INSIGHT

YEAR 12 *Trial Exam Paper*

2012

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*	Suggested times (minutes)
A	25	25	25	30
B	7	7	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.
- No calculator is allowed in this examination

Materials provided

- The question and answer book of 35 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.

A correct answer scores 1, an incorrect answer scores 0.

Marks are **not** deducted for incorrect answers.

No marks will be awarded if more than one answer is completed for any question.

Question 1

A recessively inherited condition is expressed only in individuals with type O blood. A man with type A blood has a child with a woman with type B blood. Their first child is born with the condition even though it is not expressed in either of the parents. Both the parents are heterozygous for the gene that causes the disease. What is the probability that their second child will have the condition?

A. $\frac{1}{4}$

B. $\frac{1}{16}$

C. $\frac{1}{3}$

D. $\frac{3}{4}$

Question 2

In sesame plants, pod type and leaf type are inherited independently. The one-pod condition (*P*) is dominant to the three-pod condition (*p*), and normal leaf (*L*) is dominant to wrinkled (*l*). A cross between two plants produces the following offspring:

273 one-pod, normal leaf	289 one-pod, wrinkled leaf	67 three-pod, normal leaf	56 three-pod, wrinkled leaf

The cross that would produce these results is

A. *PpLl* × *PpLl*.

B. *ppLl* × *ppLl*.

C. *PPll* × *ppLL*.

D. *PpLl* × *Ppll*.

Question 3

In humans, the genes of the major histocompatibility complex (MHC) code for human leukocyte antigens (HLA) as well as other proteins. HLA proteins are present on the surface of most body cells. The MHC consists of more than 70 genes, classified into classes I, II, and III MHC. There may be as many as one hundred different alleles at a single locus. An HLA gene could be described as

A. polymorphic.

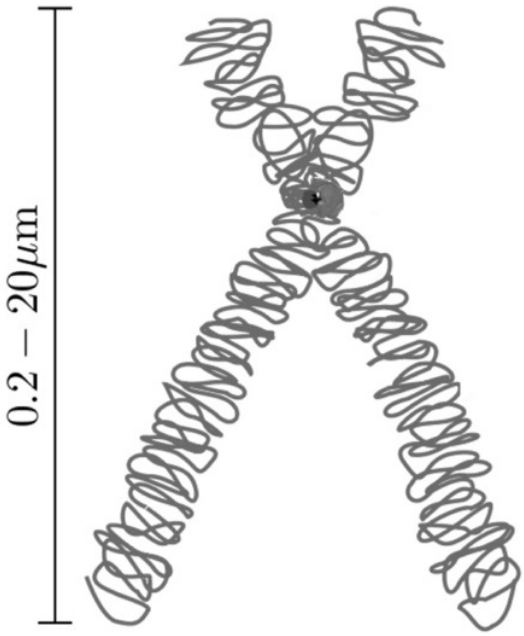
B. polygenic.

C. monomorphic.

D. monogenic.

The following information relates to Questions 4 and 5.

The image shows a diagram of a human chromosome.



Chromosome: Image by Magnus Manske

Question 4

The chromosome shown is duplicated and as a result has

A. one arm.

B. two arms.

C. three arms.

D. four arms.

Question 5

When a cell is not dividing, the chromosomes are present as

A. microtubules.

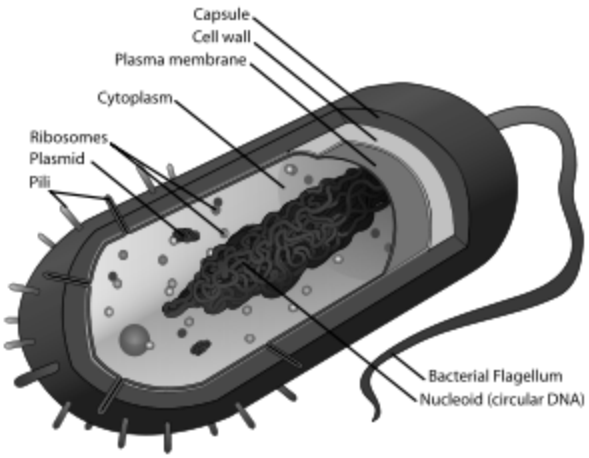
B. tubulin fibres.

C. chromatin fibres.

D. kinetochores.

Question 6

The diagram shows a prokaryote



Which of the following best describes the genetic material of the prokaryote?

	Plasmid	**Chromosome**
A.	single-stranded DNA	single-stranded DNA
B.	double-stranded DNA	double-stranded DNA
C.	single-stranded RNA	single-stranded DNA
D.	double-stranded RNA	double-stranded DNA

Question 7

Hydrangea: Image by Joachim Alves Gaspar

The hydrangea (*H. macrophylla*) is a plant characterised by a large flower-heads. The flowers can be blue, red, pink, light purple or dark purple depending on the pH of the soil. Anthocyanidins pigments found commonly in plants are responsible for colouring hydrangeas red in acid soil and blue in alkaline soil. The variation in flower colour of hydrangeas is under

A. genetic control.

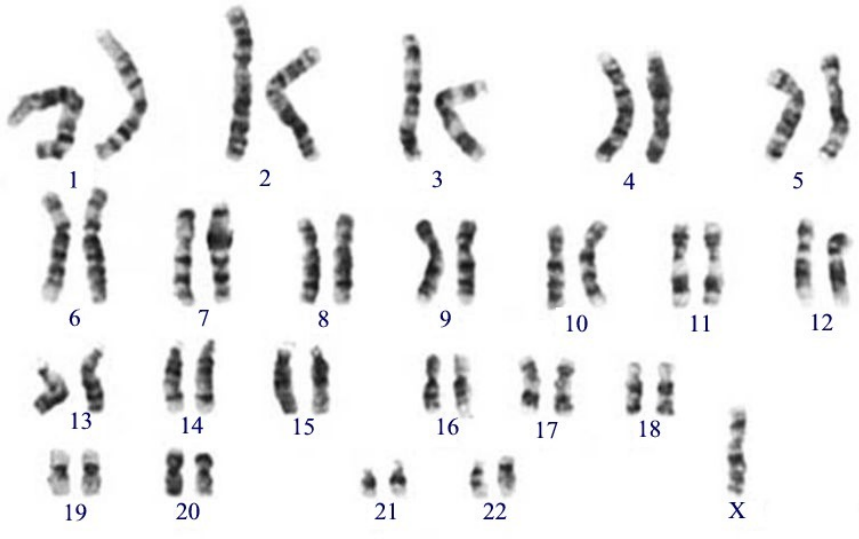
B. environmental control.

