INSIGHT

Trial Exam Paper

2009

BIOLOGY

Written examination 2

STUDENT NAME:

QUESTION AND ANSWER BOOK

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

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	25	25	25
B	8	8	50
			Total 75

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring sheets of paper or white out liquid/tape into the examination.
- Calculators are not permitted in this examination.

Materials provided

- The question and answer book of 29 pages.
- An answer sheet for multiple-choice questions.

Instructions

- Write your **name** in the box provided.
- You must answer the questions in English.

At the end of the examination

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

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

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AREA OF STUDY 1 – Heredity

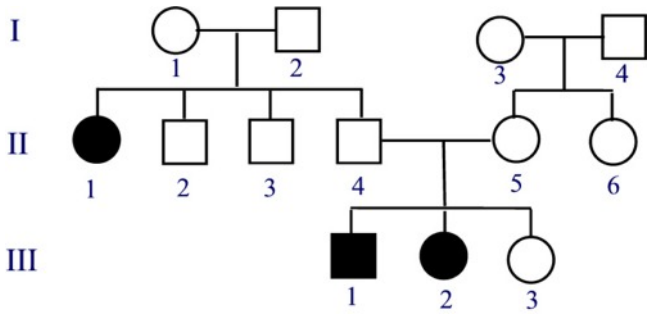
Instructions for Section A

Answer all questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
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.

SECTION A – Multiple-choice questions

Question 1

In the following human pedigree the shaded individuals have the trait being investigated.



The mode of inheritance of the trait is

A. autosomal dominant.
B. autosomal recessive.
C. X-linked dominant.
D. X-linked recessive.

Question 2

For the trait shown in the pedigree, Individual III-3 can be

A. homozygous only.
B. hemizygous only.
C. heterozygous or hemizygous.
D. homozygous or heterozygous.

The following information relates to Questions 3 and 4.

In the tomato plant, *Lycopersicon esculentum* (*L. esculentum*), smooth skin (S) is dominant to peach skin (s) and non-beaked fruit (Bk) is dominant to beaked fruit (bk).

Question 3

A heterozygous smooth, non-beaked plant was crossed with a peach, beaked plant. The gametes of the F1 would only include

A. SBk, sbk.

B. SBk, sbk, Sbk, sBk.

C. SS, BkBk, ss, bkbk.

D. SS, BkBk.

Question 4

The results of the cross between the heterozygous smooth, non-beaked plant and the peach, beaked plant are shown in the table.

	smooth, non-beaked tomato plant x peach, beaked plant			
Phenotype	smooth, non-beaked	peach, beaked	smooth, beaked	peach, non-beaked
Number of F1 offspring	195	187	56	63

The conclusion that can be drawn from these results is that

A. the genes for fruit skin type and fruit shape are linked.

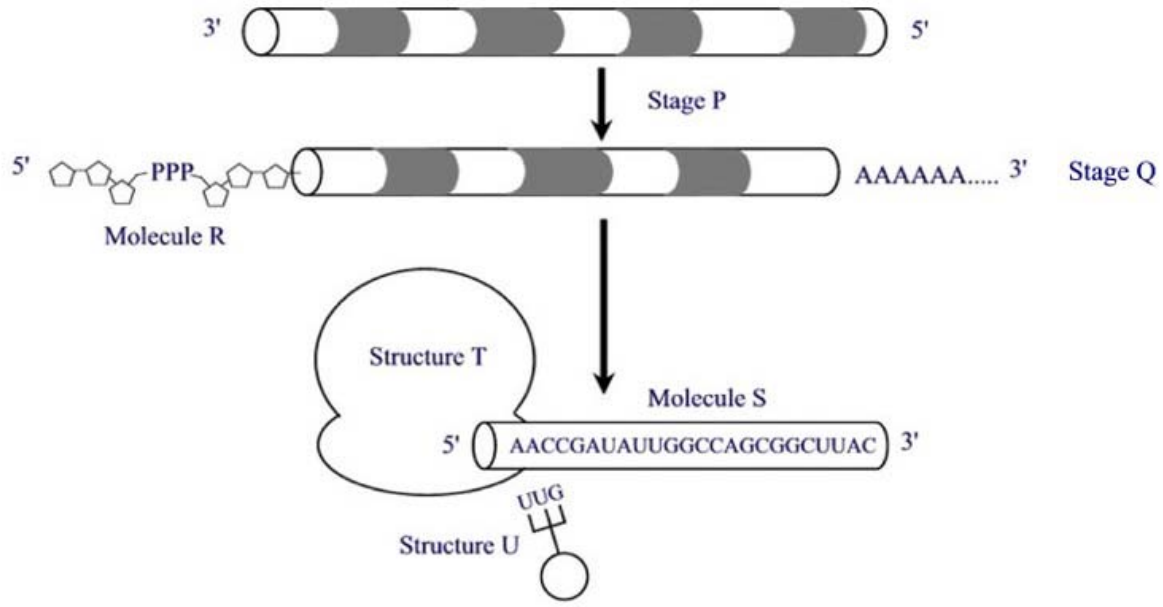
B. the genes for skin type and fruit shape are independent of each other.

C. the smooth, non-beaked and peach, non-beaked plants have the parental phenotypes.

D. the smooth, beaked and peach, beaked plants have the parental phenotypes.

The following information relates to Questions 5, 6 and 7.

The following diagram shows the process of protein synthesis in a cell following the activation of DNA.



Question 5

The correct labels for the diagram are

	Stage P	Stage Q	Molecule R	Molecule S	Structure T	Structure U
A.	translation	splicing	methylated cap	mRNA	ribosome	amino acid
B.	transcription	translation	mRNA	methylated cap	mitochondrion	tRNA
C.	translation	transcription	mRNA	methylated cap	mitochondrion	amino acid
D.	transcription	splicing	methylated cap	mRNA	ribosome	tRNA

Question 6

At Stage P

A. DNA polymerase is active.
B. RNA polymerase is active.
C. removal of introns from DNA occurs.
D. removal of exons from pre-RNA occurs.

Question 7

The DNA molecule involved in this process would have the nucleotide sequence

A. T T C C G T A T A A C G C G T C G C C G A A T G
B. T T G G C T A T A G A C T G T C G C C G A A T G
C. T T G G C T A T A A C C G G T C G C C G A A T G
D. T T G G C T T A T A C C G G A G C C C G A A T G

Question 8

Ribonucleic acid (RNA) is composed of nucleotide subunits. Which of the following statements is correct for RNA nucleotides?

