA, not associated with histone proteins, similar in size to a bacterial chromosome. It is usually inherited through the female line, because the ovum provides the original mitochondria of the embryo. mtDNA mutates faster than chromosomal DNA and is used as a 'molecular clock' for studying trends in human evolution over the last 200 000 years.

Question 10 D

The trait cannot be X-linked recessive because this would mean all males in generation III would be affected. Person III-1 is unaffected. All other modes of inheritance can be justified from this (very limited) data.

Question 11 B

Since there is no history of syndactyly in his family, person II–1 must have the genotype **nn**. Person II–5 must have the genotype **Nn** in order for person III–5 to inherit the **N** allele. Persons III–2 and III–5 must both have the genotype **Nn**. Since both of these individuals originate from the cross **Nn** $\times$ **nn**, neither can have the genotype **NN**.

Question 12 D

DNA polymerase enables the correct nucleotide to be put into position on a single strand of DNA. Restriction enzymes cut DNA. Reverse transcriptase transcribes RNA strands into cDNA.

Question 13 A

RNA is different to DNA in that Uracil replaces Thymine. All other base pairing combinations are the same. This makes option **B** incorrect. Option **C** is incorrect because there are only 12 nucleotides represented on the single strand of DNA. The first three nucleotides GAC will transcribe to CUG and this codon will be complementary to the anticodon GAC **not** GUC.

Question 14 C

When a gene is originally transcribed, the pre-mRNA contains segments that are cleaved out prior to translation. These sections that are cleaved out are referred to as introns. This leaves option **A** and option **C** as the only possible answers. Option **A** is incorrect as the DNA is not translated.

Question 15 B

The information suggests that the gene is inserted into the target cells. There is no reference to the faulty gene being removed. When the gene is inserted, the process is a little hit and miss. This means more than one copy could be inserted per cell and other genes could be disrupted as the DNA integrates into the genome of the target cell. Somatic cells often need replacing and if this type of cell is the target then the procedure would need to be repeated.

Question 16 A

If this procedure became commonplace then the generations of modified gametes would be more similar than the previous, unmodified generations of gametes. This means the variety in successive generations would be lessened. This means option **A** is correct and, by default, option **B** and option **C** are incorrect. Option **D** is incorrect as there are many situations where utilising gametes is not only legal but regarded as ethical. For example, in-vitro fertilisation (IVF) is a way that gametes can be used that is regarded as ethical.

Question 17 A

More mutagens would lead to more mutations which leads to more genetic variation. However this doesn't mean these variants will be more suited to survival. Extreme changes in environment are more likely to lead to death of many individuals, reducing variation amongst the population. Fewer crossovers will lead to fewer allele combinations and less genetic variation. Fewer offspring will not directly influence the genetic variation.

Question 18 A

Natural selection acts on organisms with the most suited characteristics. In genetics, characteristics are called phenotypes. The phenotype is an expressed trait that is present due to the interaction between the environment and the genes inherited. The genes inherited often have a variety of alleles. Sometimes different genotypes have the same phenotype. The environment is the driving force for natural selection, not the other way round.

Question 19 B

DNA hybridisation is generally used to determine genetic similarity between groups of organisms. Cloning may one day be 'in vogue' for dog breeders; it is certainly not commonplace. Random breeding will have a lower success rate of generating pure-bred dogs as they are the result of selective breeding where the breeder selects the dogs to breed so that desired traits will be kept.

Question 20 B

If organisms possess structures that have similarities in their design yet may be found in organisms that live in a wide variety of environments, then these are tell-tale signs of a common ancestral past. Hence the answer is divergent evolution.

Question 21 C

The horizontal lines provide evidence on how long ago the organisms diverged from each other. The ones that branch more recently are more closely related.