C. genetic and environmental control.

D. genetic, environmental and GM control.

The following information relates to Questions 8 and 9.

Question 8



The condition shown in the karyotype occurs as a result of

A. monosomy.

B. trisomy.

C. translocation.

D. inversion.

Question 9

From the karyotype it is possible to describe the sex of the baby as

A. male.

B. female.

C. intersex.

D. undetermined.

Question 10

The amino acid leucine can be produced by any of the following triplets:

AAT AAC GAA GAG GAT GAC

A tRNA molecule that codes for the amino acid leucine is

A. AAT.

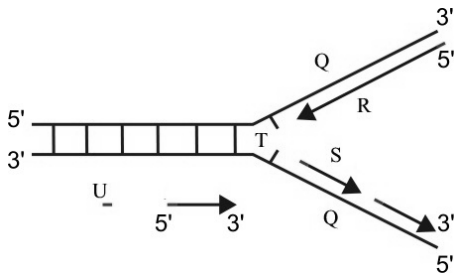
B. CTC.

C. GCU.

D. GAU.

Question 11

The diagram shows a DNA replication fork.



The correct labelling for the diagram is

	Q	R	S	T	U
A.	DNA template	lagging strand	leading strand	replication fork	Okazaki fragment
B.	DNA template	leading strand	lagging strand	Okazaki fragment	primer
C.	DNA template	leading strand	lagging strand	replication fork	primer
D.	DNA template	lagging strand	leading strand	primer	Okazaki fragment

The following information relates to Questions 12 and 13.

The mummichog fish (*Fundulus heteroclitus*) is a particularly hardy fish found along the eastern seaboard of the United States and Atlantic Canada. The mummichog fish requires a liver enzyme, lactate dehydrogenase (LDH), to maintain a high metabolic rate. A high metabolic rate enables the fish to maintain a high body temperature so they can survive and reproduce in cold waters. The diagram shows that in mummichog fish, the frequency of the allele for LDH decreases in fish sampled from Maine to Georgia. The table shows the relationship between genotype and phenotype in terms of the level of LDH in the liver.

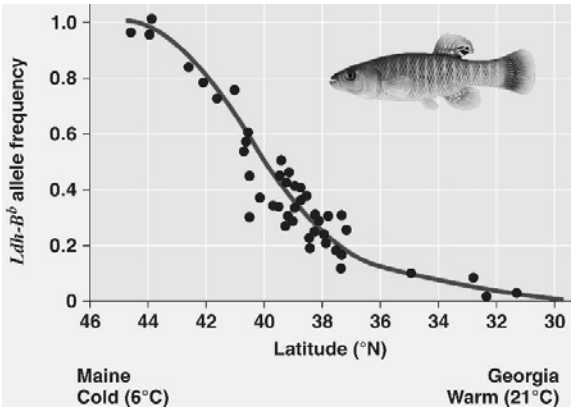


Image from Campbell, Reece, Meyers et al. Biology 8th edn

Genotype	Phenotype (level of LDH enzyme in the liver)
BB	4 units/g liver
Bb	2 units/g liver
bb	1 unit/g liver

Question 12

The range of frequencies for LDH in mummichog fish is an example of

A. geographical variation.

B. developmental variation.

C. behavioural variation.

D. structural variation.

Question 13

By chance, in one of the liver cells of a fish with the genotype *bb* there is a mutation that results in the change of a *b* allele for LDH into a *B* allele. This is unlikely to assist the fitness of the fish because

A. there will be no change in the amount of LDH produced in the liver.

B. the mummichog fish is already producing the maximum level of LDH.

C. the change in genotype will cause the rate of metabolism to decrease further.

D. the mutation has taken place in a somatic cell of the liver and will not raise the LDH sufficiently to effect a change.

Question 14

Snakes are capable of an impressive form of cranial kinesis whereby they are able to move the bones in their upper jaw to enable them to swallow prey much larger than their own head. This is an example of an adaptive evolution. The only evolutionary mechanism that consistently leads to adaptive evolution is

A. gene flow.

B. natural selection.

C. genetic drift.

D. founder effect.

Question 15

In eukaryote organisms the greatest source of genetic variation is due to

A. polymorphism.

B. masking of recessive alleles.

C. recombination.

D. mutations.

Question 16

Humans (*Homo sapiens*) and dogs (*Canis lupus familiaris*) have been living together for over 10,000 years. The images below show some of the dogs that exist today.

Mexican Wolf
Image by Trisha Shears

Chihuahua mix and Great Dane
Image by: Rogrido de Almeida

Shar pei
Image by Ellen Levy Finch

This variation in breeds is due to

A. artificial selection.

B. natural selection.

C. disruptive selection.

D. stabilising selection.

Question 17

Consider the following diagram.