A. Covalent bonds exist between ribose sugars and the bases.
B. Adenine and uracil are the purine bases.
C. Adenine in RNA will pair with uracil in a strand of DNA.
D. The equivalent of a DNA triplet on an mRNA strand is an anticodon.

Question 9

The process of complementary base pairing between two RNA molecules takes place during the process of

A. DNA replication.
B. reverse transcription.
C. transcription.
D. translation.

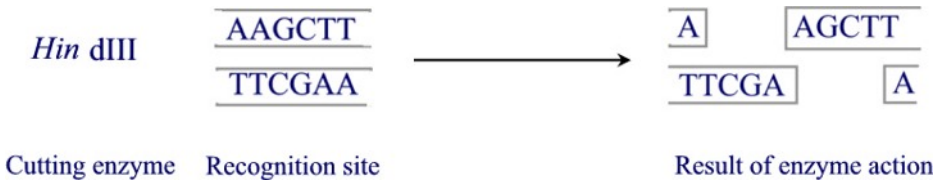
Question 10

Apoptosis is a process that causes the natural death of cells and occurs in most tissues of the vertebrate body. An example of apoptosis would NOT include the

A. removal of cells with damaged DNA.
B. phagocytosis of dead tissue.
C. destruction of B and T cells following recovery from a disease.
D. loss of a tail in a tadpole as it metamorphoses into a frog.

Question 11

The restriction enzyme *Hin* dIII has the recognition sequence AAGCTT and produces sticky ends.

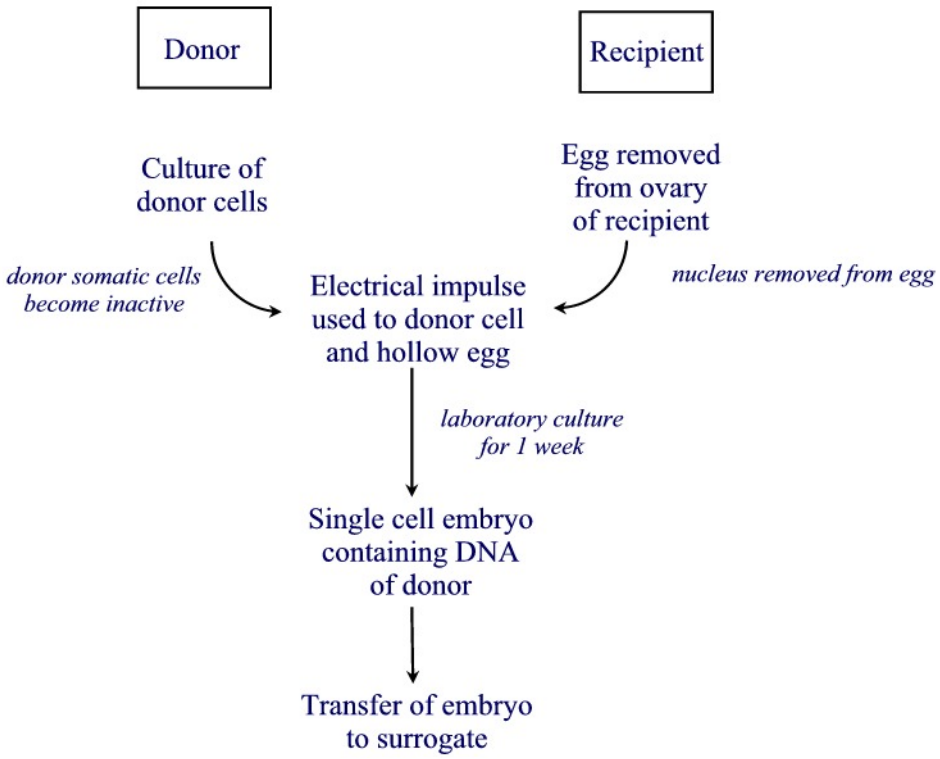


Hin dIII cuts

A. covalent bonds only.
B. hydrogen bonds only.
C. covalent and hydrogen bonds.
D. ionic and hydrogen bonds.

Question 12

The following diagram shows the steps involved in the technique of animal cloning by nuclear transfer.



Nuclear transfer involves the

A. removal of egg cells from a donor female which are fertilised *in vitro* by sperm from a male of the same species.
B. removal of mature donor somatic cells and a recipient egg from a mature animal of the same species.
C. artificial separation of the cells of an early stage embryo.
D. artificial insemination of female animals using semen from selected male animals.

Question 13

Stem cells are undifferentiated cells that have the potential to differentiate into a wide range of different and specialised cells. Which of the following is NOT a term used to describe a stem cell?

A. idempotent
B. totipotent
C. pluripotent
D. multipotent

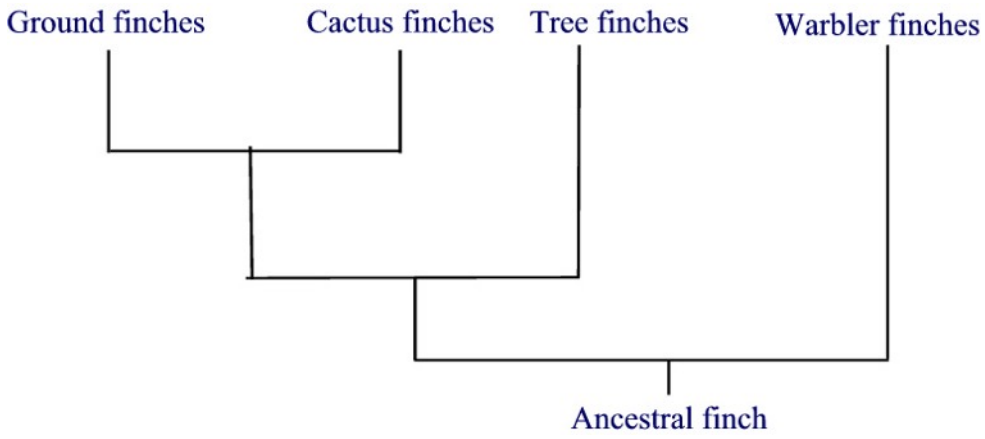
Question 14

The following table shows some mutagens and their observed effects. Which mutagen is most likely to cause a frameshift mutation?

	Mutagen	**Observed effect**
A.	nitrous acid	adenine in DNA is deaminated and behaves like guanine
B.	mustard gas	guanine in DNA is replaced by other bases
C.	acridine orange	addition and/or removal of bases in DNA
D.	colchicines	prevents spindle formation in mitosis, thus doubling the chromosome number

The following information relates to Questions 15 and 16.

