

INSIGHT
Trial Exam Paper

2008

BIOLOGY

Written examination 2

STUDENT NAME:

QUESTION AND ANSWER BOOK

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

Structure of book

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

- 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 23 pages.
- An answer sheet for multiple-choice questions.

Instructions

- Write your **name** in the box provided and on the answer sheet for multiple-choice questions.
- You must answer the questions in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions in the front cover of the question and answer book.

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

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SECTION A – Multiple-choice questions

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. 1 mark will be awarded for a correct answer; no marks will be awarded for an incorrect answer. Marks are **not** deducted for incorrect answers. No marks will be awarded if more than one answer is completed for any question.

AREA OF STUDY 1 – Heredity

Question 1

There are alleles that can cause lethal conditions. In horses there are several known lethal alleles which occur when a horse is homozygous dominant for a gene. In Quarter Horses, coat patterning is due to the arrangement of white hairs mixed in the body colour hairs.

chestnut roan – *Rr*

chestnut non-roan – *rr*

In a cross between two chestnut roan Quarter Horses, the probability of producing a viable chestnut non-roan foal is closest to

- A. 25%
- B. 50%
- C. 33%
- D. 66%

Question 2

Dominant lethal alleles are also known to persist in populations. In humans, Huntington's disease (HD) is a condition caused by a dominant lethal allele. Individuals with HD experience nerve degeneration and begin to show symptoms around the age of 40 years. HD is caused by a dominant lethal allele but it has persisted in the population because

- A. mutations always occur in populations and they are passed on through gametes.
- B. it takes effect later in life when the individual who carries the allele(s) may have already passed it on to their offspring.
- C. when the individual is heterozygous for HD, the lethal allele can be passed on undetected.
- D. some embryos are better adapted to survive lethal alleles.

Question 3

One strategy which could be used to reduce the prevalence of HD in the population is

- A. administration of medications to alleviate symptoms.
- B. adherence to a specific diet which delays onset of the condition.
- C. physical therapy to maintain physical fitness.
- D. presymptomatic testing to determine if an individual has inherited the lethal allele.

SECTION A – continued
TURN OVER

Question 4

When a eukaryote cell prepares to divide it duplicates each of its chromosomes. The diagram shows a chromosome after duplication.



How many molecules of DNA are present in this duplicated chromosome?

- A. 1
- B. 2
- C. 4
- D. hundreds

Question 5

Non-disjunction occurs when homologous chromosomes or sister chromatids fail to move apart properly producing offspring with too many (or too few) chromosomes. In one such example, a couple produces a daughter whose karyotype shows the full complement of autosomes and three X chromosomes (22XXX). The daughter's karyotype could **not** result from non-disjunction at

- A. anaphase I in the father.
- B. anaphase II in the father.
- C. anaphase I in the mother.
- D. anaphase II in the mother.

Question 6

During metaphase II of meiosis

- A. homologous pairs of chromosomes are drawn apart to opposite sides of the dividing cell.
- B. homologous pairs of chromosomes are assembled together on the spindle of the dividing cell.
- C. sister chromatids separate and are drawn apart to opposite sides of the dividing cell.
- D. sister chromatids are still connected and assemble together on the spindle of the dividing cell.

Question 7

At birth, Siamese kittens are completely white. Within weeks of birth the kittens begin to develop pigmentation which begins along the edge of their ears and gradually spreads until it reaches the face, ears, feet and tail. The pattern of pigmentation is most likely due to the

- A. heat sensitive gene which produces pigment in cooler temperatures.
- B. spread of the pigment tyrosinase to the extremities.
- C. interaction between the cat genotype and the temperature of the environment.
- D. interaction between the cat genotype and diet.

Use the following information to answer Questions 8 to 10.

In the fruit fly *Drosophila melanogaster*, two genes and their alleles are

Gene for wing type	<i>C</i>	straight		Gene for body colour	<i>E</i>	grey
	<i>c</i>	curly			<i>e</i>	ebony

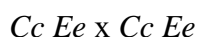
Question 8

A straight winged grey fly (*C- E-*) is found, however, its pedigree and genotype are unknown. The correct test cross to establish its correct genotype would be

- A. *C- E- x Cc Ee*
- B. *C- E- x Cc ee*
- C. *C- E- x CC ee*
- D. *C- E- x cc ee*

Question 9

The genotype of the fruit fly was established as *Cc Ee* and the gene loci were found to be on separate chromosomes. The following cross was then carried out



An F1 population of 160 fruit flies was produced and their phenotypes with respect to wing type and body colour was recorded. It is reasonable to expect that amongst the offspring there could be

- A. 10 curly winged, ebony fruit flies.
- B. no more than 10 straight winged, grey fruit flies.
- C. 10 straight winged, ebony fruit flies.
- D. no more than 10 curly winged, grey fruit flies.

