THE SCHOOL FOR EXCELLENCE (TSFX)

UNIT 4 BIOLOGY 2010

WRITTEN EXAMINATION 2

Reading Time: 15 minutes
Writing Time: 1 hour 30 minutes

QUESTION AND ANSWER BOOK

Structure of Booklet

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*	*Suggested times (minutes)*
A	25	25	25	30
B	8	8	50	60
Total			75	90

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.
- No calculator is allowed in this examination.

Materials supplied

- Question and answer book.

Instructions

- Write your name in the space provided on this page.
- All written responses must be in English.

At the end of the examination

- Place the answer sheet for the multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other electronic communication devices into the examination room.

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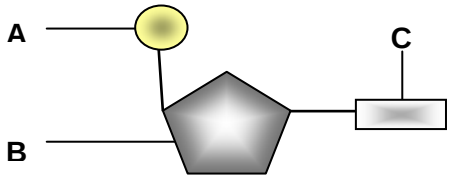
SECTION A – MULTIPLE-CHOICE QUESTIONS

Instructions for Section A

Answer all questions in pencil on the answer sheet for multiple-choice questions. A correct answer scores 1, an incorrect answer scores 0. Marks will **not** be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

QUESTION 1
The following diagram represents a nucleotide of an RNA molecule. Which of the following statements is true?



A C represents a nitrogenous group
B B represents a deoxyribose sugar
C B represents a phosphate group
D A represents a ribose sugar

QUESTION 2
Mammal sex chromosomes:

A Are found only in sex cells
B Form homologous pairs during meiosis
C Number 46 in diploid cells
D Include genes determining characteristics unrelated to sexual characteristics

QUESTION 3
DNA replication takes place prior to the processes of mitosis or meiosis. DNA polymerase recognises the section of DNA to start replicating from by the presence of a:

A Promoter sequence
B Primer
C Probe
D Methyl cap

QUESTION 4
During mitosis, the phase in which cells have the greatest number of chromosomes at any one time includes:

A Early prophase
B Late prophase
C Early metaphase
D Early anaphase

QUESTION 5
Which of the following events is least important in generating genetic diversity within a species?

A Crossing over
B Splitting of centromeres at anaphase II
C Independent assortment
D Fertilisation

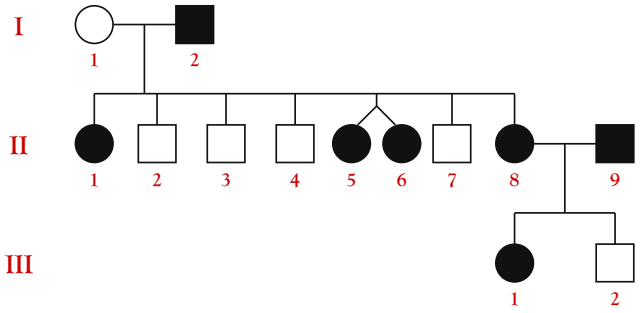
QUESTION 6
The phenotype of an allele that is fully expressed in a heterozygote is referred to as:

A Dominant
B Recessive
C Homologous
D Heterozygous

QUESTION 7
Incontinentia pigmenti is a genetic disorder that affects the skin, hair, teeth, nails, and the central nervous system. Symptoms include loss of hair, small teeth, abnormal tooth shape, and mis-shaped nails. Some patients have retinal vascular abnormalities which can lead to retinal detachment in early childhood. Cognitive delays/mental retardation are occasionally seen.

Discolored skin is caused by excessive deposits of the normal skin pigment, melanin.

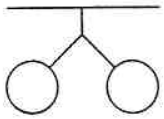
A family with this condition is depicted in the pedigree below:



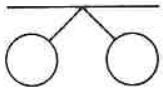
What is the most likely mode of inheritance of incontinentia pigmenti?

A X-linked dominant
B X-linked recessive
C Dominant
D Autosomal dominant

QUESTION 8
The inheritance of a characteristic within a family is often represented by pedigrees. In a pedigree symbols depicted in Diagrams I and II can be encountered.



I



II

What do these symbols represent?

A I = identical twin girls; II = non-identical twin girls.
B I = non-identical twin girls; II = identical twin girls.
C I = identical twin boys; II = non-identical twin boys.
D I = identical twin girls; II = normal sisters.