The wings of pterosaurs, bats and birds are

A. analogous as forearms.

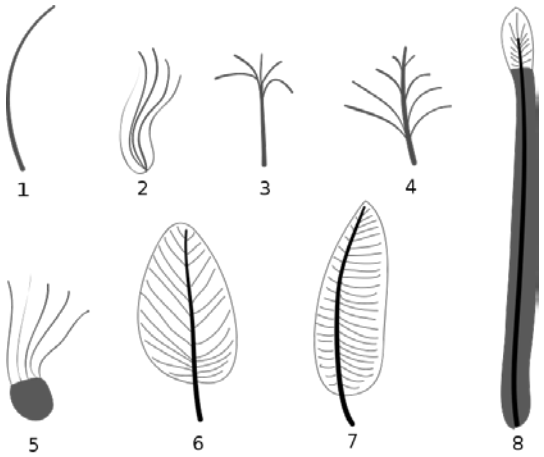
B. homogenous as forearms.

C. analogous as wings.

D. homologous as wings.

The following information relates to Questions 18 and 19.

When feathers first appeared in the fossil record, it is clear that they were not used for airborne travel. The first feathers were hairlike, hollow filaments. More mutations occurred, leading to branching of filaments which then joined together. The following diagram shows the stages of evolution in feathers.



Feather stages: Image by Matt Martyniuk

1 Single filament
2 Multiple filaments joined at their base
3 Multiple filaments joined at their base to a central filament
4 Multiple filaments along the length of a central filament
5 Multiple filaments arising from the edge of a membranous structure
6 Pennaceous feather with vane of barbs and barbules and central rachis
7 Pennaceous feather with an asymmetrical rachis
8 Undifferentiated vane with central rachis

Question 18

It would be reasonable to expect that in the fossil record there will be

A. no dinosaurs with feather-like coverings.

B. dinosaurs with feather-like coverings of many kinds.

C. dinosaurs with one kind of feather-like covering.

D. only one type of dinosaur with one kind of feather-like covering.

Question 19

Which of the following statements about feathers is NOT correct?

Feathers

A. play a role in mate selection in birds.

B. evolved to enable dinosaurs to fly.

C. are associated with thermoregulation.

D. assist in camouflage.

Question 20

The order of fossils in rock strata indicates the sequence in which the fossils were laid down. It does not however provide information about their actual ages. Which of the following techniques could be used to determine the actual age of a fossil?

A. stratigraphy.

B. biostratigraphy.

C. lithology.

D. radiometry.

The following information relates to Questions 21 and 22.

In 2011, scientists published a paper claiming that when humans eat Asian rice (*Oryza sativa*), a microRNA (miRNA) highly expressed in that rice is secreted into vesicles during digestion and then taken up by liver cells, where the miRNAs then have a physiological effect on human low-density lipoprotein (LDL) levels. All eukaryote organisms produce miRNAs, tiny non-coding sequences of RNA (only 22 nucleotides long). They enable a cell to control how much of a specific protein it produces, allowing rapid and flexible, real-time responses to changing conditions. Subsequent research has shown that the miRNA from the rice could inhibit uptake of LDLs, which can lead to atherosclerosis.

Without any scientific evidence, a writer linked miRNAs with genetically modified organisms (GMOs), in an attempt to alert people to the danger that manipulating plant DNA will lead to an increase in human diseases such as cancer, Alzheimer's disease and diabetes.

GMOs were not used in the Asian rice study.

Question 21

A GMO is an organism

A. whose genome has been artificially changed.

B. whose genome has been altered by recombination during meiosis.

C. which has been cloned.

D. which has been exposed to mutagens.

Question 22

Theoretically miRNAs from Asian rice are not harmful to humans because

A. they are small molecules.

B. they are comprised of nucleic acid.

C. miRNAs are present in everything we ingest.

D. they are enclosed in vesicles which do not break open.

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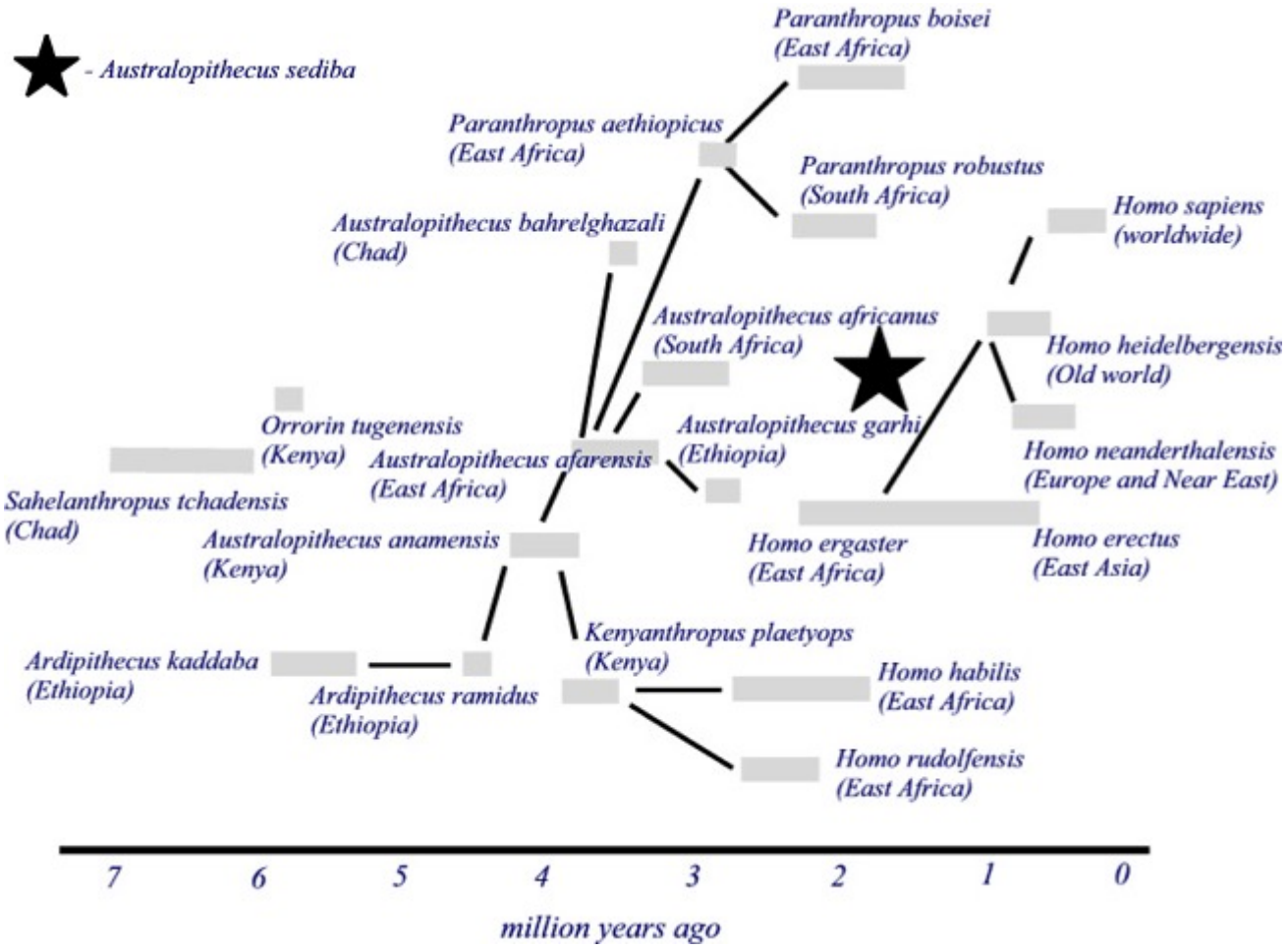
The following information relates to Questions 23, 24 and 25.