Question 10

The relationship between the alleles for wing type and body colour in *D. melanogaster* show

- A. incomplete dominance.
- B. partial dominance.
- C. complete dominance.
- D. co-dominance.

Question 11

The **p53 gene** is usually expressed to produce **p53 protein** when there is damage to the DNA in a cell. When p53 protein is produced it functions as a transcription factor, acting as a regulatory protein that binds to DNA and stimulates transcription of specific genes. If DNA damage is irreparable, p53 activates 'suicide' genes whose protein products cause

- A. endocytosis.
- B. symbiosis.
- C. mycosis.
- D. apoptosis.

Question 12

A single strand of a molecule of RNA has the base sequence

A A C C G A U A U U G G C C A G C G G C U U A C

The DNA molecule which produced this strand of RNA is

- A. T T G G C T A T A A C C G 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 C C G T A T A A C G C 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 13

In prokaryotes and eukaryotes

- A. transcription and translation occur in the nucleus.
- B. the mRNA lasts for approximately the same duration of time.
- C. there is post-transcriptional modification of mRNA.
- D. the ribosomes translate information in mRNA to produce polypeptides.

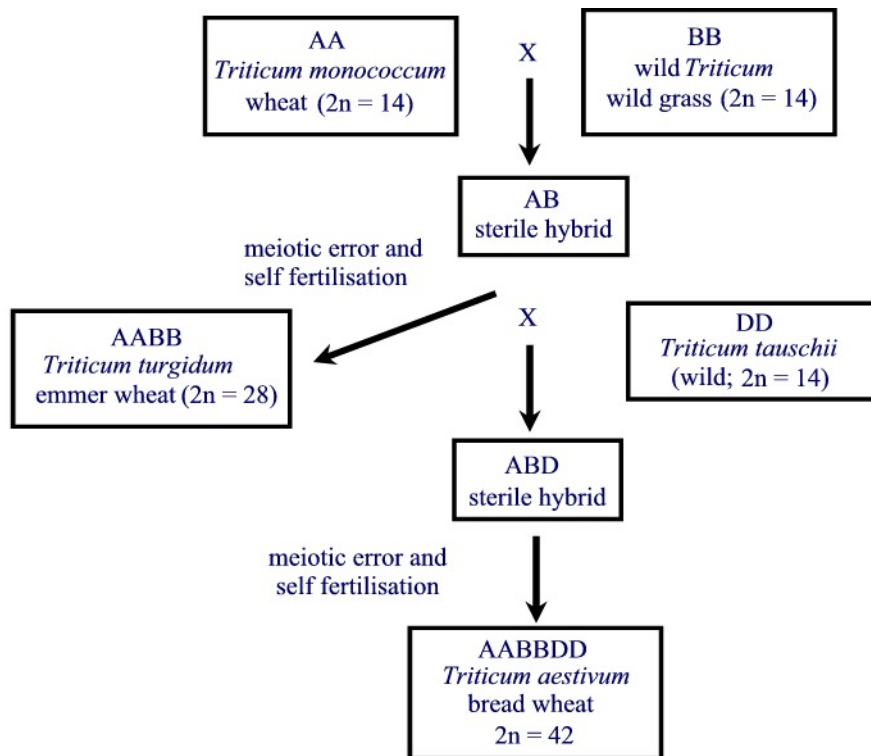
Question 14

Many agricultural crop plants (e.g. oats, wheat, potatoes) grown for human consumption are polyploids. A polyploid is an organism

- A. with genes from more than one species.
- B. with three copies of one chromosome.
- C. which possesses more than two complete sets of chromosomes.
- D. which possesses one complete set of chromosomes.

Question 15

Bread wheat is the evolutionary result of two hybridisation-meiotic error events. The first gave rise to emmer wheat, which has been cultivated in the Middle East for more than 11,000 years. The second event, which occurred about 8,000 years ago, produced bread wheat.