The Galapagos Islands are home to 13 species of finches which are grouped into four genera. Small finches, the original colonisers of the islands, flew from South America across the Pacific Ocean to the Galapagos Islands. The diagram shows the evolution of these finches, also known as Darwin's Finches.



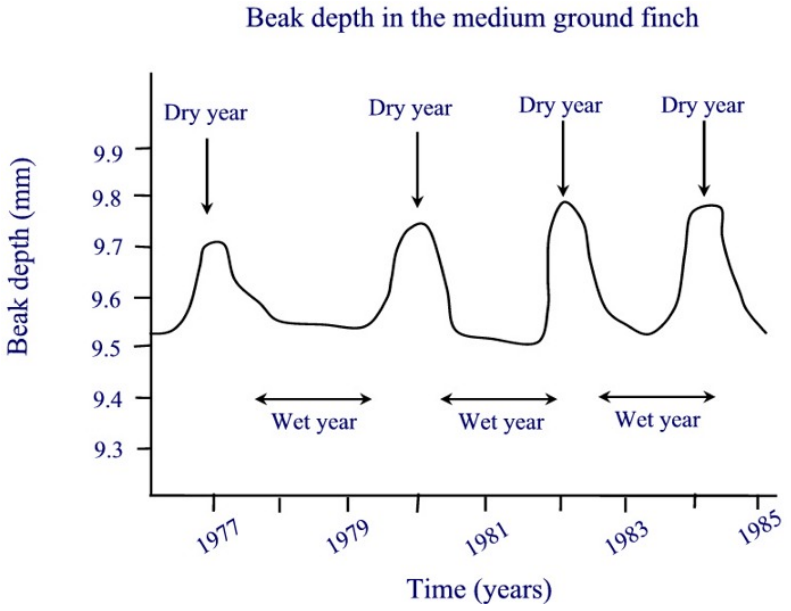
Question 15

The pattern of evolution observed in Darwin's Finches is known as

A. divergent evolution.
B. convergent evolution.
C. parallel evolution.
D. co-evolution.

Question 16

The medium ground finch, *Geospiza fortis*, uses its beak to crush seeds. The finches actively choose small seeds over large seeds, probably because they are easier to crush. During wet years, small seeds are in abundance and the finches consume relatively few large seeds. In dry years, seeds of all sizes are more scarce and the finches tend to eat proportionally more large seeds. Over a 10-year period, the change in diet is correlated with a change in the average depth (from top to bottom) of the birds' beaks. The graph reflects this pattern of change.



What is the most likely explanation for this for this observation?

A. Beak size is a polygenic trait which shows continuous variation in *Geospiza fortis*.

B. Beak size is an acquired trait and increases in size when *Geospiza fortis* exercises its beak on large seeds.

C. The environment determines whether beaks are specialised for larger or smaller seeds, depending on the annual rainfall.

D. Birds with stronger beaks have a feeding advantage and greater reproductive success during dry years.

Question 17

An allele coding for plumage colour in a population of the red-headed crimson rosella *Platycercus elegans elegans* is most likely to be eliminated from the population if

A. genetic drift acts against the phenotype.

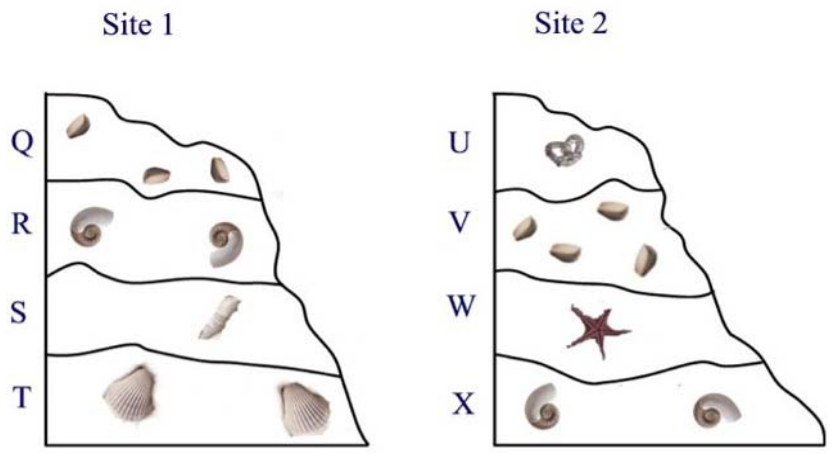
B. it codes for the dominant phenotype which is selected against.

C. it codes for the recessive phenotype which is selected against.

D. gene flow causes it to pass into other populations.

Question 18

The diagram shows a section through two samples of fossil-bearing strata discovered at two different locations.



From the data provided it could reasonably be concluded that

A. Stratum T contains fossils that are younger than those found in Stratum S.
B. Stratum U contains the oldest fossils.
C. Stratum R contains fossils of the same age as those found in Stratum X.
D. Stratum X contains the youngest fossils.

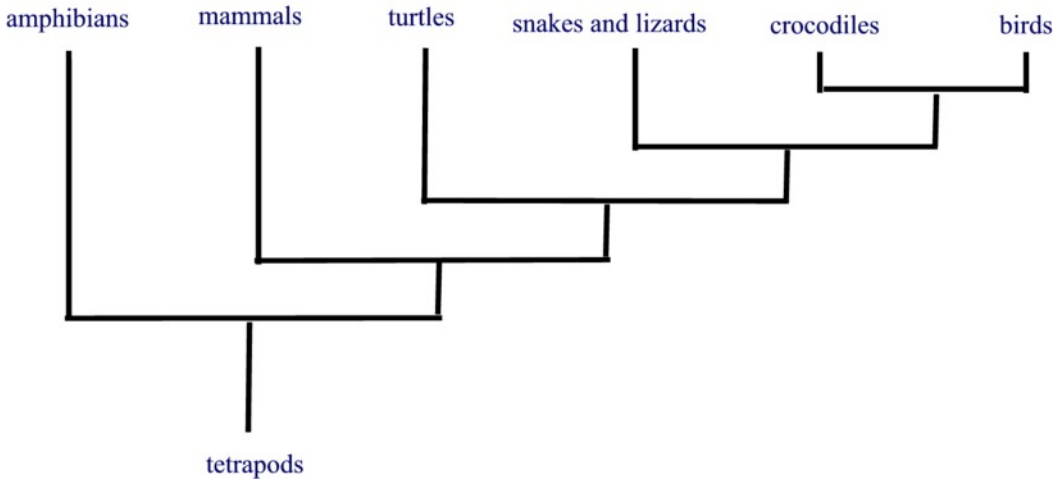
Question 19

The technique of electron spin resonance (ESR) has been used to date corals, mollusc shells and human remains by analysing tooth enamel. ESR

A. is a relative dating technique.
B. is an absolute dating technique.
C. is used to date material of one million years and older.
D. measures the decay of potassium-40 to argon-40.

