Neap:

Trial Examination 2010

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 A

The genome of an organism includes all the DNA within a cell. This includes the genes (both introns and exons), the sections of DNA that control genes, and all DNA remaining which may not have a function at present but is the focus of much research.

Question 2 B

Chromosomes that carry the same genes are said to be homologous. It cannot be concluded that the chromosomes are autosomal because they could be the sex chromosomes from a female. If haploid, only one chromosome would be illustrated. There are many genes along each chromosome and the individual would be heterozygous (example: **Bb**) as well as homozygous (example: **AA**).

Question 3 C

The number of genes is equal to the number of different letters on the diagram or the number of letters along one chromosome. There are 16 different alleles illustrated.

Question 4 C

The cell cycle is the sum of the events occurring from the production of one cell all the way to the generation of new cells from this pre-existing cell. The cycle starts with a growth phase (G1) followed by DNA replication (S) and then the DNA coils to form chromosomes (G2). This is collectively called interphase. Once the chromosomes are visible, the cell then goes through a process of division (mitosis or meiosis).

Question 5 B

Single stranded DNA would not contain uracil so **A** is incorrect. DNA is usually double stranded, meaning there should be an equal amount of A and T as well as an equal amount of G and C. Both **B** and **D** show this kind of relationship. In single stranded DNA it is neither necessary nor likely for A to equal T and G to equal C. Therefore **B** best confirms the idea that the DNA is single stranded.

Question 6 B

The DNA needs to unwind and mRNA forms along the template strand. Exons are removed before the mRNA leaves the nucleus to bind to a ribosome. Translation then occurs where the anticodons from the tRNA bind to the codons along the mRNA. The tRNA has an amino acid bound to it and it is placed in order on the growing peptide.

Question 7 D

There are twenty amino acids that are the building blocks for protein. The mRNA is read in groups of three nucleotides (codons) which mean there are 64 different codons possible. It is imperative that the correct amino acid is placed in the correct position in the polypeptide for specificity. The DNA code is said to be degenerate (many codons coding for fewer amino acids). More than one codon may provide the blueprint for the same amino acid and there is also room for the code to have a starting point (start) and an end point (stop). The 'start' codon codes for the amino acid methionine.

Question 8 C

For the parents to have children with the four different blood types, they would both need to be heterozygous. One parent would have the genotype $\mathbf{I^A\,i}$ and the other $\mathbf{I^B\,i}$. This means there would be a chance of each blood type A, B, O and AB.

Question 9 B

The pure-breeding genotypes will be **AABB** (all offspring will inherit the **A** and **B** alleles), **aaBB** (all offspring will inherit the alleles **a** and **B**), **AAbb** (all offspring will inherit the alleles **A** and **b**) and **aabb** (all the offspring will inherit the **a** and **b** alleles).

Question 10 A

The cross is **Aabb** (male) × **aaBb** (female).The possible gametes and the possible offspring genotypes and phenotypes are shown in the following Punnett square.

	Possible female gametes	
Possible male gametes	**aB**	**ab**
Ab	**AaBb** (walnut comb)	**Aabb** (pea comb)
ab	**aaBb** (rose comb)	**aabb** (single comb)

Question 11 A

The RNA polymerase binds to the DNA and 'reads' the template DNA and converts it to mRNA to be translated. For the RNA polymerase to bind to the DNA, the operator would need to be activated, not repressed. If a repressor is involved, the presence of lactose would inactivate it (remove it from the operator) so the operator is 'available' for the RNA polymerase to bind to it.

Question 12 D

At least one gene must contain the genetic code for assembling a single polypeptide. Three enzymes are required by *Mucor* to convert raw materials into arginine, so a minimum of three genes must be involved.

Question 13 C

Eco RI and *Not* I together cut the DNA sample at four points. Because the DNA is linear, the number of lengths of DNA resulting from digestion by restriction enzymes is $n + 1$, where n is the number of cuts.

Question 14 D

A recombinant plasmid is a piece of extra-chromosomal bacterial DNA containing an inserted gene or genes that originated from a different genome. To prepare such a plasmid, it is cut open with a restriction enzyme that produces 'sticky ends' to which the inserted length of donor DNA (the 'foreign' gene) can be annealed by the enzyme DNA ligase. **C** is therefore incorrect, and the wording of **A** is also incorrect since 'sticky ends' are complementary to other 'sticky ends', not DNA ligase. It is often true that recombinant plasmids contain antibiotic resistance genes to help in the identification of those bacteria that contain them. However, it is *most* important that both the plasmid and the donor DNA are cut with the same type of restriction enzyme so that complementary 'sticky ends' are produced.