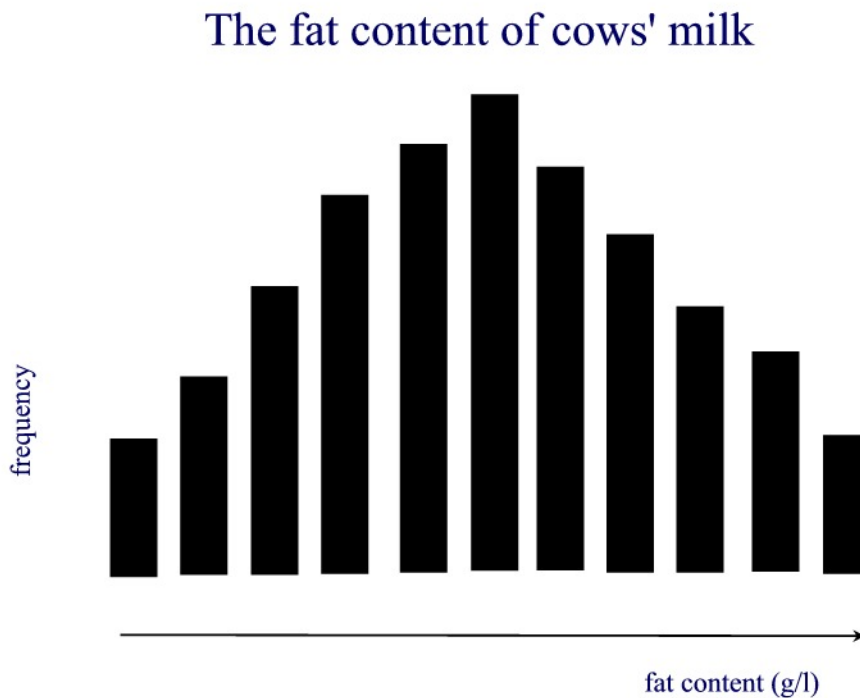


Emmer wheat and bread wheat are both examples of allopolyploids, which are a polyploid species produced when two or more different species interbreed and combine their chromosomes. From the diagram it is possible to deduce that the number of ancestors that bread wheat derives its chromosomes from is

- A. 4
- B. 3
- C. 2
- D. 1

Question 16

The graph shows the fat content of milk produced by dairy cows on several farms owned by one farmer.



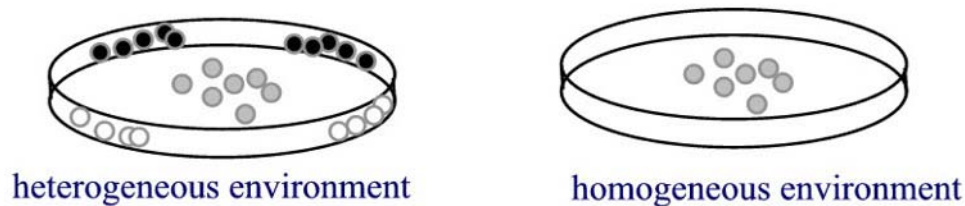
A student was asked to explain the pattern shown by the data. What reasonable conclusion could be drawn?

- A. Fat content is a monogenic trait which shows continuous variation in this population of dairy cows.
- B. Fat content is a polygenic trait which shows continuous variation in this population of dairy cows.
- C. Fat content is a monogenic trait which shows discontinuous variation in this population of dairy cows.
- D. Fat content is a polygenic trait which shows discontinuous variation in this population of dairy cows.

Use the following information to answer Questions 17 to 19.

Bacteria have short generation times and can show evolutionary change within relatively short time frames.

Evolution in *Pseudomonas fluorescens* (*P. fluorescens*) was studied experimentally. Colonies of *P. fluorescens* were cultured in a heterogeneous broth medium in a glass petri dish. After a short period of time the ancestral population (S-bac) was observed to have adapted to the different environments to produce two new morphs (F-bac and W-bac) with clear niche specificity. After the initial experiment, using identical incubation conditions, researchers cultured the S-bac in a homogeneous broth (created by shaking the broth before pouring into the petri dish). The results are shown in the diagram.



- F-bac (colonises broth-glass interface)
- S-bac (colonises surface of broth)
- W-bac (colonises air-broth interface at the glass)

Question 17

The results of these experiments demonstrate that

- A. there is no genetic variation in S-bac.
- B. bacteria have the ability to evolve to occupy available niches.
- C. conditions in the broth medium were not optimal for the bacteria in the second experiment.
- D. there is no competition between strains of *Pseudomonas fluorescens*.

Question 18

The ability of *Pseudomonas fluorescens* to resist antibiotics is an example of evolutionary change which has occurred in a relatively short time frame. Such change can have widespread effects. Antibiotic resistance does **not** occur

- A. primarily to natural mutations that occur in the bacterial genome.
- B. due to overuse of antibiotics to treat bacterial infections in humans.
- C. as a result of the presence of antibiotics in animal feed.
- D. due to the use of antibiotics by immunosuppressed patients.

Question 19

Antibiotic resistance and the ability of *Pseudomonas fluorescens* to exploit a heterogeneous growth medium are both examples of

- A. adaptive convergence.
- B. heterozygote advantage.
- C. adaptive radiation.
- D. allopatric speciation.

Question 20

In the 1890s the population of northern elephant seals in North America was reduced to around 20 individuals by intense hunting. The seals were declared a protected species and since then the population has increased to over 30 000 animals. Researchers have analysed 24 gene loci in a significant proportion of the population and no genetic variation was found. The fixing of a single allele at each of the 24 loci is most likely due to

- A. a bottleneck effect.
- B. the absence of mutation over time.
- C. natural selection.
- D. gene flow.