The following information relates to Questions 20 and 21.

The phylogenetic tree below depicts the evolutionary relationship between tetrapods based on comparative anatomy.



Question 20

Using the phylogenetic tree it can be concluded that the most closely related species to the crocodile is

A. turtles.
B. amphibians.
C. birds.
D. snakes and lizards.

Question 21

It can also be concluded that

A. amphibians and birds have no common ancestors.
B. snakes and lizards are more closely related to birds than they are to amphibians.
C. snakes and lizards are the most closely related group to the crocodiles.
D. the most recent common ancestor of mammals and birds existed approximately 80 million years ago.

Question 22

The term 'hominid' was once used to refer very broadly to humans and their extinct erect-walking ancestors. Currently, scientific journals and scientific institutions use the term 'hominin'. Which one of the following primates would NOT be considered a hominin?

A. *Pongo pygmaeus* (orang-utan)
B. *Australopithecus afarensis* (Lucy)
C. *Homo floresiensis* (The Hobbit)
D. *Kenyanthropus platyops* (Flatface)

The following information relates to Questions 23 and 24.

In East Africa, in the latter part of the Miocene, the climate became cooler and drier causing significant habitat changes for the arboreal dwelling hominids. Extensive areas of savannah became established and continued to expand as the forests continued to shrink. Fossils of early bipedal hominins have been found in a range of habitats including open woodland, closed woodland, forest and savannah.

Question 23

The most logical explanation for this observation is

A. hominins unable to adjust to the increasing areas of savannah retreated into the forests, existing in smaller populations.

B. hominins that retreated into the forests eventually became extinct.

C. bipedalism is a cultural response to habitat changes in the cooler and drier climate of East Africa.

D. anatomical adaptations resulted when early hominins adopted new behaviour patterns, enabling them to survive the changing habitat.

Question 24

Adaptations for bipedalism would NOT include

A. position of the foramen magnum toward the back of the skull.

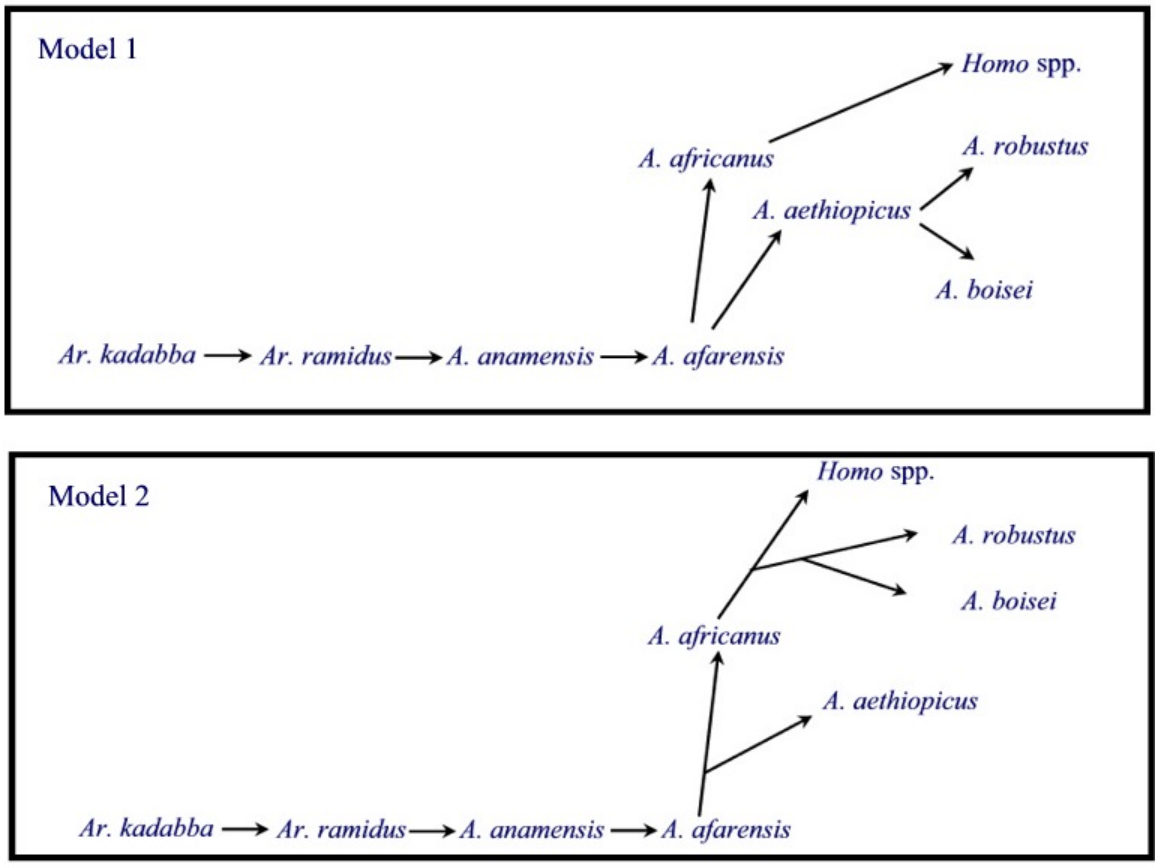
B. outward slanting femur.

C. s-shaped curve in the vertebral column.

D. bowl-shaped pelvis.

Question 25

There is rarely complete agreement over schemes that describe evolutionary relationships. The diagram shows two models put forward to explain the possible ordering of species in the genus *Australopithecus*. Note that in the diagram of Model 1 and Model 2, *A.* is the abbreviation for the genus *Australopithecus* and *Ar.* is the abbreviation for the genus *Ardipithecus*.



Whilst the models are not identical, they do agree that

A. *A. afarensis* gives rise to *A. africanus* and *A. aethiopicus*.
B. *A. robustus* and *A. boisei* are direct descendants of *A. aethiopicus*.
C. *Homo* spp is the only descendant of *A. africanus*.
D. *Ar. ramidus* is a descendant of Australopithecines.