In September 2011, researchers revealed new details about the brain, pelvis, hands and feet of *Australopithecus sediba* (*A. sediba*), a primitive hominin that existed around the same time early *Homo* species first began to appear. The fossils of a juvenile male (MH-1) and an adult female (MH-2) *A. sediba* were found together in the Malapa caves in South Africa in 2010. The fossil record for early *Homo* is very ambiguous. Many fossils are attributed to several species and their dating can be inaccurate. *A. sediba* has a number of derived characteristics, which it shares with the genus *Homo*. *A. sediba* has many more traits in common than any other early *Homo* (*H. rudolfensis*, *H. habilis*) with *H. erectus*.
The diagram shows an interpretation of the evolutionary relationship of the genus *Homo*.



Question 23

The diagram suggests that *A. sediba* is likely to be

A. a descendant of *H. rudolfensis*.

B. an ancestor of *A. afarensis*.

C. a descendant of the first species of the *Homo* genus; *H. erectus*.

D. an ancestor of the first species of the *Homo* genus; *H. erectus*.

Question 24

The wrist and hand of MH-2 were only missing a few bones, making them the most complete hand fossils for an early hominin on record. The hand showed a strong flexor apparatus (which hints at tree-climbing) and also had a long thumb and short fingers (a sign of precision gripping). Considering the long thumb and short fingers of the hand it is highly likely that *A. sediba*

A. was highly adept at tree climbing.

B. engaged in tool making.

C. was an agile quadruped.

D. was skilled at cave painting.

Question 25

What radiometric dating method would have been used to date the age of *A. sediba*?

A. uranium–lead dating

B. carbon-14 dating

C. electron-spin resonance

D. potassium–argon dating

END OF SECTION A

END OF SECTION A

SECTION B – Short-answer questions

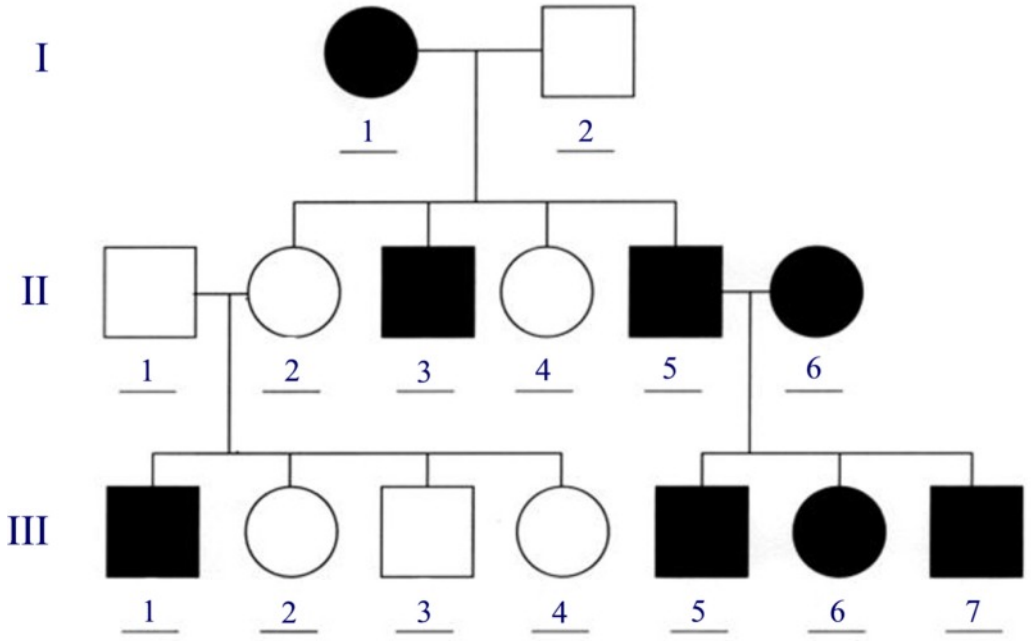
Instructions for Section B

Answer this section in pen.