Question 15 B

The pedigree shows a couple who are both unaffected with the condition, having a child with the condition. This shows the trait 'skips' a generation which is indicative of recessive patterns of inheritance. To eliminate sex-linked inheritance you need to find an affected female. For the trait to be located on the X chromosome, her father must be affected as well as any sons she may have. This is clearly not the case in the pedigree.

Question 16 B

Now it is established that the pattern of inheritance is autosomal recessive. Person 1 must be heterozygous and so has 2 bands on the profile. Person 2 must be homozygous as they express the condition and because the faulty allele is smaller it would move further through the gel compared to the normal allele. Person 3 is heterozygous and would thus have a profile similar to person 1.

Question 17 C

The only clear conclusions that can be made are that the plants are all the same species but those growing at different altitudes grow to different heights. This means they are phenotypically different because the phenotype is the observed appearance of an organism which can be brought about by the environment as well as the genes present.

Question 18 D

To test this idea you need to make a comparison. Taking seeds from one altitude and planting it at another altitude would be the best way to make a clear comparison. The results show the bigger the difference in altitude, the bigger the difference in height. There is not much difference in the height of plants at 1000 m and 1200 m but there is a big difference in height from 1000 m to 3000 m.

Question 19 C

Genetic drift refers to random changes in allele frequencies due to non-biological causes. It is only likely to cause a systematic increase in the frequency of alleles for long beaks in small populations of birds with a relatively high initial frequency of these alleles. Likewise, in the absence of further information it is hard to see how migration processes could produce such a directional change. It would appear that a selection pressure selecting for longer beak length is acting on this bird population.

Question 20 A

Host organisms for parasitic bacteria rarely double their numbers every 20–30 minutes like the bacteria do. **B** is obviously false. Parasitic bacteria select for parasite resistance in host organisms. Although individual host organisms are often killed by parasitic bacteria, bacterial disease rarely renders a whole population of host organisms extinct since this would simultaneously result in the extinction of the parasite. Parasitic bacteria and their host species therefore co-evolve with selection against the most virulent strains of bacteria. **C** and **D** are therefore unlikely to be the best answers.

Question 21 C

The horns/antlers of some beetles and mammals have similar functions (display and combat during territorial or mating disputes) and have evolved in response to similar selection pressures. However, they are structurally different since the horns of beetles are chitinous extensions of the exoskeleton while those of mammals are formed from bone (e.g. deer, antelope) or highly compressed hair (e.g. rhinoceros). This is therefore a clear example of convergent evolution.

Question 22 B

D is unlikely since the volcano is extinct and its crater would not have been a suitable habitat for frogs while it was active. **A** is incorrect because a specific mutation (e.g. fangs) can occur spontaneously in an individual organism but not in a whole population. It is unlikely that the crater would be accessible to mutant fanged frogs and not to non-mutant, wild-type frogs, with which they would interbreed to suppress the mutant phenotype. **C** is therefore unlikely. **B** is the best answer because it correctly describes a necessary part of the process of allopatric speciation.

Question 23 B

The S-shaped spinal column of hominins evolved to permit an upright bipedal gait. **A** is incorrect because hominids include not only the hominins but also the quadrupedal great apes (e.g. gorillas) which have sloping foreheads. **C** is incorrect because the reduction in size and specialisation of teeth is apparent in *Australopithecus* species and *Homo habilis* without a flattening of the face, which coincided with the later evolution of a much bigger brain. Bipedalism is believed to have provided hominins with a more diverse and more easily digestible diet requiring smaller teeth, so **D** is unlikely.

Question 24 A

The earliest known hominin fossils (about 2–3 million years old) do indeed originate from East Africa, so **B** is wrong. **C** and **D** are also incorrect. Radiocarbon dating is only useful for measuring the age of very recent hominin fossils, not the earliest, because all the detectable 'radiocarbon' (14C) in a fossil would have decayed to nitrogen gas after approximately 50 000 years. Radiocarbon dating is used to date the organic material in a fossil directly, rather than the rock containing the fossil. However, stone tools (often made of flint) do not contain organic carbon.

Question 25 A

In a sequence of sedimentary rocks, generally the lower-most layer of rock is the oldest and the top-most is youngest. Layers of rock that contain the same fossils are the same age. Using this logic, the layers can be arranged in order of increasing age as follows.