QUESTION 9
Pre-mRNA consists of coding sections (exons) and non-coding sections (introns). It was previously thought that a particular section of a gene was always an exon or an intron. It has since been discovered, however, that in approximately 30% of all human genes, what constitutes an intron and an exon for the one particular gene can vary. These variations occur at different stages of the body's development, or when the gene is located within different types of cells.

A consequence of this discovery is that:

A One gene can code for more than one polypeptide.
B DNA is not a truly universal molecule.
C The pre-mRNA transcribed from these genes must be of greater length than other pre-mRNA molecules.
D Most genes of eukaryotic cells lack introns.

QUESTION 10
A particular mammalian cytochrome c protein consists of 104 amino acids. The expected number of codons making up the mRNA molecule responsible for the synthesis of this protein would be:

A 103
B 104
C 105
D 106

QUESTION 11
A mutation is a permanent change in the genetic material (or DNA sequence) of an organism. The following is true of mutations:

A Mutations can be induced by mutants.
B All organisms surviving today are present after millions of years of evolution, so any mutation occurring today would be harmful.
C A substitution is an example of a frame shift mutation.
D Premature stop codons can result from substitutions, additions or deletions.

QUESTION 12
An mRNA code dictionary is shown below:

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU - Phe	UCU - Ser	UAU - Tyr	UGU - Cys	U
	UUC - Phe	UCC - Ser	UAC - Tyr	UGC - Cys	C
	UUA - Leu	UCA - Ser	UAA - stop	UGA - stop	A
	UUG - Leu	UCG - Ser	UAG - stop	UGG - Trp	G
C	CUU - Leu	CCU - Pro	CAU - His	CGU - Arg	U
	CUC - Leu	CCC - Pro	CAC - His	CGC - Arg	C
	CUA - Leu	CCA - Pro	CAA - Gln	CGA - Arg	A
	CUG - Leu	CCG - Pro	CAG - Gln	CGG - Arg	G
A	AUU - Ile	ACU - Thr	AAU - Asn	AGU - Ser	U
	AUC - Ile	ACC - Thr	AAC - Asn	AGC - Ser	C
	AUA - Ile	ACA - Thr	AAA - Lys	AGA - Arg	A
	AUG - Met/start	ACG - Thr	AAG - Lys	AGG - Arg	G
G	GUU - Val	GCU - Ala	GAU - Asp	GGU - Gly	U
	GUC - Val	GCC - Ala	GAC - Asp	GGC - Gly	C
	GUA - Val	GCA - Ala	GAA - Glu	GGA - Gly	A
	GUG - Val	GCG - Ala	GAG - Glu	GGG - Gly	G

The mRNA sequence *AUG – CUC – GAU – UAA – CGA – ACC* would code for the peptide:

A Met – Leu – Asp – stop – Arg – Thr
B Ile – Leu – Asp – stop – Arg – Thr
C Met – Leu – Asp
D Ile – Leu – Asp – Tyr

QUESTION 13
As a result of gene technology, many creatures are genetically modified organisms (GMOs). In most cases, these creatures are also transgenic organisms (TGOs).

Which of the following organisms are GMOs, but not TGOs?

A Herbicide-resistant corn plants.
B Potatoes with antifreeze genes, allowing for their growth in alpine conditions.
C Cats with small interfering RNA (siRNA) molecules which destroy allergen mRNA molecules within salivary gland cells.
D Bacteria that produce insulin.

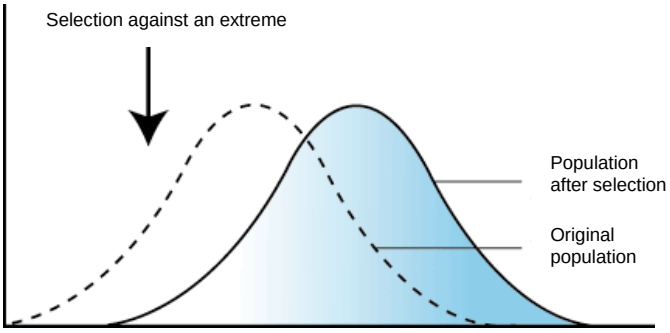
QUESTION 14
Multinational companies that develop genetically modified (GM) crop species (eg. GM corn) have been accused of forcing farmers into growing their transgenic seed varieties, otherwise, buyers for their produce will be difficult to find. This is because the same companies are often the buyers of the farmers' produce.