Question 22 B

The more differences in the amino sequences there are, the more distantly related the species are. This is the rule of thumb for such information. DNA codes for proteins and so the more differences there are in a protein sequence, the more different the corresponding DNA sequences will be. The DNA and amino acid differences serve as an evolutionary clock. Option **A** is incorrect as we are dealing with different DNA sections. Option **C** is incorrect as a result of silent mutations due to the degenerative nature of the DNA code. Option **D** is incorrect as you cannot determine whether the pig or the chicken is closer to the human when both the pig and the chicken have three differences.

Question 23 B

Since there were no matings there is no evidence of sexual selection. There is no evidence that the shrimp populations were very small, which is necessary for genetic drift to be significant. There is no evidence to support option **D**, because there is no information in the question concerning selection pressures and the shrimps have not evolved any obvious new adaptations. The refusal of shrimps from geographically isolated populations to interbreed is an example of reproductive isolation.

Question 24 D

Stratigraphic correlation is a useful way to determine the relative ages of fossils. When taking both areas into account, the layers from oldest to youngest are: *H, GM, FL, K, EJ, I*. Location 1 has the oldest layer as there is a layer below *G* which is also found as layer *M* in location 2.

Question 25 D

Most parts of organisms are destroyed in the fossilisation process as it is unlikely they will be in a situation conducive to this process. Hence single-celled organisms are very unlikely to be fossilised as are soft tissue parts. Organic material is usually replaced by minerals in the fossilisation process.

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. **i.** **BbGg** 1 mark

ii. **BBgg** OR **Bbgg** 1 mark

b. Two solutions are possible from the breeder's stock of plants.

Solution 1:

Cross TtBb × TtBb (both parents loose-headed and produce substance B).

	TB	tB	Tb	tb
TB	TTBB	TtBB	TTBb	TtBb
tB	TtBB	<u>ttBB</u>	TtBb	<u>ttBb</u>
Tb	TTBb	TtBb	TTbb	Ttbb
tb	TtBb	<u>ttBb</u>	Ttbb	ttbb

Of the offspring, $\frac{3}{16}$ will have the desired characteristics (genotypes underlined).

3 marks
1 mark for correct cross
1 mark for correct Punnett grid
1 mark for highlighting ttBB and ttBb genotypes as $\frac{3}{16}$ of the offspring

Solution 2:

Cross TtBb (loose-headed, produces substance B) × ttbb (tight-headed, cannot produce substance B)

	TB	Tb	tB	tb
tb	TtBb	Ttbb	<u>ttBb</u>	ttbb

Of the offspring, $\frac{1}{4}$ will have the desired characteristics (genotype underlined).

3 marks
1 mark for correct cross
1 mark for correct Punnett grid
1 mark for highlighting ttBb as $\frac{1}{4}$ of the offspring

c. **i.** polyploid OR tetraploid

1 mark

ii. In the sterile hybrid, the 10 chromosomes inherited from *Brassica rapa* could not form homologous pairs with the eight chromosomes inherited from *Brassica nigra* so gametes could not form. In the fertile polyploid hybrid *B. juncea* the chromosomes are able to form homologous pairs in meiosis. (Chromosomes will segregate normally into gametes which have n = 18).

2 marks
1 mark for identifying why original hybrid was sterile
1 mark for identifying why brown mustard plants are fertile
Total 8 marks

Question 2

a. In the (nitrogenous) bases OR in adenine, thymine, guanine and cytosine.

1 mark

b. Each of the two strands of the original ^{15}N-DNA acts as a template strand in DNA replication. However, because only ^{14}N is available in the medium, new complementary strands are made of ^{14}N nucleotides. As such, all the first generation DNA will be 'hybrid' (^{14}N/^{15}N-DNA) with one ^{15}N parent strand being conserved in each new DNA molecule.

3 marks
1 mark for identifying that ^{15}N-DNA forms a template strand in DNA replication
1 mark for identifying complementary strands as ^{14}N
1 mark for identifying the first generation as a hybrid

c. The bar chart should show 25% of molecules are ^{14}N/^{15}N-DNA and 75% of molecules are^{14}N-DNA.