END OF SECTION A

SECTION B – Short-answer questions

Instructions for Section B

Answer **all** questions in the spaces provided.

Question 1

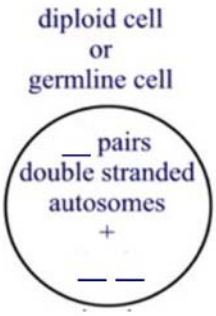
In humans and other mammals, sex is determined by the sex chromosomes X and Y. The SRY gene is located on the Y chromosome and is responsible for triggering the development of the testis.

1a. What is the name given to the chromosomes that are **not** involved in sex determination?

_____

1 mark

1b. Using the diagram provided as a starting point, show the principle stages involved in gamete formation in a human male. Begin by filling in the blank spaces (dashes) in the diploid cell provided. Indicate how many chromosomes are found in each gamete. You do not need to show ALL stages of gamete formation, nor do you need to draw all the chromosomes involved in the process.



2 marks

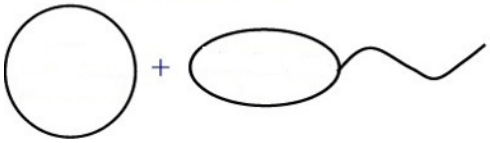
Turner's syndrome is a genetic condition affecting 1 in 2500 females. Affected individuals show that they can be missing one X chromosome. Characteristics of the condition include short stature, absence of sexual maturation and webbing of skin between neck and shoulders.

1c i. Two possible combinations of gametes will produce zygotes with Turner's syndrome. Complete the following diagram to show the chromosomes present for each of these combinations.

Combination 1

AND

Combination 2



2 marks

1c ii. What error could have occurred during meiosis to produce these abnormal gametes?

_____

1 mark

The cotton plant *Gossypium sp.* has an ancestral haploid number of 13 (n = 13). Presently however, its chromosome number is 52 (4n = 52).

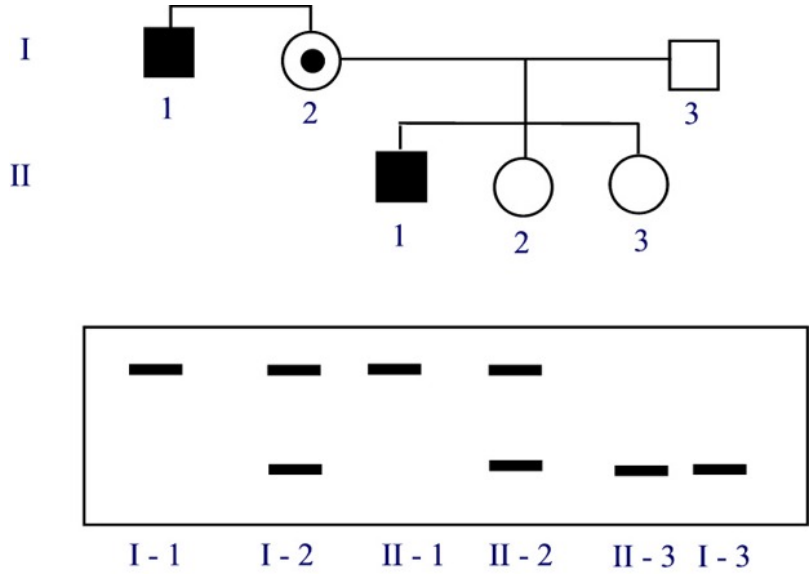
1d. What is the name used to describe the state of the chromosome number of *Gossypium sp.*?

_____

1 mark
Total 1 + 2 + 2 + 1 + 1 = 7 marks

Question 2

Haemophilia is an X-linked condition in which the body's ability to clot or coagulate blood is severely impaired. There are three types of haemophilia, A, B and C, each of which is due to the absence of clotting Factor VIII, IX and XI respectively. The diagram shows the RFLP patterns taken from a family in which some members have haemophilia.



2a. Explain what is meant by the abbreviation RFLP.

_____

_____

_____

1 mark

2b. Using the pedigree above, complete the table to show what is indicated by the following symbols.

Symbol	Explanation
	–
	–

2 marks

2c. Of the individuals II-1, II-2 and II-3, explain which is a carrier of haemophilia.

_____

_____

_____

2 marks
Total 1 + 2 + 2 = 5 marks

Question 3

Huntington disease (HD) is an autosomal dominant disorder in which individuals experience nerve degeneration and gradual deterioration of physical, cognitive and emotional abilities. It is a condition that affects adults and usually appears between the ages of 30 and 50. However, it can affect people under the age of 20 (Juvenile HD) and in the later stages of life.

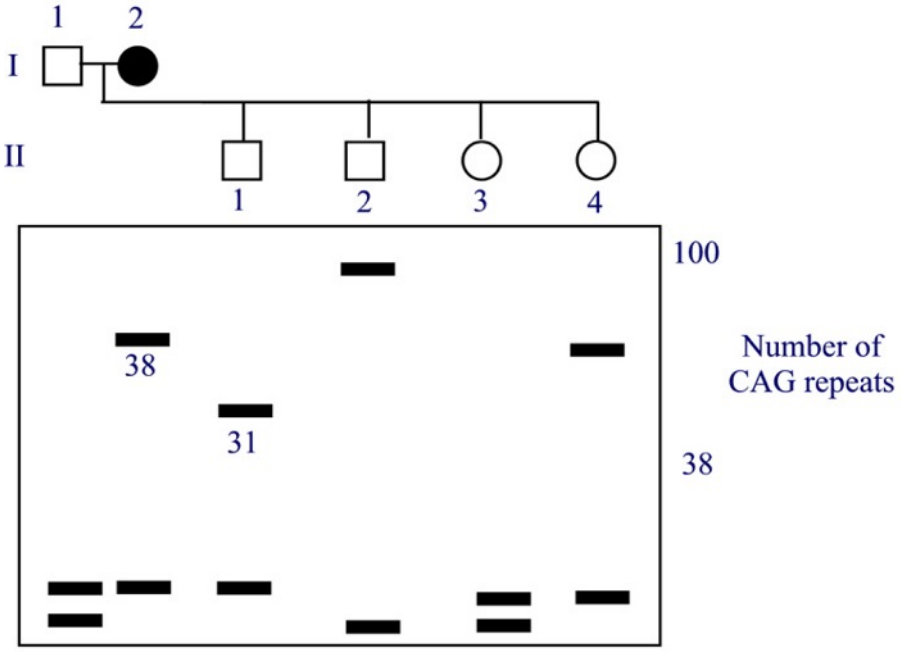
3a. Suggest why the allele for HD has remained in the human population despite it being a fatal condition with no known cure.