Question 21

Reproductive isolation occurs when two or more species are prevented from producing viable fertile offspring. Reproductive isolating mechanisms (RIMs) can be categorised as prezygotic or postzygotic depending on whether they form before or after fertilisation. An example of a prezygotic RIM is

- A. the production of incompatible gametes in species of freshwater fish.
- B. the failure of hybrid offspring of frogs from the genus *Rana* to complete development.
- C. the production of a sterile hybrid mule when a horse and a donkey breed.
- D. hybridisation of fertile cotton that produces offspring which die as seeds or grow into weak, defective plants.

Question 22

In October 2004, the fossil of a new hominin species was found in a cave on Flores Island in Indonesia. The 18 000-year-old adult female fossil included a skull, teeth and jaw and was named *Homo floresiensis*. Scientists hypothesised that *Homo floresiensis* hunted, killed and butchered animals. Evidence that would support this hypothesis could include

- A. the small brain capacity.
- B. small teeth in a parabolic-shaped jaw.
- C. bones from animals showing evidence of cutting.
- D. animal hides with puncture marks, held together with fibres.

Question 23

The regional continuity (multiregional) and out-of-Africa (monogenesis) hypotheses for the origin of modern humans confer that

- A. *Australopithecines* migrated out of Africa.
- B. the ancestors of modern humans in Europe are Neanderthals.
- C. the origin of modern *Homo sapiens* is from Africa only.
- D. *Homo erectus* had an African origin.

Question 24

Transgenic organisms (TGOs) possess foreign genes or DNA as part of their genome following experimentation. An example of a TGO is

- A. a cat with the 'cat allergen' gene silenced.
- B. *E. coli* with plasmids carrying the gene for human insulin.
- C. a cow produced by cloning.
- D. a hybrid produced by breeding wheat and rye plants together.

Question 25

Which of the following is **not** an example of a reproductive technology that would be used in selective breeding programs for commercial herds and flocks?

- A. artificial insemination (AI)
- B. artificial pollination (AP)
- C. oestrus synchronisation (OS)
- D. multiple ovulation and embryo transfer (MOET)

**END OF SECTION A
TURN OVER**

SECTION B – Short-answer questions**Instructions for Section B**

Answer this section in **pen**.

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

Question 1

In the honey bee *Apis mellifera* colony, the adult queen bee is the reproductive female. Honey bees are classified in the order Hymenoptera and demonstrate haplodiploidy, where males develop from unfertilised eggs and so are haploid drones, and females are diploid individuals.

If a queen bee mates only once with a drone, her daughters will be highly related to one another and are known as supersisters.

- a.** Why would the daughters be so closely related?

1 mark

Female bees have 16 chromosomes in their germ cells.

- b.** How many chromosomes would be present in the somatic cells of drones?

1 mark

It was previously thought that sex determination in a colony was controlled by the queen and that on return from a mating flight she could ‘choose’ whether to lay fertilised or unfertilised eggs which would develop into females or males, respectively. It is now known that sex determination in bees is controlled by alleles at a single locus. If a bee has two different alleles it will be female, if it has a single allele it will be a normal fertile male, if it has two identical alleles it will be an infertile male.

- c. i.** What is a locus?

1 mark

- ii.** What is the term used to describe the genotype of a normal fertile male honey bee?

1 mark

- iii.** Is a colony of honey bees monomorphic or polymorphic for sex determination?