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

Question 1

The pedigree shows the inheritance of a condition in a family over several generations. Shading indicates expression of the condition.



a. What is the mode of inheritance?

_____

1 mark

b. If III5 has a child with an individual who is heterozygous for the condition, what is the chance that they will have a child with the condition?

_____

1 mark

c. Using appropriate allele symbols, assign a genotype to Individual II2

_____

1 mark

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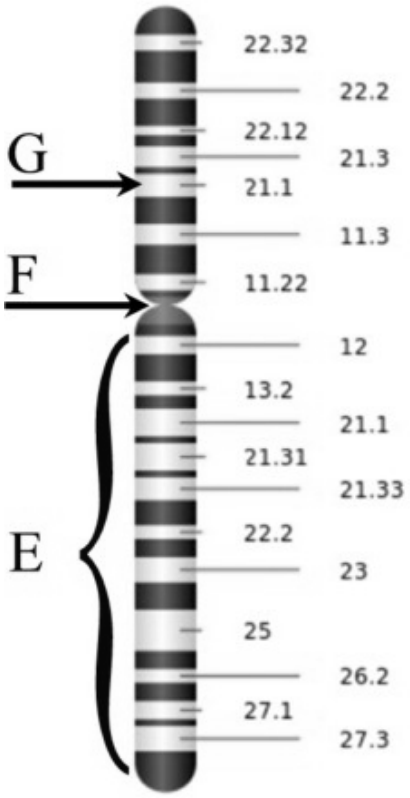
An ideogram of the chromosome that carries the gene for the inherited condition in the pedigree is shown below.



d. Complete the labelling of the diagram by filling in the table.

Structure	Name	Function
E	q – arm	
F		point of mitotic spindle attachment during cell division
G	locus	

2 marks

e. How many copies of this chromosome would be present in a normal germline cell?

_____

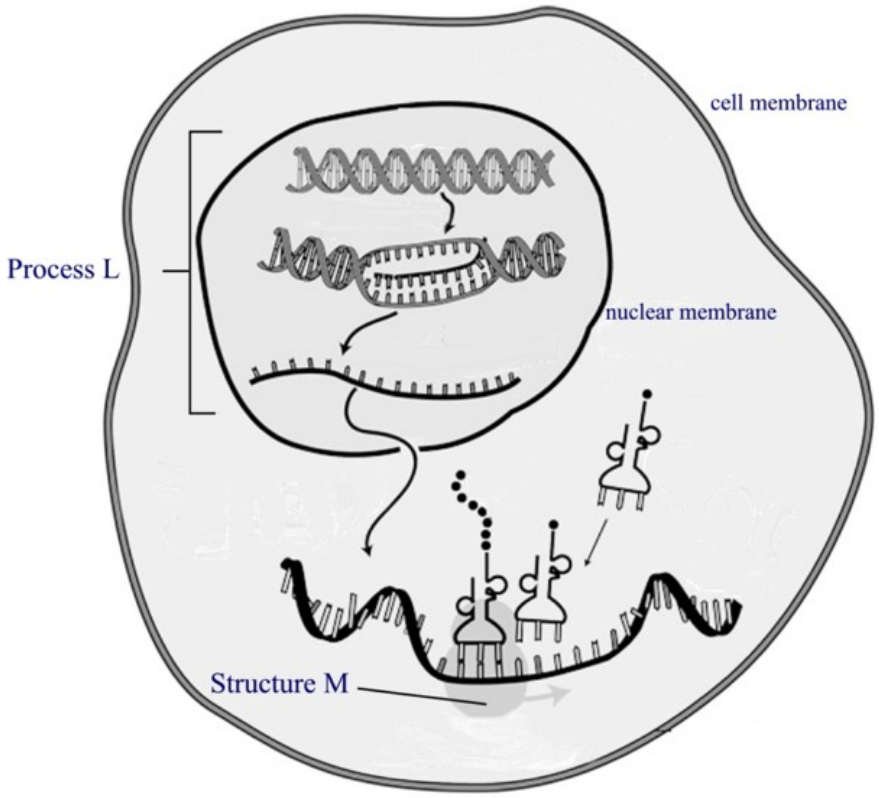
_____

1 mark

Total 6 marks

Question 2

The following diagram outlines processes that occur within a living cell. The diagram is not drawn to scale.



a. What is the name given to the structure in which helicase is found?

_____

1 mark

b. Describe the function of helicase.

_____

_____

_____

_____

2 marks

c. **i.** Identify the process that occurs at L.

_____

1 mark

ii. Describe the sequence of events that takes place during the process at L.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

3 marks

d. Name structure M. Explain how it contributes to protein production.

Structure M: _____

_____

_____

1 mark
Total 8 marks

Question 3

Haemoglobin is the iron-containing protein in red blood cells that carries oxygen in the human body. The haemoglobin molecule (HbA) is made up of four polypeptide chains which consist of two alpha (α) globin chains and two beta (β) globin chains. Individuals with beta (β) thalassaemia do not produce β-globin and therefore cannot produce HbA. Mutations in the HBB gene cause β-thalassaemia.

Haemoglobin: Image by Richard Wheeler

There are over 250 mutations in the HBB gene that are known to cause β-thalassaemia. One such mutation is directly associated with a condition known as sickle cell anaemia (SCA), in which an abnormal version of β-globin called haemoglobin S (HbS) replaces both β-globin chains in the haemoglobin molecule, causing the red blood cells to elongate, curve and take on a sickle shape. This change makes the sickled red blood cells less efficient at transporting oxygen through the bloodstream. The mutation that causes SCA is shown below.

HBB Sequence in Normal Adult Haemoglobin (HbA)

Nucleotide	CTG	ACT	CCT	GAG	GAG	AAG	TCT
Amino acid	Leu	Thr	Pro	Glu	Glu	Lys	Ser
	3			6			9

HBB Sequence in Mutant Adult Haemoglobin (HbS)

Nucleotide	CTG	ACT	CCT	GTG	GAG	AAG	TCT
Amino acid	Leu	Thr	Pro	Val	Glu	Lys	Ser
	3			6			9

a. Identify the mutation that causes SCA.