_____

_____

1 mark

The diagram below shows the result of electrophoresis for a family whose mother has HD. PCR fragments have been amplified using probes for the altered HD site. The region of the chromosome under observation has a variable number of repeating CAG sequences. Individuals who do not have the condition can have up to 30 copies of each sequence, but individuals with HD have 37 to more than 100 copies. The number that appears below the band from the PCR fragment indicates the age at which the symptoms first began.



3b. Draw an arrow on the diagram to indicate the direction of movement of DNA fragments.

1 mark

3c. Using the electrophoresis results, complete the following table, showing the possible phenotypes and genotypes of Individual II-2 and Individual II-3.

For each phenotype select from:

- will develop Huntington disease
- will not develop Huntington disease
- not possible to determine from information provided

Use the following symbols to represent the alleles involved: H, h.

	Phenotype	**Genotype**
Individual II-2		
Individual II-3		

2 marks

The restriction enzyme *Eco* P151 was used to prepare the fragments for the gel electrophoresis. The recognition site for *Eco* P151 is CAGCAG.

3d i. On the **continuous** sequence of a single strand of DNA below, circle all the recognition sites that would be cut by the enzyme *Eco* P151.

TCACCCGATCAGCAGCGAGGCAATCCTTAGCCGATCAGCAGCCCCGGGGTAT

TCCGACTCAGCAGAGGTCACACCCCAGCAGAATGGGTACCAG

1 mark

3d ii. How many fragments of DNA will be created by digesting the fragment with *Eco* P151?

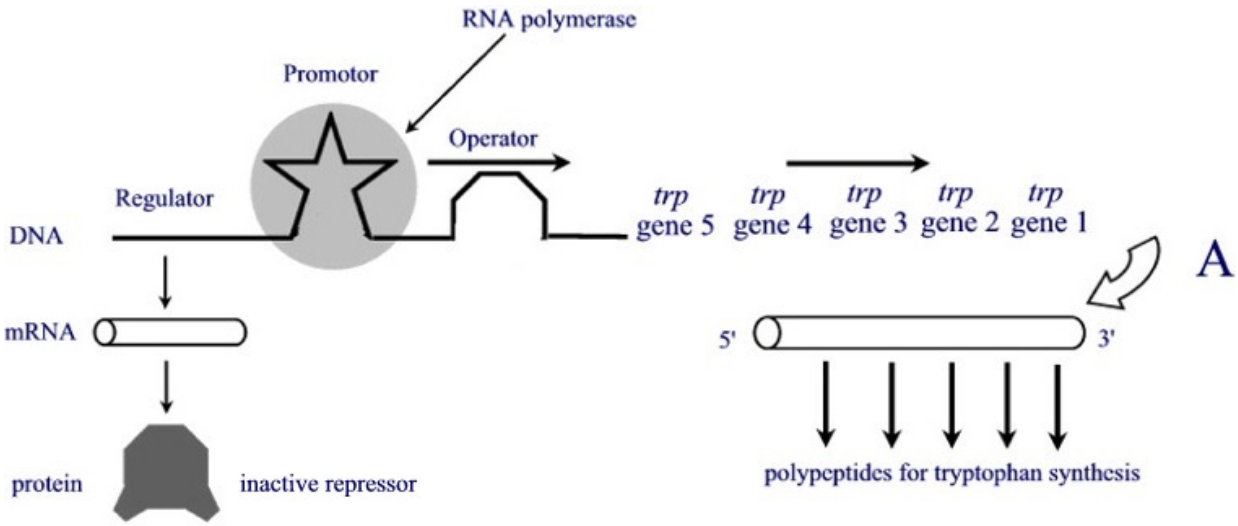
_____

1 mark

Total 1 + 1 + 2 + 1 + 1 = 6 marks

Question 4

Escherichia coli (*E. coli*) is a bacterium which lives in the environment of the human colon which is constantly changing due to the dietary habits of the host. *E. coli* relies on an amino acid, tryptophan (*trp*), to survive and is capable of synthesising it from a precursor molecule. The diagram illustrates the *trp* operon in the absence of tryptophan.



4a. What is an operon?

_____

_____

1 mark

4b. Identify and describe the function of **two** components of an operon.

Component 1: _____

_____

Component 2: _____

_____

2 marks

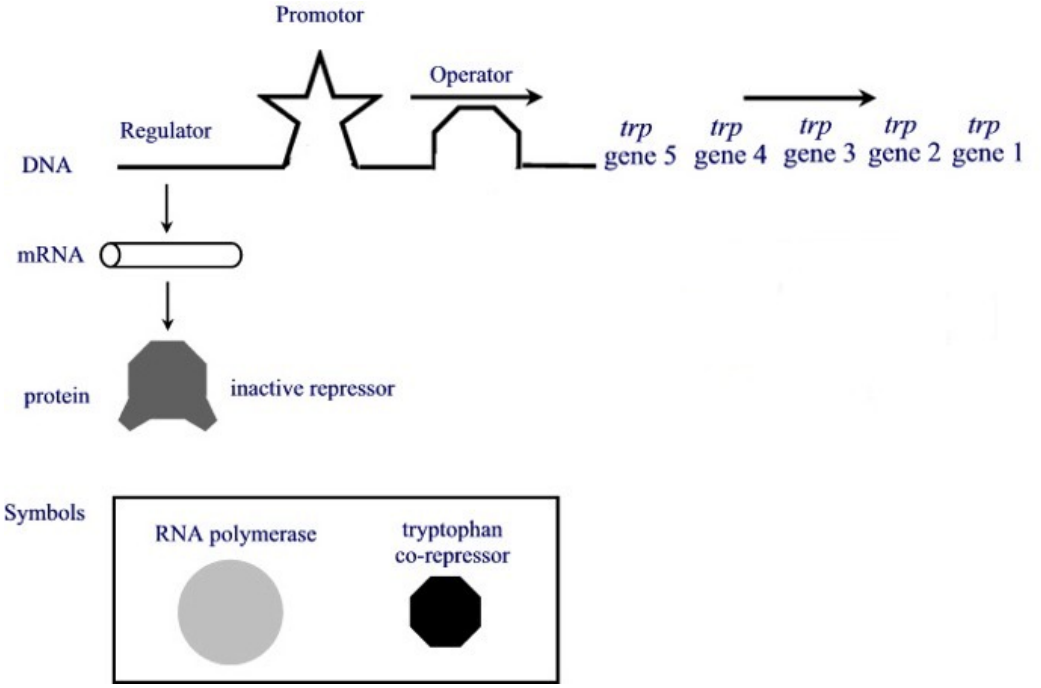
4c. What process is occurring at **A**?