1 mark

d. Graph 1 = molecule *A* only; Graph 2 = molecule *C* only; Graph 3 = molecules *B* and *C*.

2 marks
2 marks if all three correct
1 mark if only one error
otherwise 0 marks
Total 7 marks

Question 3

a. DNA is heated to about 70°C. This breaks the hydrogen bonds between nucleotides so that single-stranded DNA is produced (1). The single-stranded DNA is cooled – and with heat-tolerant enzymes and free nucleotides – new double-stranded DNA molecules are formed along each single strand. The process is repeated through cycles (1).

2 marks
1 mark for denaturing reaction
1 mark for polymerase reaction

b. **i.**

3' A C A T T A G T G T A A T C G A T T A C A C T A A T G T A A 5'
5' A C A T T A G 3'

1 mark

ii. The DNA probe will anneal backwards to the single strand because DNA is anti-parallel and the sequence is complementary to the GATTACA DNA probe.

1 mark

c. As DNA is an acid it is negatively charged in solution. This is the reason why it moves through the gel away from the negative electrode.

1 mark

d. Male 1 is the father as his band pattern has bands in common with both children whereas male 2 does not.

2 marks
1 mark for correct answer
1 mark for explanation
Total 7 marks

Question 4

a. ribosomes

1 mark

b. Enzymes such as RNA polymerase break the hydrogen bonds between complementary nucleotides. Single-stranded RNA (where U replaces T) nucleotides are placed on the template strand so that the mRNA is formed in the 5'–3' direction.
(RNA polymerase is the catalyst for this process).

2 marks
1 mark for breaking H bonds
1 mark for mRNA synthesis

c.

Normal DNA

DNA template	T T G A T G C A C
mRNA	A A C U A C G U G
amino acid	asn tyr val

Mutated DNA

one change	T T **T** A T G C A C
mRNA	A A **A** U A C G U G
amino acid	**lys** tyr val

Note: There are other changes that would give a correct answer but they could only be the first or second nucleotide.

2 marks
1 mark for identifying the pre-mutational amino acid sequence
1 mark for showing post-mutation amino acid sequence

d.

stop signal	T T G A T C A C
peptide	asn stop

Note: This nucleotide is the only one that could be deleted to code for a stop signal.

1 mark

e. The stop signal is more likely to cause more disruption. The single base change is likely to change one amino acid. However, the stop interrupted the protein's formation near the start of the polypeptide and so no more amino acids would be placed onto the growing amino acid chains.

*Note: The other mutation types may **or** may not code for a stop.*

2 marks
1 mark for correct answer
1 mark for explanation
Total 8 marks

Question 5

a. In recent years (1995, 2005) a greater percentage of fungal strains are more resistant to higher concentrations of fungicide.

1 mark

b. **i.** Fungicide (triadimenol) concentration.