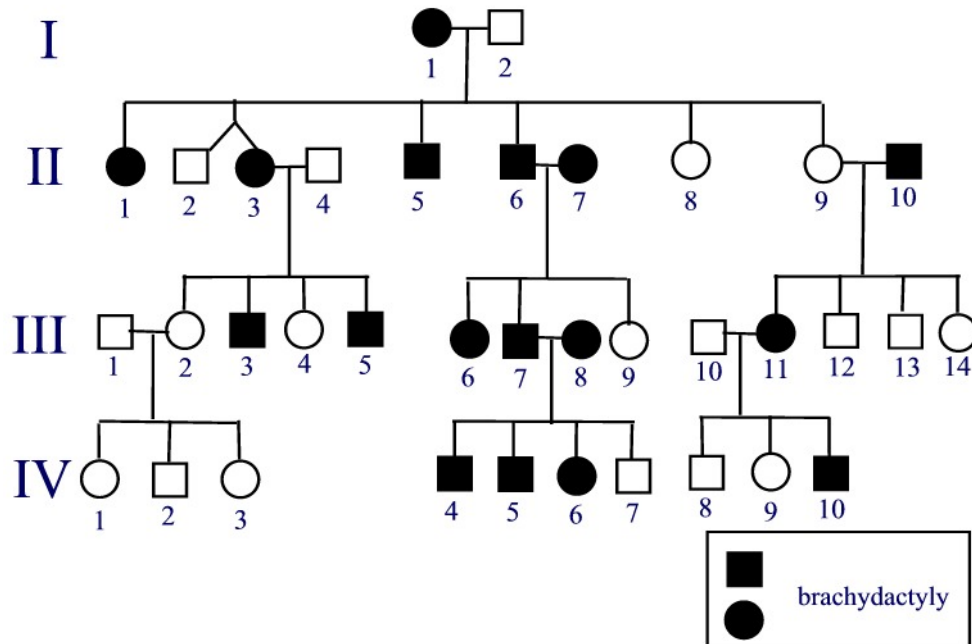
1 mark

Total 5 marks

SECTION B – continued

Question 2

Brachydactyly (BD) is a condition in humans in which underdevelopment of the bones in the hands and feet leads to shortening of the fingers and toes. The pedigree represents a family, some members of which have brachydactyly.



It has been suggested that brachydactyly is an autosomal dominant trait.

- a. What evidence from the pedigree supports this suggestion?

1 mark

- b. Assign allele symbols to represent brachydactyly and normal hand and foot development.

1 mark

SECTION B – continued
TURN OVER

- c. Use the symbols assigned in **2b** to complete the table. Show the genotypes and state the phenotypes of individuals I2 and II5.

	genotype	phenotype
Individual I2		
Individual II5		

2 marks

- d. If the couple III10 and III11 were to have another child, what is the likelihood that it will have brachydactyly? Show your working using a Punnett square.

2 marks

Total 6 marks

Question 3

Escherichia coli (*E. coli*) is a bacterium which lives in the environment of the human colon. This is a constantly changing environment due to the dietary habits of the host. *E. coli* is capable of modifying its metabolism to survive in the fluctuating conditions. One strategy used by *E. coli* is to activate the production of new enzymes in response to the presence of a new substrate.

- a. What mode of reproduction is shown by *E. coli*?

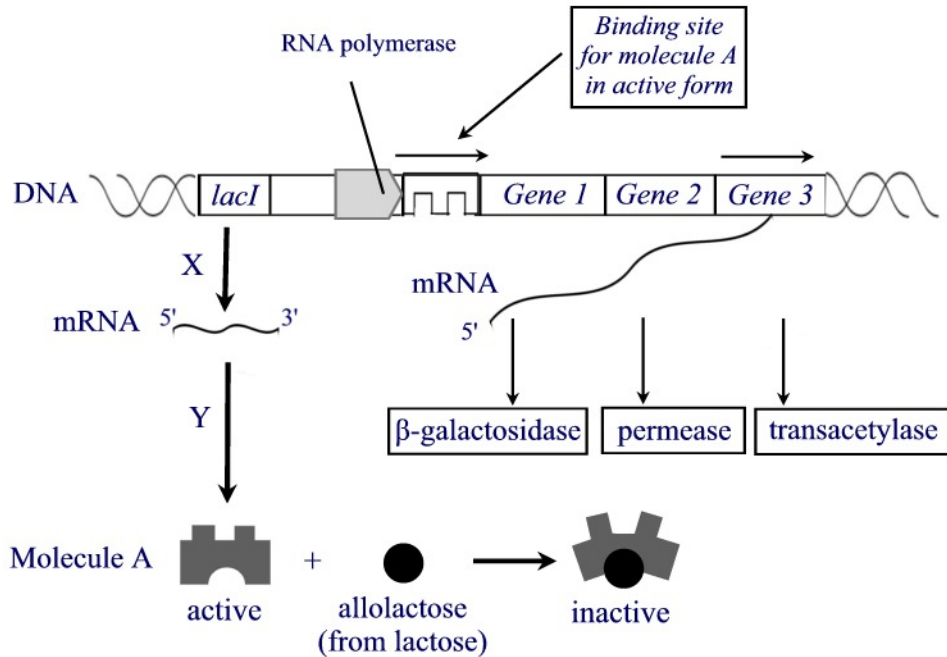
 1 mark

- b. What is the name of the process which enables *E. coli* to initiate the production of new enzymes?

 1 mark

In *E. coli*, lactose can be absorbed, broken down for energy or used as a source of organic carbon for synthesising other compounds. Lactose metabolism relies on the enzyme β -galactosidase which is only present in very small amounts in bacteria that have been growing in the absence of lactose (in a host with a low dairy product diet). However, if lactose is added to the nutrient medium of *E. coli*, within 15–20 minutes the amount of β -galactosidase increases one thousand times. The diagram below shows the outcome of adding lactose to a nutrient medium.