One of the genetic issues associated with the growth of GM crops is:

A That biodiversity of crop varieties is falling.
B Designer babies are only the next step in using this technology.
C Organic crop producers suffer lowered self esteem.
D Plants are being produced for the sole purpose of providing body parts.

The following information refers to Questions 15 and 16:

Different types of natural selection can take place within a population. In cases of directional selection, one extreme of the trait distribution experiences selection against it. This process can ultimately lead to the evolution of new species.



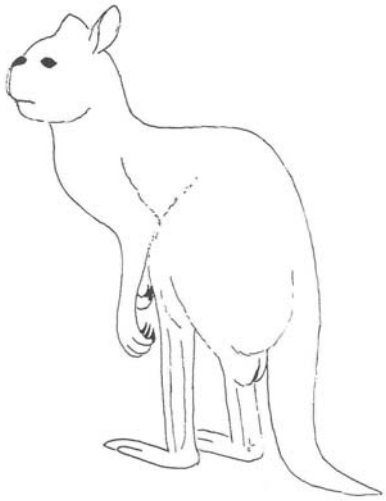
QUESTION 15
The following is an example of directional selection:

A The deep sea coffin fish is a living fossil.
B Short members of an ancestral plant variety, *Calocephalus*, were not able to compete with other plants of the same species for sunlight, however, extremely tall plants were more susceptible to wind damage, so selection pressures favoured medium height plants.
C In Galapagos finches, big beaks are well suited for big seeds, and small beaks for small seeds, however, medium-sized beaks cannot be used to retrieve small seeds, and are not tough enough to crack open the bigger seeds.
D A selection pressure existed against ancestral giraffes with short necks, as individuals with short necks could not reach as many leaves on which to feed.

QUESTION 16
In which of the examples given in Question 15 is a polymorphic population most likely to result?

A The form of the deep sea coffin fish.
B The height of *Calocephalus* plants.
C The beak sizes of Galapagos finches.
D The neck lengths of giraffes.

Thousands of years ago Australia was largely forested. Kangaroos living in this period were browsers on the foliage of trees and shrubs, and they all possessed short noses to accommodate this diet.



As the continent dried out, however, and grasslands became the dominant species in many habitats, all kangaroo species developed long grazing snouts from their short-nosed browsing ancestors, resulting in the species found today.

QUESTION 17
The development of grazing snouts in today's kangaroo species from the browsing snouts of their ancestors is an example of:

A Parallel evolution
B Allopatric speciation
C Divergent evolution
D Adaptive radiation

QUESTION 18
Today's large flightless birds, the ratites (eg. ostriches, emus and cassowaries), are found only in Africa, South America, Australia, Papua New Guinea and New Zealand. Their distribution and features:

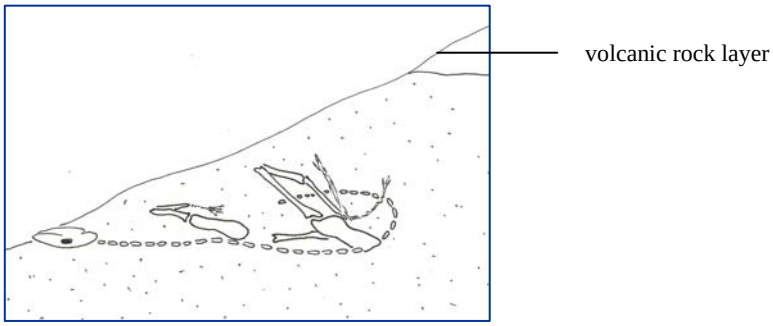
A Represent examples of convergent evolution.
B Indicate the existence of an ancestral species which originated in Gondwana.
C Indicate the existence of an ancestral species that was a water bird.
D Represent examples of parallel evolution.

QUESTION 19
Remnant homologous structures of no or marginal use are known as vestigial structures. Vestigial structures of the human embryo that have disappeared in the adult human body include:

A The coccyx
B The appendix
C Wisdom teeth
D Gill slits

The following information refers to Questions 20 and 21:

After a vicious attack by a tyrannosaurus approximately 90 million years ago, an ailing dinosaur collapsed in the shallows of a nearby lake and died. Over millions of years, a fossil of the dinosaur formed. Since the fossil formation, volcanic activity in the region created another layer of rock which formed above the layer of rock containing the dinosaur.