IX $\rightarrow$ VIII $\rightarrow$ IV + VII $\rightarrow$ III $\rightarrow$ II + VI $\rightarrow$ I + IV

SECTION B: SHORT-ANSWER QUESTIONS

Question 1

a. **i.** chinchilla – $\mathbf{C^{Ch}C^{Ch}}$, $\mathbf{C^{Ch}C^{H}}$, $\mathbf{C^{Ch}C^{a}}$ 1 mark

ii. agouti – $\mathbf{C^{A}C^{A}}$, $\mathbf{C^{A}C^{Ch}}$, $\mathbf{C^{A}C^{a}}$, $\mathbf{C^{A}C^{H}}$ 1 mark

b. A heterozygous Himalayan rabbit must be $\mathbf{C^{H}C^{a}}$

The albino rabbit must be $\mathbf{C^{a}C^{a}}$

Genetic diagram as follows:

	Female parental genotype $\mathbf{C^{H}C^{a}}$ **Possible female gametes**	
Male parental genotype $\mathbf{C^{a}C^{a}}$ **Possible male gametes**	$\mathbf{C^{H}}$	$\mathbf{C^{a}}$
$\mathbf{C^{a}}$	$\mathbf{C^{H}C^{a}}$ (Himalayan)	$\mathbf{C^{a}C^{a}}$ (albino)
$\mathbf{C^{a}}$	$\mathbf{C^{H}C^{a}}$ (Himalayan)	$\mathbf{C^{a}C^{a}}$ (albino)

1 mark

If the Himalayan rabbit is heterozygous, some albino offspring will be produced (50% expected), so the friend's statement is true. 1 mark

Note: There must be a genetic diagram for both marks to be awarded, and it must show parental (as well as offspring) genotypes and phenotypes and include some form of clearly constructed grid (Punnett square)

c. Himalayan rabbits express the $\mathbf{C^{H}}$ allele. This allele is switched on by low temperatures so melanin is made; extremities of the rabbit's body are cooler than the rest of the body in winter so the gene is expressed here and pigment forms giving black fur. 1 mark

Black agouti rabbits express the temperature-independent $\mathbf{C^{A}}$ allele so pigment is formed all year round in all skin cells, giving black fur. 1 mark

d. Big Ears has the genotype $\mathbf{C^HC^aMm}$

The male agouti rabbit must be $\mathbf{C^AC^aMm}$ 1 mark

Male parental genotype C^AC^aMm **Possible male gametes**	**Female parental genotype C^HC^aMm** **Possible female gametes**			
	C^HM	**C^Hm**	**C^aM**	**C^am**
C^AM	**C^AC^HMM** (agouti, normal)	**C^AC^HMm** (agouti, normal)	**C^AC^aMM** (agouti, normal)	**C^AC^aMm** (agouti, normal)
C^Am	**C^AC^HmM** (agouti, normal)	**C^AC^Hmm** (agouti, affected)	**C^AC^amM** (agouti, normal)	**C^AC^amm** (agouti, affected)
C^aM	**C^aC^HMM** (Himalayan, normal)	**C^aC^HMm** (Himalayan, normal)	**C^aC^aMM** (albino, normal)	**C^aC^aMm** (albino, normal)
C^am	**C^aC^HmM** (Himalayan, normal)	**C^aC^Hmm** (Himalayan, affected)	**C^aC^aMm** (albino, normal)	**C^aC^amm** (albino, affected)

1 mark

The expected proportion of affected agouti offspring is $\frac{2}{16}$ $\left(\text{or } \frac{1}{8}\right)$. 1 mark

Total 9 marks

Question 2

a. **i.** 54 1 mark

ii. 4 1 mark

b. Sex chromosomes do not assort independently as there are only two 'types' of sperm (those containing $X_1X_2X_3X_4X_5$ OR $Y_1Y_2Y_3Y_4$). 1 mark

This would lead to conception of females (only X chromosomes) and males (X and Y chromosomes). 1 mark

c. **i.** A fluorescent probe is a section of DNA that is charged with a 'desired' section of DNA with a fluorescent marker attached. 1 mark

ii. By increasing the size of the probe, the likelihood of sections of DNA other than the desired section being targeted is reduced. 1 mark

Total 6 marks

Question 3

a. apoptosis/programmed cell death 1 mark

b. DNA is a long term form of the genetic code stored in the nucleus while mRNA is a short-lived form of part of the genetic code that leaves the nucleus. 1 mark

DNA is genetic code that is transcribed to make mRNA while mRNA is translated to make protein. 1 mark

Note: clear comparative statements must be made to earn both marks

c. **i.** siRNA is smaller than mRNA OR contains fewer nucleotides OR only matches part of gene 1 mark
siRNA is double-stranded while mRNA is single-stranded 1 mark

ii. hydrogen bonding (between purines and pyrimidines) 1 mark
involving the (complementary) base-pairing of A with U and C with G 1 mark

d. The siRNA is injected into cells as a drug; drug treatments cannot be inherited.