The lac operon



c. i. Identify the processes occurring at X and Y respectively.

X _____

Y _____

1 mark

ii. What is the function of Molecule A?

1 mark

iii. What is the function of the molecule allolactose?

1 mark

SECTION B – continued
TURN OVER

E. coli only produces increased quantities of β -galactosidase when lactose is included in the nutrient medium.

- d.** Explain the selective advantage in this metabolic strategy.

2 marks
Total 7 marks

Question 4

The protein SATB1 is found in the nuclei of cells and acts as a genome organiser. SATB1 is produced by the SATB1 gene which regulates the immune response and antibody production in healthy individuals; however, if a person has cancer, it can act as a master regulator.

- a.** Explain what is meant by the term ‘master regulator’.

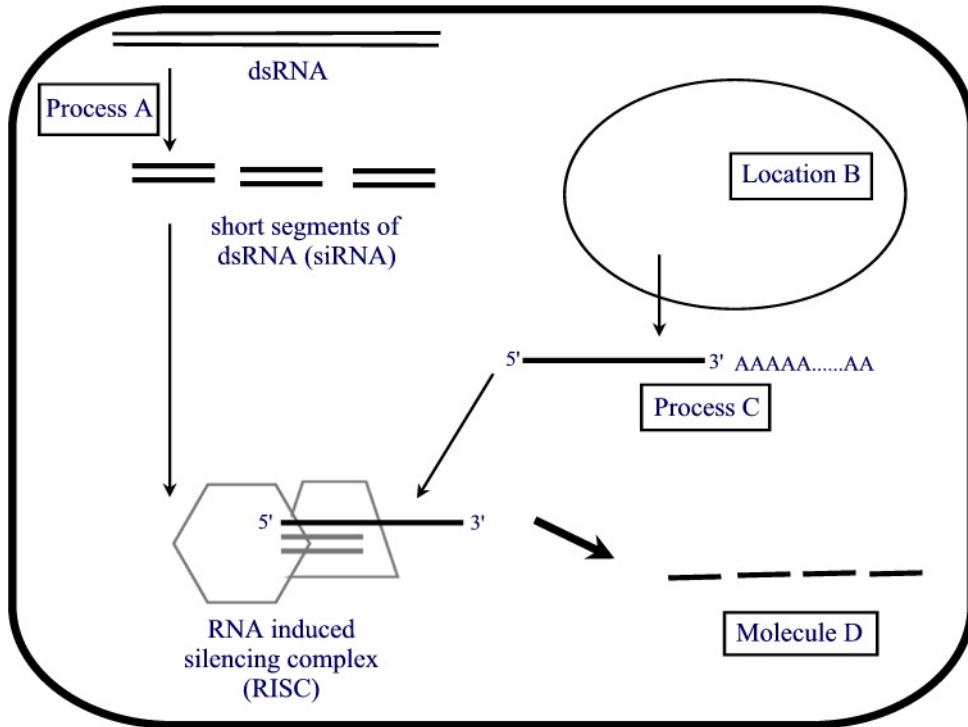
1 mark

SATB1 causes loops of DNA to clump together and as a result, the spatial arrangement of the DNA can change. Consequently, the position of proteins which surround some sections of the genome can be changed.

- b.** What is the likely effect of changing the position of the proteins which surround the genome?

1 mark

Research indicates that SATB1 acts a marker in tumour cells. Once it is expressed in breast cancer cells it is inevitable that they will proliferate and spread (metastasise). In a series of experiments on mice, the SATB1 gene in tumour cells was ‘knocked out’. The technique removed the RNAs required for SATB1 gene multiplication. The process is summarised in the following diagram.



c. i. What is the name given to the technique?

1 mark

ii. Complete the diagram with appropriate labels.

2 marks

iii. Explain the outcome of ‘knocking out’ the SATB1 gene in this experiment.

1 mark

d. What could be an unintended negative consequence of this technique?

1 mark

Total 7 marks

SECTION B – continued

TURN OVER

Question 5

Serious breeders of guinea pigs strive to produce strong pedigrees by mating their animals with strong genetic stock. When pups are sold to breeders, their family pedigrees are required. A breeder selling pups (GP26, GP27, GP28, GP29) claimed they were bred by a prize winning male (GP30) and female (GP25) was challenged as to whether the claim was true. To confirm or exclude GP30 as the breeding male of the pups, DNA profiles using STRs were prepared. The results are shown in the following table.