1 mark

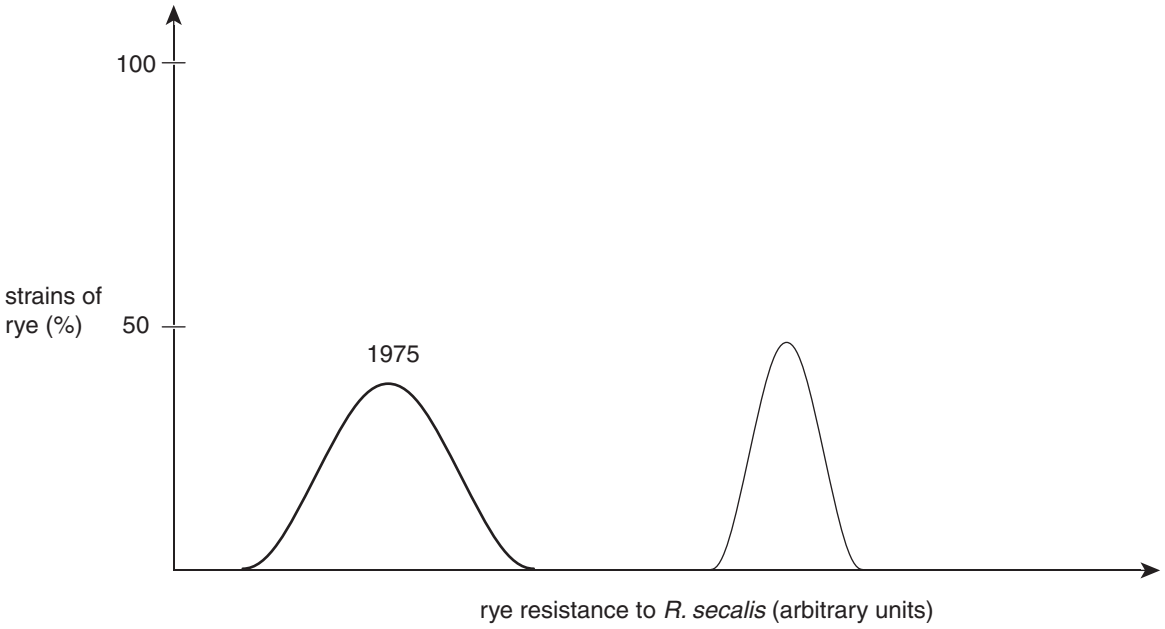
ii. Fungal resistance to fungicide (triadimenol).

1 mark

c. Obtain a large number of genetically identical fungicide sensitive *R. secalis* fungus (1).
Expose one group to fungicide (triadimenol). Do not expose the other group (1).
If genetic, most/all fungi from the exposed group will die (1).

3 marks

d. **i.**



1 mark

ii. Some rye strains would be naturally resistant to the fungus and would survive to pass their resistant alleles onto successive generations. This would shift the distribution curve of resistance to the right. At least one characteristic (height, width and distance) of the curve from its original position should be discussed.

Height: one would expect more strains of rye to be resistant.

Width: because the fungus is wiping out some strains, the spread of resistance would be more narrow.

2 marks
1 mark for mentioning a shift to the right
1 mark for mentioning height, width or distance of the curve's movement

Total 9 marks

Question 6

a. **i.** A condition (1) and an explanation (1). Such as:

- Rapid burial (1) so that predators will not destroy it (1).
- Low oxygen (1) which reduces decomposition (1).
- Other answers are acceptable as long as the condition is explained.

2 marks

ii. Radiometric dating (1) where the relative abundance of a radioisotope (e.g. ^{40}K) and its stable daughter atoms (e.g. ^{40}Ar) in the rock surrounding the fossil is used to calculate the rock's age (1).
As it is an included fragment, the skull will be slightly older than the rock layer. Carbon dating is incorrect here due to the age of the material.

2 marks

b. **i.** Any two of:

- The paucity of the fossil record makes clear comparisons difficult.
- The differences between forms could be caused by age differences and sexual dimorphism of the specimens.
- There is overlap between species in the range of sizes of skulls and teeth - the largest brains of *A. boisei* are the same size as the smallest ones of *H. habilis.*
- Fossils cannot be made to interbreed to determine if they are the same species or not.

2 marks

ii. Any one of:

- The relative position of the foramen magnum – a basal position on the skull is a good indicator of upright stance.
- Opposability of thumb to digits – this enables the precision and power grips essential for the manipulation of tools.
- Longer legs compared with arms – the higher the ratio, the more efficient the bipedal gait.

2 marks
1 mark for a correct skeletal feature
1 mark for its significance

c. **i.** Any one of

- The social and technological changes that have taken place in human societies over time.
- Non-genetic means of adaptation for survival.
- Changes in human societies due to the accumulation of knowledge through successive generations.
- A change in learned behaviour that is communicated to others over time.

1 mark

ii. Any two of

- The ability to make and use tools is the basis for technological development.
- A larger brain provides greater capacity for learning new knowledge and skills.
- The capacity for speech enables learnt information or behaviour to be communicated from one generation to the next.

2 marks
Total 11 marks