After some of its skull was exposed (see above), the entire fossil was recovered recently from what is now a desert region in Asia.

QUESTION 20
A possible technique used in assisting the dating of this dinosaur fossil could have been:

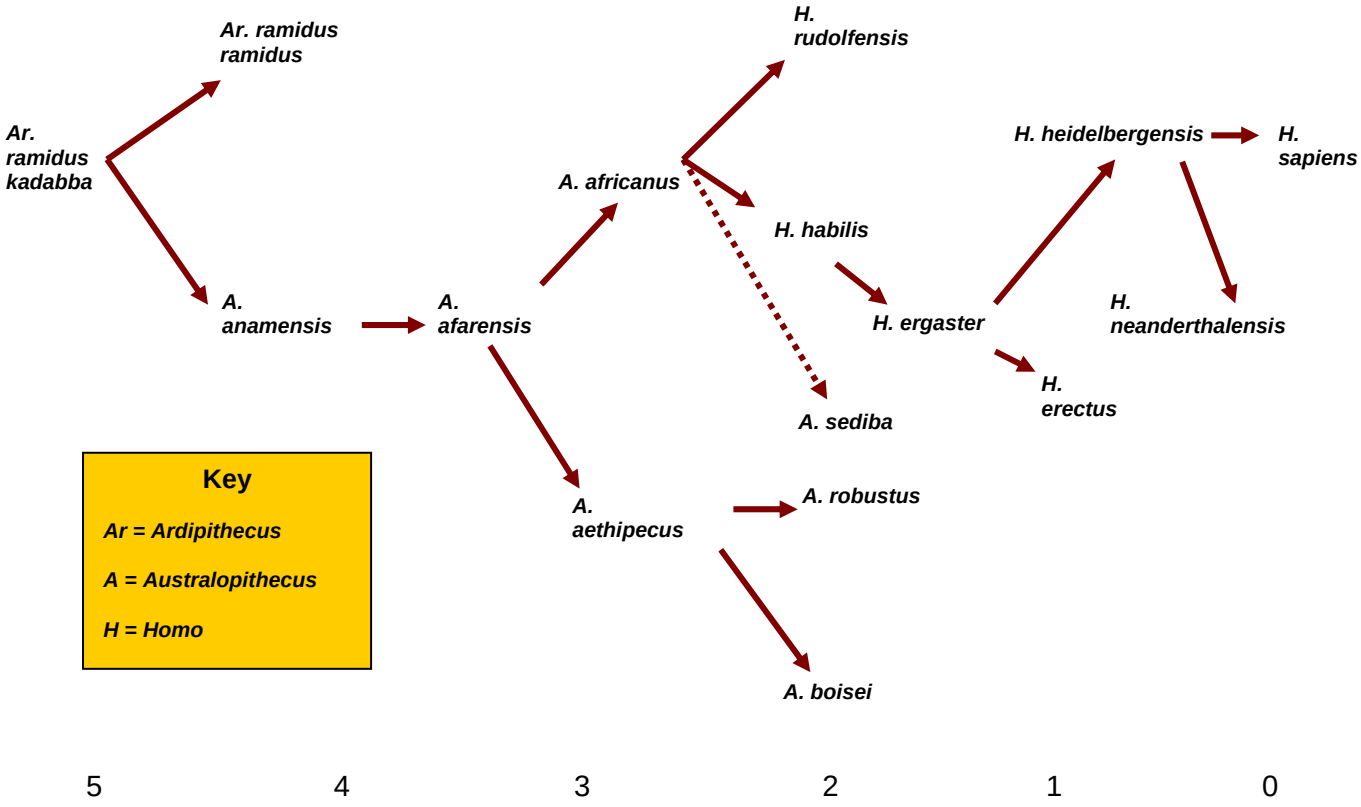
A Potassium-argon dating of the volcanic rock layer.
B Radio-carbon dating of the volcanic rock layer.
C Radio-carbon dating of the fossil.
D Potassium-argon dating of the fossil.

QUESTION 21
Fossilisation of the dinosaur was probably enhanced by:

A Dying in sediment in a dry desert environment.
B A coating of sand particles on bones and teeth.
C Rapid decomposition of soft tissues.
D Dying in sediment in an aquatic environment.