Alternatively, the siRNA is not encoded in or transcribed from a gene (DNA) in the mouse genome and cannot therefore be inherited. 1 mark

Total 8 marks

Question 4

a. Snails have a shell for protection, but sea slugs need a different defence such as poison or the bright colours that are recognised as warnings of poison by predators. 1 mark

b. *Any three of the following*:

- a more accurate alternative measurement of fish feeding, e.g. mass of food consumed or frequency of visits to the red ring
- use of a suitable control, e.g. the red ring contains no food or inedible floating material of similar appearance to fish food
- use the same colour rings for both food and unpleasant material
- repeat the experiment more times OR with other species of fish
- use a much larger number of goldfish
- control key variables, e.g. water temperature, the age and sex and developmental stage of the fish
- any other sensible suggestion 2 marks

1 mark for two points; 2 marks for three points

c. **i.** Fish learn to associate warning patterns, rather than specific species of sea slugs, with poison. 1 mark

Shared warning pattern minimises fish attacks and increases survivorship in any species that displays this pattern of pigmentation. 1 mark

ii. Predation (by fish) is a selective pressure acting on a population of sea slugs (with white sea slugs getting eaten) in which a random OR spontaneous OR chance mutation in a gene (which produces red-spotted sea slugs) gives rise to a selective advantage. 1 mark

Red-spotted sea slugs are more likely to survive, reproduce and pass on (red-spot) allele/mutated gene to their offspring. 1 mark

This selective process is repeated over many generations so that the frequency of the red-spot allele OR red-spotted sea slugs increases in frequency in the population. 1 mark

Total 8 marks

Question 5

a. i. *Any one of:*

- Compsognathidae
- Tyrannosauridae
- Ornithomimosauria
- Alvarezsauridae 1 mark

ii. absence of simple filamentous feathers would place it closer to Carnosauria as the presence of these feathers would place them with Other Compsognathidae 1 mark

If the age of the *Juravenator* were similar to Other Compsognathidae (which would be more recent), it would have diverged from them rather than the older Carnosauria. 1 mark

b. i. Rapid burial (to avoid scavenging), generally at the bottom of a lake 1 mark

Low decomposition rate generally found under water as it is colder and less conducive to decomposition 1 mark

ii. Radioisotopic dating (not carbon dating) such as potassium argon dating 1 mark

Measure how much of the isotope is present in the fossil compared to how much is present in new rock. Each isotope has a known half-life and so the age of the fossil could be determined. 1 mark

c. Proposal is inaccurate. A mutation may have occurred that produced a feather that was more complex but it must have been a pre-existing mutation 1 mark
as the environment does not cause specific mutations to occur. This is a Lamarckian statement. 1 mark

Total 9 marks

Question 6

a. Technological evolution is the development of better tools to enable a higher quality of life 1 mark

and so genetically modified food is a form of technological evolution because past developments (such as gene mapping, DNA cutting) have enabled this technology to become a reality. 1 mark

b. using a vector like a plant virus OR bacterial plasmid (carried in a bacterium) OR a gene gun OR a liposome 1 mark

c. The plants are unable to reproduce or cross pollinate with other non-GM soyabean crops. 1 mark

Human consumption of the plant's products show no health concerns. 1 mark

Total 5 marks

Question 7

a. Hominins are humans and their bipedal ancestors. 1 mark

b. i. Size of the brain case is much bigger in the human compared to the hobbit. 1 mark

ii. If several hobbits were found and not all had small brain cases then it may suggest that not all hobbits had small brain cases. 1 mark

c. Mitochondria are inherited through the maternal line. mtDNA only varies due to mutation and mutations occur at a set rate. 1 mark

Mutations accumulate over time so the more recently the human and hobbit diverged, the more similarity they would have in their mtDNA. 1 mark

Total 5 marks