_____

1 mark

Tryptophan is also available through the dietary intake of the host. When tryptophan is readily available to the cell *E. coli* will stop its own synthesis, using the amino acid already supplied.

4d. Using the symbols provided below, add to the diagram to illustrate what would occur in the *trp* operon when tryptophan is readily available.



2 marks
Total 1 + 2 + 1 + 2 = 6 marks

Question 5

Australian researchers at the Centre of Excellence for Kangaroo Genomics (KanGo) have produced the first detailed map of the kangaroo genome, revealing large sections in common with the human genome. The tammar wallaby, *Macropus eugenii* (*M. eugenii*), is a marsupial with around 20 000 genes located on its 16 chromosomes. The human genome has 20 000 – 25 000 genes. Humans are placental mammals and have 46 chromosomes in their karyotype.

5a. How many chromosomes are found in the germline cells of *M. eugenii*?

_____

1 mark

The tammar wallaby has a similar number of genes to humans (20 000), yet they are significantly different organisms.

5b. Explain the basis for this anomaly in terms of chromosome number and phenotype.

Chromosome number: _____

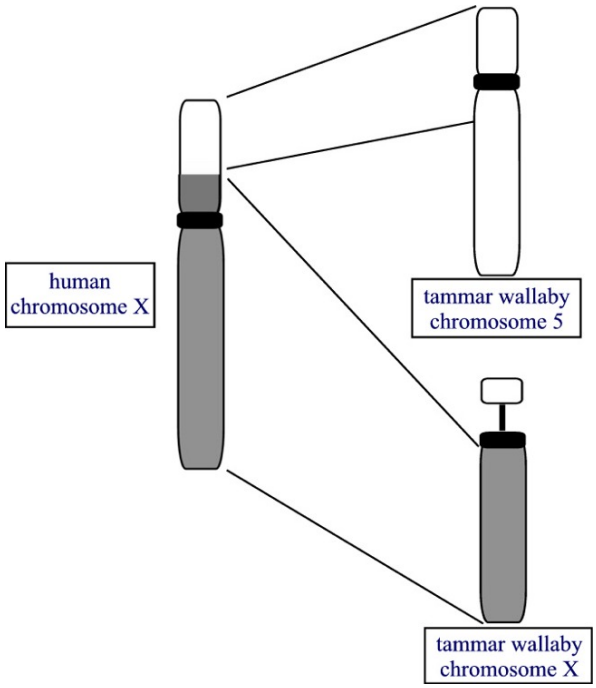
_____

Phenotype: _____

_____

2 marks

The human X chromosome is made up of segments from the number 5 and X chromosomes of *M. eugenii*. The two segments joined around 150 million years ago. Further, it has been found that the q-arms of the X chromosome of humans and *M. eugenii* are homologous.



5c. What circumstances might have existed to produce a human X chromosome that is a composite of chromosomes 5 and X in the tammar wallaby?

_____

_____

1 mark
Total 1 + 2 + 1 = 4 marks

Question 6

The bacterium *Bacillus thuningensis* (*B. thuningensis*) produces crystal proteins of insecticidal endotoxins, coded for by the *cry* 1 Ac gene located on the bacterial chromosome. When ingested the crystal proteins are activated by an alkaline gut pH. Once activated, they become embedded in gut cell membranes, causing swelling, lysis and death. The *cry* 1 Ac gene has been introduced into the cotton plant *Gossypium sp.*, creating cotton that is resistant to moths, butterflies, mosquitoes, flies and beetles. This cotton is also known as Bt cotton.

6a. Having identified the *cry* 1 Ac gene on the chromosome of *Bacillus thuningensis*, what steps would be required to produce Bt cotton?

_____

_____

_____

_____

_____

_____

2 marks

6b. By distinguishing between genetically modified organisms (GMOs) and transgenic organisms (TGOs), indicate whether Bt cotton is a GMO or a TGO.

_____

_____

_____

2 marks

6c. Explain a benefit of growing Bt cotton.

_____

_____

1 mark

Whilst the development of Bt cotton has been widely successful it should not be considered the solution to the problem. The cotton bollworm moth, *Helicoverpa armigera* (*H. armigera*), is insecticide resistant to nearly every class of chemical insecticide used for its control. Recently, *H. armigera* has shown resistance to Bt cotton.

6d i. Explain what is meant when the bollworm moth is described as insecticide resistant.

_____

_____

1 mark

6d ii. Name the process by which the cotton bollworm moth would have become insecticide resistant.

_____

1 mark
Total 2 + 2 + 1 + 1 + 1 = 7 marks

Question 7

In the 1930s, the cane toad *Bufo marinus* (*B. marinus*) was introduced to Australia in an effort to control the beetles that were damaging sugar cane crops. The cane toad releases a potent cardiac toxin from a large gland on its shoulder and there are many reports of cane toads causing the death of native predators. Native animals that are known to eat the cane toad include quolls, crocodiles, lizards and snakes. Amongst these native animals, there is variable vulnerability to the toxin, ranging from susceptibility to tolerance.

In Australia, the cane toad places a selective pressure on the predator population.