_____

1 mark

Malaria is a disease caused by a parasite of the genus *Plasmodium. Plasmodium* infects red blood cells and, whilst within, multiplies asexually. The parasite thrives in red blood cells that contain HbA, but is unable to survive in red blood cells containing HbS. However, individuals with red blood cells containing HbS have SCA. Consider the table below.

Genotype	**Phenotype**	**Effect of genotypes**	
		Malaria-affected environments	**Malaria-free environments**
HbA HbA	normal red blood cells haemoglobin A only	no sickling can die from malaria	no sickling
HbA HbS	red blood cells capable of sickling haemoglobin A and S	minor effects of sickling resistant to malaria	minor effects of sickling
HbS HbS	severe sickle cell anaemia haemoglobin S only	can die from sickle cell anaemia resistant to malaria	can die from sickle cell anaemia

b. Explain the observation that in areas with persistent malaria outbreaks, individuals with the HbA–HbS genotype occur in far greater numbers.

_____

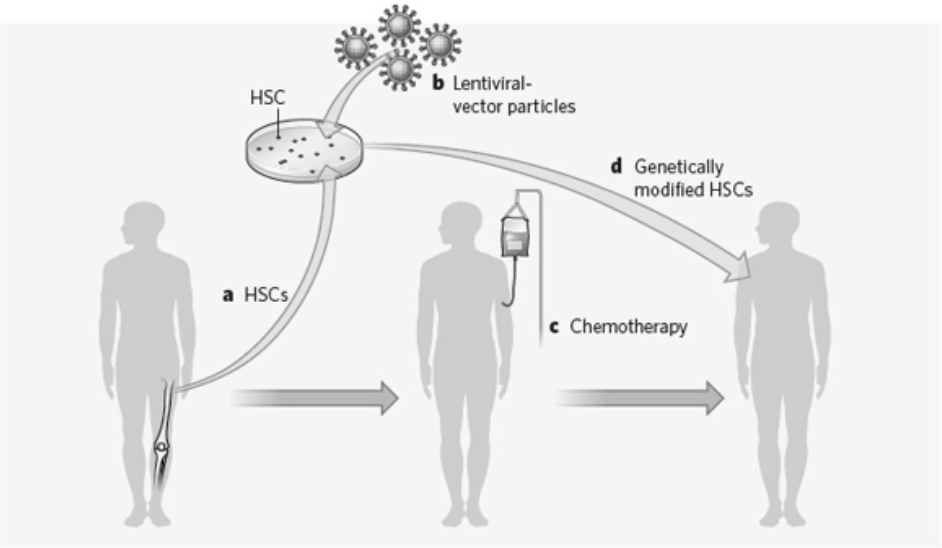
_____

_____

_____

2 marks

In 2007, an international team of scientists, led by biotherapist Marina Cavazzana-Calvo, took a sample of haematopoietic stem cells (HSCs) from the bone marrow of an 18-year-old man with β-thalassaemia who was dependent on blood transfusions for survival. The cells were cultured and mixed with lentiviral-vector particles into which a functional copy of the β-globin gene had been introduced. The genetically modified cells were transplanted. Levels of healthy red blood cells with normal β-globin chains gradually rose until, around a year after the treatment, he no longer required transfusions.



c. **i.** Why are HSCs so suitable for gene therapy?

_____

_____

1 mark

ii. What would need to be guaranteed when using the viral vectors for the gene therapy?

_____

_____

1 mark

Before receiving the genetically modified HSCs, the man was given chemotherapy.

d. Explain why chemotherapy was necessary at this stage of the procedure.

_____

_____

1 mark

The treatment has been viewed as successful; however the scientific community remains cautious. Concerns have been raised about overexpression of a protein called HMGA2 which resulted in a high proportion of the genetically modified cells. HMGA2 has been linked to cancers.

e. **i.** What event might have triggered overexpression of HMGA2?

_____

_____

1 mark

ii. If future treatments are to proceed, how might overexpression of HMGA2 be avoided?

_____

_____

1 mark

Total 8 marks

Question 4

The Komodo dragon (*Varanus komodoensis)* has the ZW chromosomal sex-determination system. Female dragons carry one Z and one W chromosome and males carry two Z chromosomes. In 2005 at London Zoo, after being separated from a male Komodo dragon for more than two years, a female dragon (Sungai) laid a clutch of eggs. Scientists erroneously believed that she had been able to store sperm from an earlier encounter. In 2006, it was reported that another Komodo dragon (Flora) at a different zoo, laid a clutch of unfertilised eggs. Of the 11 eggs, seven hatched, all of them male.

Genetic tests were carried out on three eggs that collapsed after being moved to an incubator. The results reported that the offspring were not identical clones.

a. What is the term used to describe the female Komodo dragon genotype?

_____

1 mark

b. Explain whether it is possible for all offspring to be homozygous at all loci.

_____

_____

_____

_____

2 marks

c. Draw a diagram to clearly demonstrate the mechanism that produces unfertilised eggs that develop into male Komodo dragons. Include written explanations for clarity.

2 marks

One advantage of this reproductive strategy is that Komodo females can reproduce without male mates. In the wild, a female Komodo dragon could swim to a new island, lay a clutch of unfertilised eggs and potentially found an entirely new colony on its own.

d. What is the disadvantage of parthenogenetic reproduction in Komodo dragons?