Parentage Evaluation Report – DNA Profiles														
LAB ID	STR1		STR2		STR3		STR4		STR5		STR6		STR7	
Claimed breeding female: GP25 (Carrie)	172	172	243	243	111	119	189	189	279	287	136	142	197	201
GP26 (Brownie)	172	188	238	243	111	111	180	189	279	315	120	142	194	197
GP27 (Tiny)	168	172	238	243	111	111	180	189	287	315	120	142	201	204
GP28 (Patch)	172	172	243	245	111	119	189	189	279	287	142	142	197	201
GP29 (Snowball)	172	172	233	243	111	119	189	189	279	287	142	142	201	201
Claimed breeding male: GP30 (Pete)	168	188	238	245	111	111	180	190	315	315	120	142	194	204

a. What is an STR?

1 mark

b. What do the numbers entered in the columns labelled STR represent?

1 mark

A scientist analysing the results of the DNA profile assumes that a female passes one of her two alleles at each STR locus to her offspring.

c. Explain clearly whether this assumption is correct.

2 marks

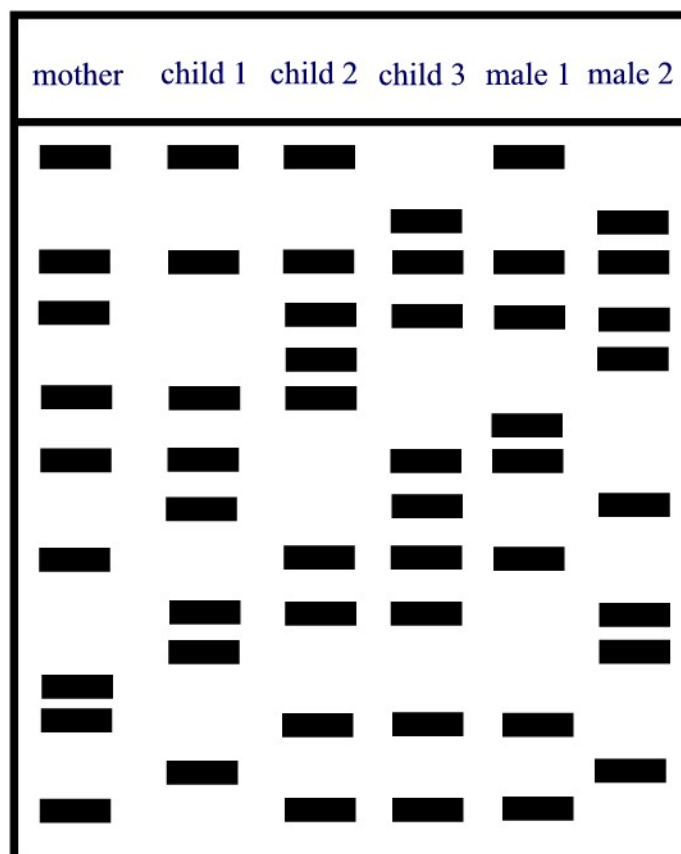
- d. Explain whether Pete is the breeding male of the pups.

2 marks
Total 6 marks

Question 6

On 17 July 1918, it was reported that all the Romanovs (Tsar Nicholas II, his wife Alexandra, their four daughters and one son), the Russian royal family and several of their attendants were killed and buried in an unmarked grave. In 1991, in a forest near Ekaterinberg in Russia, a shallow unmarked grave was found to contain the skeletal remains of nine people – three young females, three adult females and three adult males. Analysis of nuclear DNA suggested that there were five members of the same family and four unrelated individuals.

The results of a variable region analysis carried out on the remains are shown in the following diagram.



- a. Explain which of the males is the father of the children.

2 marks

SECTION B – continued
TURN OVER

In order to confirm identities, it was necessary to analyse the D-loop of the mitochondrial DNA (mtDNA) from each of the skeletons. The mtDNA was extracted and then amplified.

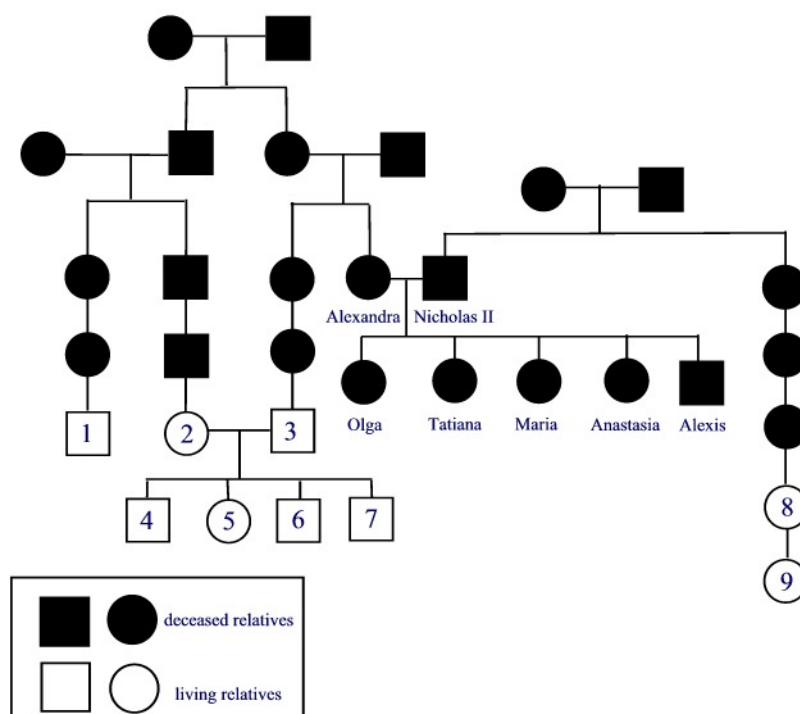
- b. i. Why is it necessary to use the D-loop of mtDNA specifically in this analysis?