The following information refers to Questions 22 to 24:

A proposed hominin phylogenetic tree is shown below:



QUESTION 22
The gracile Australopithecines depicted in the above phylogenetic tree include:

A *Australopithecus africanus* and *Australopithecus afarensis*
B *Australopithecus boisei* and *Australopithecus afarensis*
C *Australopithecus robustus* and *Australopithecus africanus*
D *Australopithecus afarensis* and *Australopithecus robustus*

QUESTION 23
Which of the following hominin species is thought by most anthropologists to have been the first to leave Africa?

A *Homo heidelbergensis*
B *Australopithecus boisei*
C *Homo ergaster/erectus*
D *Homo neanderthalensis*

QUESTION 24
To the excitement of the scientific world, a complete specimen of *Ardipithecus ramadus* was recently discovered in Africa. Previously only known from a limb bone and jaw fragment, fragments from 35 other individuals were also found with the complete specimen. Known as Ardi, many of her features were far more primitive than those of today's chimpanzees, with a similar brain size of 400 mL.

Primitive hominin features of Ardi could have included:

A Thumbs on her feet.
B A reduced brow ridge.
C A foramen magnum underneath her skull.
D Antelope and peacock fossils located alongside her skeleton.

QUESTION 25
Some scientists question the theory that hominins evolved entirely in Africa. With the discovery of the 'hobbit' on Flores Island in Indonesia, some debate has arisen about the origin of hominins. The hobbit was a hominin of very small stature, reaching just over one metre in height, and it possessed many features in common with early *Homo* species, or even Australopithecines.

This discovery has led some scientists to believe that *Homo* species have evolved outside of Africa at a similar time to their evolution within Africa, while most scientists still believe that the original *Homo* species only evolved within Africa (the Out of Africa theory), and from Africa they spread to all parts of the globe.

Evidence to support the Out of Africa theory would include:

A Transitional forms of hominins being found in Africa, Europe and Asia.
B The discovery of New World monkeys with a pelvis adapted for bipedalism.
C Variation in mtDNA being greater in African populations than in other populations.
D Modern humans appearing in the fossil record throughout Africa, Asia and Europe during the same period.

SECTION B – EXTENDED RESPONSE QUESTIONS

Instructions for Section B

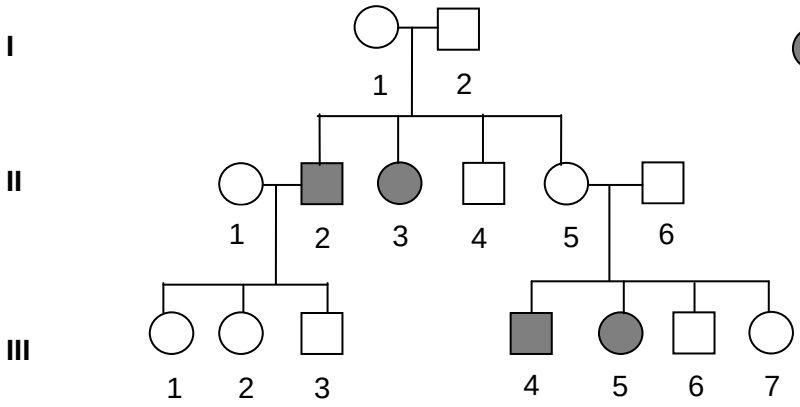
Answer this section in **pen**.
Answer all questions in the spaces provided.

QUESTION 1

In mice, fur colour can be black or white.

○ and □ = black

● and ■ = white



(a) State the mode of inheritance for white fur.

_____

1 mark

(b) State the reasoning for your answer.

_____

_____

_____

_____

2 marks

(c) State the possible genotypes of the following individuals.

I1 _____ II 1 _____ II5 _____ III 4 _____

2 marks

(d) If individuals I 1 and II 5 are mated, determine the phenotypes possible in their offspring and state their expected frequencies. Show all working.

2 marks

Total 7 marks

QUESTION 2
Gene expression is the process by which information from a gene is used in the synthesis of a functional gene product. In genetics, gene expression is the most fundamental level at which genotype gives rise to the phenotype.

(a) What is the product of transcription?

_____

1 mark

(b) Before this molecule leaves the nucleus it undergoes some modifications. State two of these changes to the molecule.

_____

_____

_____

_____

2 marks

(c) Geneticists have made use of the enzyme reverse transcriptase.

(i) What function does this enzyme perform?