_____

_____

_____

_____

2 marks

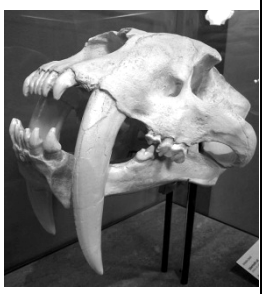
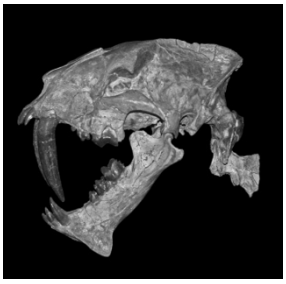
Total 7 marks

Question 5

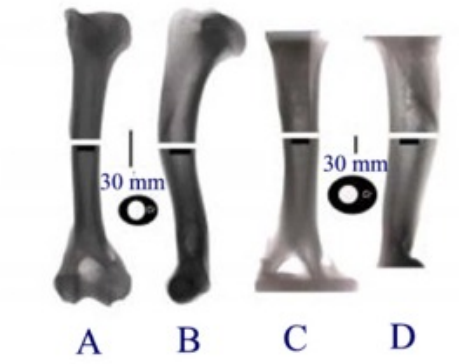
The sabre-toothed cat *Smilodon* (2 mya–1 mya) has been described as a 'hyper-ambush' hunter. Instead of using the ambush–chase strategy seen in modern cats, it is believed *Smilodon* would hide and lie in wait for its prey. When prey did pass by, *Smilodon* would leap out at it, probably knocking it off balance and attacking.

Unlike the modern cat which imparts death by using its jaws to close off the throat or nose of its prey, the sabre-toothed cat used its teeth to inflict quick lethal stabs. The teeth of the modern cat are conical and able to withstand forces in all directions. Sabre teeth were long and flattened and if they struck the bones of prey during a bite would have shattered very easily.

Studies of fossils suggest that at least three different groups of ancient animals hunted in the same way. The following table presents information about four groups of 'hyper-ambush' hunters.

Smilodon fatalis (sabre-tooth cat)	***Hoplophoneus primaevus*** Nimravidae	***Barbourofelis loveorum*** Barbourofelidae	***Panthera atrox*** (extinct American lion)
North America South America	North America Eurasia	North America Eurasia Africa	North America
2 mya–1 mya	42 mya–7 mya	16 mya–9 mya	0.34 mya–11,000 ya
 *Image: Stickpen*	 *Image: H Zell*	 *Image: Dallas Krentzel*	 *Image: Claire H*

X-rays comparing the cross-sectional dimensions of the upper arm bone of a jaguar (A and B) with *Smilodon fatalis* (C and D) showed that the upper arms had extra-thick, reinforced bone with significantly large attachment points.



a. Explain the significance of the upper arm bones and the implications for the teeth of the sabre-toothed cat.

_____

_____

_____

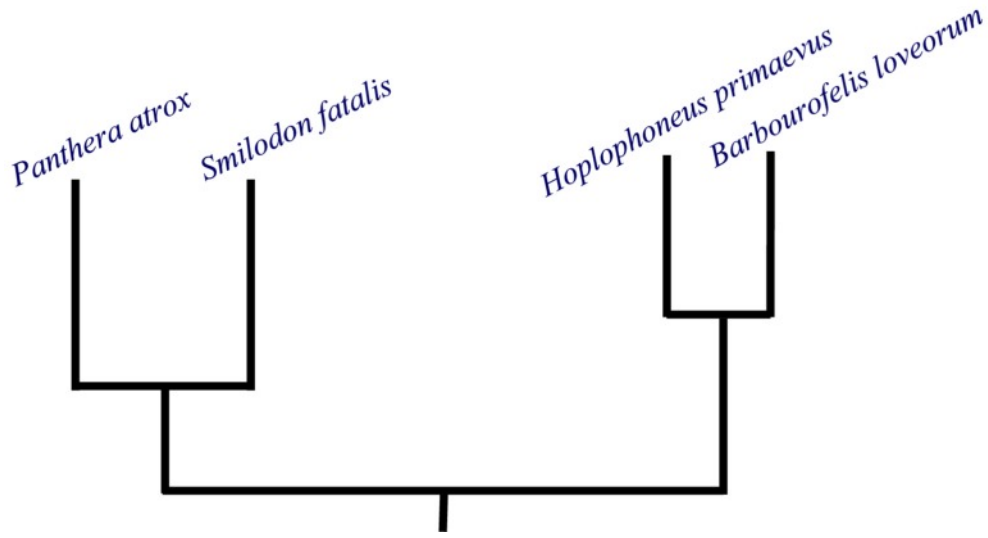
2 marks

b. What prediction could be made about the relationship between tooth length and the size and shape of forelimb bones?

_____

1 mark

The cladogram shows the evolutionary relationship that exists between the four groups of 'hyper-ambush' hunters. They are separated by considerable distance in geological time.



c. Given the strong similarities shown by each of these groups, identify and describe the kind of evolution that has taken place.

_____

_____

_____

_____

2 marks

In many regions around the globe, 'hyper-ambush' hunters are known to have hunted the same prey as their shorter-toothed relatives.

d. Suggest two strategies the 'hyper-ambush' hunters might have used in order to reduce competition and live side by side with their shorter-toothed relatives.

Strategy 1: _____

_____

_____

Strategy 2: _____

_____

_____

2 marks

Total 8 marks

Question 6

The common monkey-flower *Mimulus guttatus* is an annual (lives for one year) or perennial (lives for two years) herbaceous wildflower that has a very broad geographical and ecological range in western North America.

	Ecotype	Habitat	Flowering time
Mimulus guttatus (AN)	annual	Dry inland	early in the season
Mimulus guttatus (PE)	perennial	moist and cool coastal	late in the season

a. Explain the likely effect of the different flowering times on the two ecotypes of *Mimulus guttatus*.

_____

1 mark

The diagram shows chromosome AN and chromosome PE. The chromosomes carry the same genes.