2 marks

- ii. What is the name of the technique is used to amplify the mtDNA extracted from the skeletons?

1 mark

The relationship between the adult female and the three female children was confirmed, they were mother and daughters. However, whether they were the remains of Tsarina Alexandra and three of her daughters was yet to be determined. The pedigree shows part of the family tree of the Romanovs.



- c. Explain which living relative would be the best person to confirm the remains of Tsarina Alexandra?

2 marks

Total 7 marks

SECTION B – continued

Question 7

To establish whether giant pandas and lesser pandas are true bears or members of the racoon family, their evolutionary relationship was analysed using DNA-DNA hybridisation. In this process, single-stranded DNA from the species being compared was mixed and complementary base sequences allowed to anneal.

- a. Why is single-stranded DNA used in the process of DNA-DNA hybridisation?

1 mark

After the strands of DNA have annealed, the stability of the bonds is tested by heating the double-stranded molecule until the bonds separate again. The results of such a process are shown in the following table.

Species	Temperature at which DNA strands separate (°C)
1 and 2	77
1 and 3	81
2 and 3	74

- b. i. Explain with reference to the results in the table, the significance of the different temperatures.

2 marks

- ii. Which two species seem more closely related?

1 mark

SECTION B – continued
TURN OVER

- iii.** Use the results of the DNA-DNA hybridisation to demonstrate the evolutionary relationship between the three species using a cladogram (phylogenetic tree).

1 mark

- c.** Of what does the technique of DNA-DNA hybridisation provide a measure?

1 mark

In the past, scientists have studied single genes to gain knowledge about evolution. Researchers can now use comparative genomics to clarify evolutionary history.

- d.** Explain how comparative genomics enables the clarification of evolutionary history.

1 mark

Total 7 marks

Question 8

The Riversleigh world heritage area in Northern Queensland is a renowned fossil location. In the late 1990s, a near-complete skeleton of *Nambaroo gillespieae*, a prehistoric kangaroo, was unearthed. The new species is one of the earliest known predecessors of the modern kangaroo.

The skeleton of *Nambaroo gillespieae* was dated at 25 million years old.

- a.** Describe the dating techniques which would have been used to date the skeleton of *Nambaroo gillespieae*.

2 marks

Nambaroo gillespieae was about the size of a small dog and had canine fangs, large muscular forearms, opposable big toes and flexible feet, and lived in dense forest.

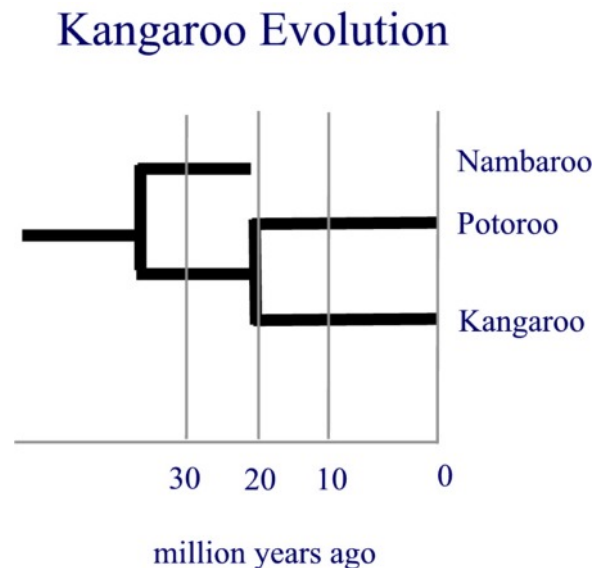
- b. Using evidence, describe two possible methods that *Nambaroo gillespieae* used to move around.

Method 1 _____

Method 2 _____

2 marks

The Nambaroo is part of an extinct group of kangaroos known as the Balbaridae which have been replaced over time by the direct predecessors of contemporary kangaroos. The diagram below shows the evolutionary history of the kangaroo.



- c. What kind of evolution has produced this history?

1 mark
Total 5 marks