_____

_____

1 mark

(ii) Describe one situation where there is an advantage in using this enzyme.

_____

_____

_____

1 mark

(d) Using microarray technology, scientists can study thousands of genes in an individual at once. What is the purpose of this technology?

_____

_____

1 mark

(e) Scientists have determined that all genes are not expressed in all cells at any one time. State two reasons why you believe this is the case.

_____

_____

_____

_____

_____

2 marks

Total 8 marks

QUESTION 3

Doctors working in eastern Africa regularly prescribed the use of antibiotic Z to treat bacterial eye infections. However, within two years the same drug had almost no effect. They also discovered that many patients did not finish their tablets, instead stopping after a day or two when their eyes started to clear up.

Image: africa-countries-horn.png

(a) Explain what has happened to the bacterial population over the two years

3 marks

A new drug Z23 has been developed for use on the same eye infections. Before using it on people it is to be tested on the bacteria in the lab.

(b) Design the experiment to test the effectiveness of Z23. Begin by stating the hypothesis. State the results that would support your hypothesis.

5 marks

Total 8 marks

QUESTION 4

PCR is a technique routinely used in genetic laboratories. It is particularly useful in forensic investigations where trace amounts of DNA can be obtained from clothing, body fluids, hair etc.

(a) What do the letters PCR stand for?

_____

1 mark

A researcher wishes to amplify a sample of DNA found at a crime scene. The DNA is believed to belong to a 20 year old male who assaulted a school boy.

(c) State four ingredients he would add to the tube.

_____

_____

_____

_____

2 marks

The victim gave an unusual description of his attacker. His attacker had jerky movements (including hand-flapping), and an oddly happy demeanour.

The forensics team believe the police may be looking for someone with Angelman syndrome in which sufferers have a portion missing on chromosome 15. They decide to test the DNA sample and begin by amplifying a region on chromosome 15.

'Normal' chromosome 15: … ATGTAAGGGATAGTTTTAGAAA**CT**…

Attacker's chromosome 15: …ATGTAAG**CT**…

Note: The cysteine and thymine at the end of each sequence above are the same.

(c) What type of mutation has occurred?

_____

1 mark

This mutation creates a recognition sequence for the *Alu I* enzyme which cuts at AGCT between the guanine and cysteine.

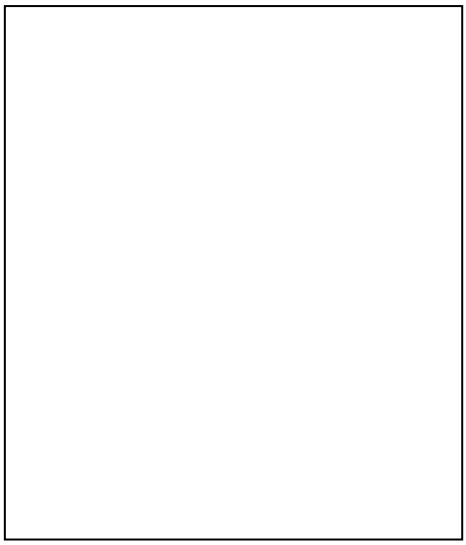
(d) On the DNA sequence above, clearly show the cutting site(s) for *Alu I*.

1 mark

The amplified DNA from the region of chromosome 15 is now cut with *Alu I* and run on a very sensitive polyacrylamide gel.

Sufferers of Angelman syndrome inherit a normal copy of chromosome 15 from their father, but a mutated version of chromosome 15 from their mother.

(e) Draw a gel showing the wells, and the fragments of different sizes for both a control individual and a person with the mutation. Fully label your diagram.



2 marks

(f) To which terminal does DNA move? Explain.

_____

_____

2 marks

Total 9 marks

QUESTION 5

The dingo is a carnivorous mammal that is believed to have migrated to Australia with the second wave of Aborigines approximately 10,000 years ago. At that time, these dogs were more closely related to their wild Asian Gray Wolf parent species, *Canis lupus* than they are today.

Over time, they have developed features which distinguish them from all other canines and have been classified as *Canis lupus dingo,* which is a distinct subspecies from the domestic dog, *Canis lupus lupus*.

DNA tests of the dingo populations have shown that gene flow is occurring between their populations and those of domestic dogs. Approximately 80% of dingoes along the eastern seaboard of Australia are hybrids.

(a) What is meant by gene flow?