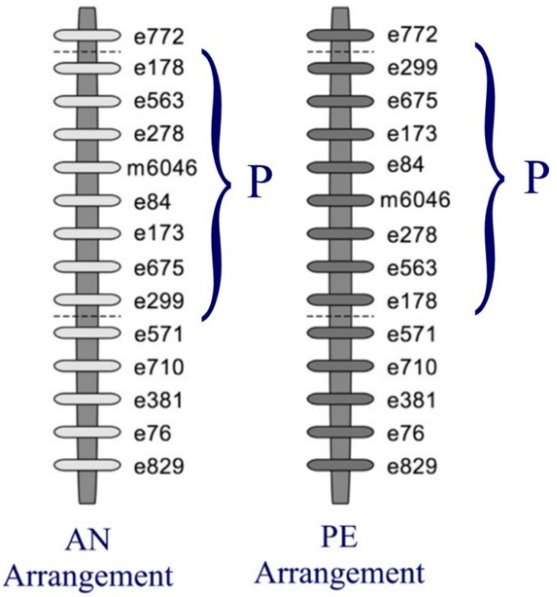


Image: Lowry DB, Willis JH (2010) A Widespread Chromosomal Inversion Polymorphism Contributes to a Major Life-History Transition, Local Adaptation, and Reproductive Isolation.

b. Suggest a likely explanation for the appearance of these two chromosomes and state what event could have caused this to occur.

_____

_____

2 marks

David Lowry, the researcher investigating the monkey-flower, found a large suite of 350 adaptive genes within the section shown at P. These genes determine whether the plant will survive in an inland or a coastal habitat. The adaptive genes of the inland and the coastal monkey-flower appear to be 'locked'-in position. If transplanted to the other environment, neither variety is able to reproduce successfully. The consequence of its spread is reproductive isolation and potentially a new species.

c. **i.** Explain the mechanism resulting in the reproductive isolation of *M. guttatus* (AN) and *M. guttatus* (PE).

_____

_____

_____

2 marks

ii. What form of evolution is taking place within the *M. guttatus* population?

_____

1 mark

Total 6 marks

Question 7

The genus of plants *Penstemon* is endemic to the Great Basin region of the western United States.

Populations of *Penstemon* are found living at high elevation on separate mountain tops. The seeds are all dispersed by gravity and do not move very far from the parent plant.

a. Suggest how gene flow is most likely to occur between these populations.

_____

_____

1 mark

b. What is a polymorphic microsatellite?

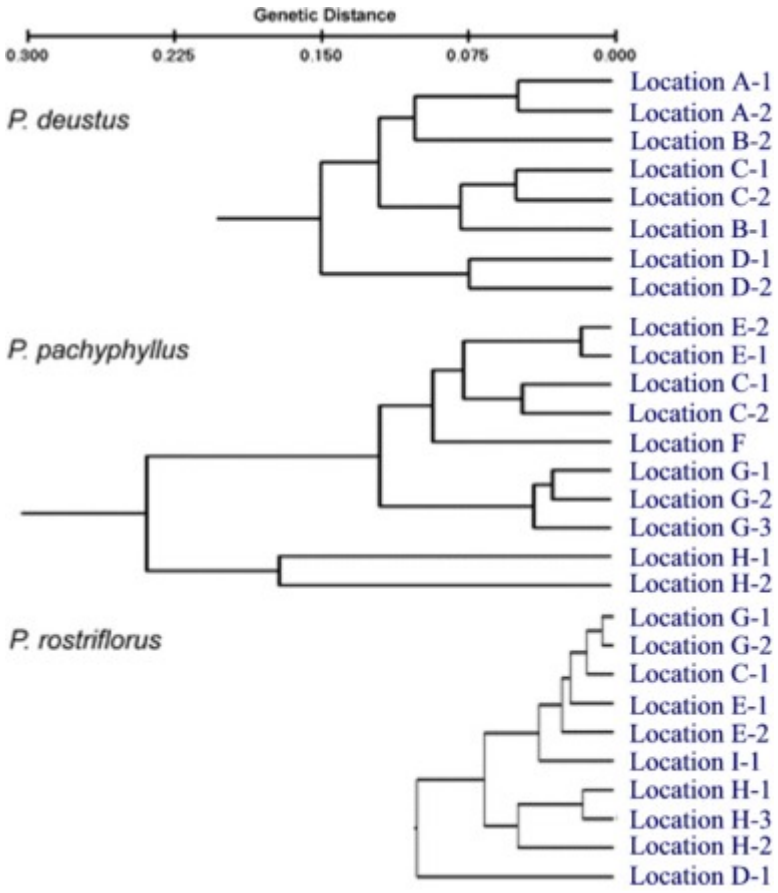
_____

_____

_____

2 marks

This data was then used to determine patterns of gene diversity both within each population on a mountain top and between more distant populations found on other mountain tops. The degree of genetic distance between the different populations is shown below.



c. In relation to the cladogram, what can be observed about the genetic distance that exists in the populations of *P. pachyphyllus* and *P. rostriflorus*?

_____

_____

_____

1 mark

The table shows three species of *Penstemon* and their mode of pollination.

Species of *Penstemon*	Mode of pollination
P. pachyphyllus, P. deustus	bees
P. rostriflorus	hummingbirds

d. Suggest an explanation for the genetic distance observed in *P. rostriflorus*.

_____

_____

_____

1 mark

The study showed that bee-pollinated species of *Penstemon* were genetically clustered and distinct for each mountain range. There was little or no mixing of genetic material between mountain ranges.

e. Clearly outline the stages of the process that would have resulted in the genetic isolation of *P. pachyphyllus* and *P. deustus*.

_____

_____

_____

_____

_____

3 marks

Total 8 marks

END OF QUESTION AND ANSWER BOOK