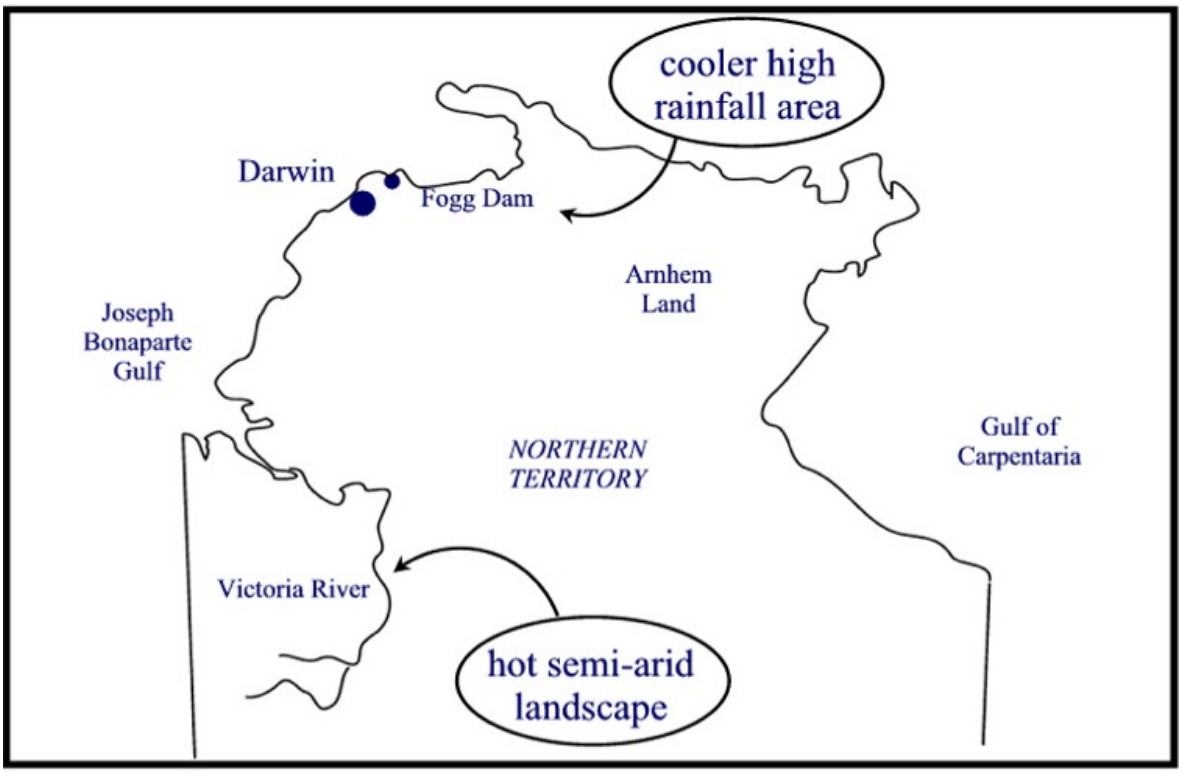
7a. What characteristic must be present in a population if a selecting agent is to have any effect?

_____

_____

1 mark

The freshwater crocodile *Crocodylus johnstoni* (*C. johnstoni*), inhabits the Victoria River and is also found at Fogg Dam in the Northern Territory. The map shows the location of Fogg Dam and Victoria River in the Northern Territory.



Researchers have documented massive mortality of *C. johnstoni* due to the effect of cane toad toxin. At Victoria River dead crocodiles spanned a wide size range. Population densities of crocodiles plummeted by as much as 77% following toad invasion, and population size structures have changed over several generations.

Crocodiles surveyed at Victoria River during Study	
Size range of live crocodiles	0.25–3.0 metres
Full size range of dead crocodiles	0.6–2.1 metres
Size range of most dead crocodiles	0.6–1.5 metres

7b **i.** From the table, what can be concluded about mortality rates in *C. johnstoni*?

_____

_____

1 mark

7b ii. Identify what evolutionary process is taking place in the population of *C. johnstoni*.

_____

1 mark

The impact of cane toads on *C. johnstoni* increases with increasing aridity. The negative impact of toads on crocodiles appears to be greater in hot semi-arid landscapes (Victoria River) than in cooler, higher rainfall areas (Fogg Dam).

7c. Suggest why the environmental conditions at Victoria River and Fogg Dam have different outcomes for *C. johnstoni*.

_____

_____

_____

_____

1 mark

Different species of Australian snakes show variation in their response to cane toad toxin.

Generally, snakes with larger ratio of body length to head size are less affected by cane toad toxin. The longer a snake, the smaller its head is compared to its overall body length. Given that the size of a snake's head limits the size of its prey, a longer snake is less likely to eat a toad large enough to poison it.

An evolutionary biologist hypothesised that the body shape (length) of snakes has evolved in response to exposure to cane toad toxin. She studied four species of snake found in Queensland and in order to test her hypothesis, predicted that two of the species would be highly sensitive to cane toad toxin and that the other two would not.

High sensitivity	No sensitivity
Pseudechis porphyriacus (red-bellied black snake)	*Hemiaspis signata* (swamp snake)
Dendrelaphis punctulatus (green tree snake)	*Tropidonophis mairii* (keelback snake)

7d **i.** What are **three** essential factors that should be included by the biologist in the design of her research?

1. _____

_____

_____

2. _____

_____

_____

3. _____

_____

_____

3 marks

7d **ii.** What result would support the hypothesis?

_____

_____

_____

1 mark

Total 1 + 1 + 1 + 1 + 3 + 1 = 8 marks

Question 8

In 2005, archaeologists in Germany uncovered a multiple burial grave site in Eulau, Saxony-Anhalt. One of the graves contained the 4600-year-old skeletons of four *Homo sapiens* – a female, a male and two children. *Homo sapiens* (*H. sapiens*) are the only species to have reached this time period, also known as the Neolithic Age. Some paleoanthropologists believe there is strong evidence to show that *H. sapiens* evolved from the species *Homo erectus* (*H. erectus)*.

8a. Identify and compare **two** significant structural features in the skulls of *H. erectus* and the skeletons of the family found at Eulau.

Structure 1: _____

_____

Structure 2: _____

_____

2 marks

In their analysis of the remains at Eulau, researchers used several sources of data, including information from autosomal and Y chromosomes, to determine that the group was a family consisting of a mother, a father and two sons. The results of the analysis provide the earliest evidence, dating back to the Stone Age, of a nuclear family.

8b. What technique would have been used to establish the relationship between the individuals?

_____

1 mark

Researchers were also able to learn about the social organisation of the group using strontium isotope analysis. Strontium is found in food and is incorporated into growing teeth. By measuring the strontium isotopes in the teeth of the skeletons, researchers were able to draw conclusions about where the skeletons had spent their pre-adult years.

8c. How can the measurement of strontium isotopes be used to indicate the place where these people grew up?

_____

_____

_____

2 marks

The strontium analysis showed that the female had spent her childhood in a different region from the male and children. This is a demonstration of the practice of exogamy (marrying out) and patrilocality (females moving to the area of the males).

8d **i.** What would be the importance of the practices of exogamy and patrilocality to the people of this group?

_____

_____

_____

1 mark

The practice of burying the dead is one example of the cultural changes that have occurred in human societies over time.

8d **ii.** Explain the difference between biological and cultural change.

_____

_____

_____

1 mark
Total marks 2 + 1 + 2 + 1 + 1 = 7 marks

END OF QUESTION & ANSWER BOOK