_____

1 mark

(b) How does gene flow affect allelic frequency?

_____

_____

1 mark

(d) What sort of event could cause a bottleneck in the dingo population?

_____

_____

1 mark

Total 3 marks

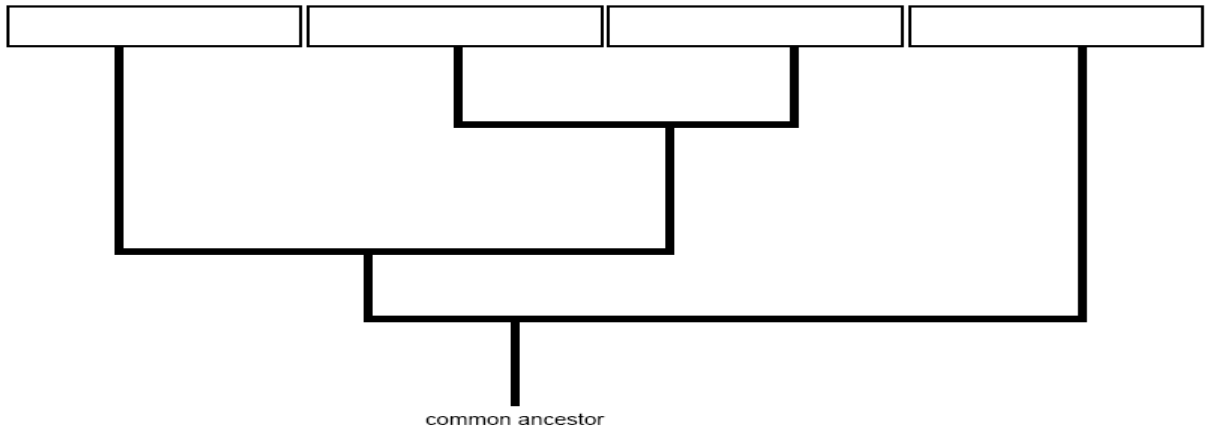
QUESTION 6
The platypus is an egg-laying mammal which produces milk and has fur. It has a bill like a duck and venom similar to that of a snake flowing from a spur under its hind feet.

Scientists have revealed that it is one of the first mammals to have evolved from reptiles, possessing the characteristics of both animal groups. Researchers have also discovered that the venom genes found in male platypuses, are similar to those of snakes and reptiles.

The platypus has been described as the missing link in our understanding of how mammals first evolved. It is now believed that the first mammals laid eggs and suckled their young, and as such the platypus is known as a ***monotreme***.

Younger mammals, (which diverged later), include the marsupials and placentals. Marsupials (such as kangaroos, koalas etc.) have a pouch and give birth to their young at a very immature stage of development. Placental mammals have a placenta, a longer period of gestation (pregnancy) and give birth to young which are more developed.

(a) Based on the information above, write the names of these four groups (marsupials, placentals, monotremes and reptiles) in the boxes at the top of the diagram below. Ensure that the evolutionary relationships between them are consistent with the information provided.



2 marks

(b) What term would be used to describe the evolution of these four animal groups?

_____

1 mark

(c) What evidence would you look for to support your answer in (b)?

_____

_____

1 mark

(e) The platypus was described as a ***'missing link'*** in the fossil record. What does this mean?

_____

_____

_____

1 mark

(d) Platypus DNA has been compared to echidna DNA using DNA hybridisation studies. What does this involve?

_____

_____

_____

_____

_____

_____

2 marks

Total 7 marks

QUESTION 7

(a) Some of the major adaptive features of primates are shown in the table below. Complete the table.

Feature	Adaptive advantage
Opposable thumb	Hands able to grasp
	Three-dimensional vision
Nails	
	Omnivorous diet
Upright locomotion	

4 marks

(b) The 'Out of Africa' theory suggests that modern humans originated in Africa about 100,000 years ago, and then spread out to other parts of the world. What fossil evidence supports this?

_____

_____

1 mark

(c) Name a possible technique that could be used to determine the age of these modern humans.

_____

1 mark

The development of complex speech is genetically controlled. Structural changes needed included the development of the hyoid bone at the base of the tongue and of the temporal lobe of the brain.

(d) State two ways in which the development of speech aided human evolution.

_____

_____

_____

_____

_____

_____

2 marks

Total 8 marks

End of Paper