

Student Name: _____

Biology

Written examination 2



2005 Trial Examination

Reading Time: 15 minutes
Writing Time: 1 Hour and 30 minutes

QUESTION AND ANSWER BOOK

Structure of Book

<i>Section</i>	<i>Number of questions</i>	<i>Number of questions to be answered</i>	<i>Number of marks</i>
A	25	25	25
B	5	5	50
			Total 75

- 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.
- Calculators are NOT permitted in this examination.

Materials supplied

- Question and Answer Book of 21 pages.
- Answer sheet for multiple choice questions.

Instructions

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

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

SECTION A- Multiple choice questions

Specific Instructions for Section A

A correct answer scores 1, an incorrect answer scores 0. Marks are not deducted for incorrect answers. If more than 1 answer is completed for any question, no mark will be given. You should spend approximately 30 minutes on this section.

Select the most appropriate alternative for each of the following 25 questions

Question 1

Albinism in humans is inherited as an autosomal recessive trait. A cross between two individuals, both heterozygous for albinism, could be represented by:

- A. $AA \times AA$
- B. $aa \times aa$
- C. $Aa \times Aa$
- D. $Aa \times aa$

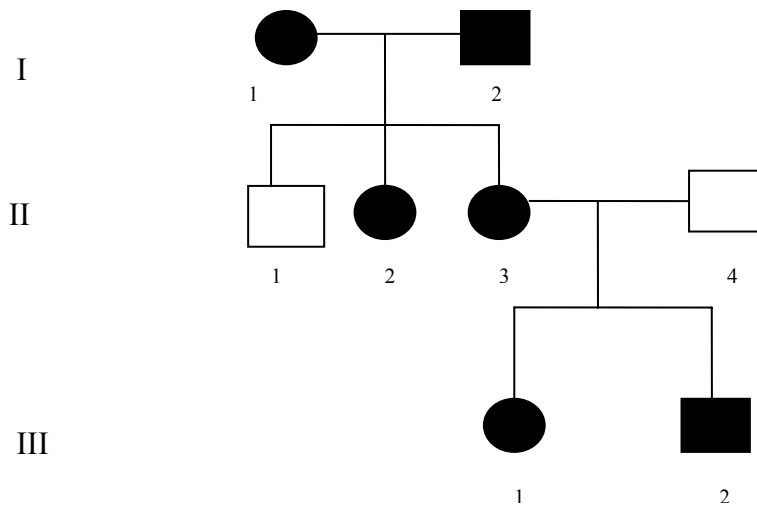
Question 2

A cross that would confirm that a prize-winning dog is a carrier for albinism would be:

- A. $AA \times AA$
- B. $aa \times aa$
- C. $AA \times Aa$
- D. $Aa \times aa$

Question 3

Incontinentia Pigmenti (IP) is an X-linked dominant disorder for which the phenotype can include short stature, dental abnormalities and unusual skin pigmentation. The diagram below shows a pedigree for Incontinentia Pigmenti in humans. Shaded individuals have the disorder.



From the pedigree it is certain that an individual who is heterozygous is:

- A. I - 1
- B. II - 1
- C. II - 3
- D. III - 2

Question 4

If II – 3 and II – 4 have another child, it could be concluded that the chance of it being affected by IP is:

- A. 0/4
- B. 1/2
- C. 1/3
- D. 3/4

Question 5

For Incontinentia Pigmenti, it is also reasonable to conclude that:

- A. males can inherit the disorder from their fathers
- B. all sons of a heterozygous female will have Incontinentia Pigmenti
- C. a homozygous female with Incontinentia Pigmenti will have a father with the disorder
- D. half of the daughters of a male with this disorder will have Incontinentia Pigmenti

Question 6

The ABO blood group system is under the control of a single gene with the alleles

I^A	:	presence of antigen A on red blood cells
I^B	:	presence of antigen B on red blood cells
I^{AB}	:	presence of both antigens on red blood cells
I^O	:	presence of neither antigen on red blood cells

With respect to this gene:

- A. an individual could have one of eight different genotypes
- B. an individual could have one of six different genotypes
- C. a child could have antigen A even if both parents lacked antigen A on their red blood cells
- D. a child with neither antigen A nor B could have a mother with antigen A and a father with antigen B

Question 7

The ABO blood group system is an example of the expression a trait being due to a single gene. Other traits are due to the action of many genes. These traits are said to be due to:

- A. multiple alleles
- B. polymerases
- C. polyploidy
- D. polygenes

Use the following information for Questions 8 to 10

In Galloway cattle, some offspring are born with severely stunted limbs. Calves with this phenotype are described as “amputated” and die shortly after birth. The gene affected has two alleles:

N	-	normal
n	-	amputated

Galloways, which are usually pure black, can also have a white saddle-shaped marking which gives a “belted” phenotype. This also is controlled by a single gene:

B	belted
b	black

Question 8

The appearance of the allele giving rise to the amputated phenotype is the result of:

- A. recombination
- B. gene flow
- C. mutation
- D. independent assortment

Question 9

If a heterozygous normal belted bull was crossed with a black cow heterozygous for the amputated condition, the genotypes of these two parents would be

- A. NnBb x nnbb
- B. NNBb x Nnbb
- C. NNBb x nnBb
- D. NnBb x Nnbb

Question 10

What proportion of the surviving offspring of this cross would be belted?

- A. 100%
- B. 50%
- C. 75%
- D. none

The following information relates to Questions 11 and 12.

The figure below represents a length of DNA and its cutting sites for the restriction enzymes *Taq* I, *Hin* dIII, *Eco* RI and *Bam* HI.



Question 11

The shortest single piece of DNA would be produced by incubating this DNA in a tube containing:

- A. *Taq* I
- B. *Hin* dIII
- C. *Eco* RI
- D. *Bam* HI

Question 12

Incubation of this DNA in a tube containing:

- A. *Taq* I would result in three pieces of DNA
- B. *Hin* dIII would result in two pieces of DNA
- C. *Eco* RI and *Taq* I would result in five pieces of DNA
- D. *Bam* HI and *Hin* dIII would result in four pieces of DNA

Question 13

Mitosis occurs during tissue growth in human tissues. The number of chromosomes in a human cell during anaphase of mitosis is best represented by:

- A. $2n$
- B. n
- C. $3n$
- D. $4n$

Question 14

Meiosis occurs during the formation of human gametes. Compared with the amount of nuclear DNA in a human nerve cell, the amount of nuclear DNA in a sperm-forming cell during anaphase II of meiosis will be:

- A. half
- B. a quarter
- C. the same
- D. double

Question 15

Protein synthesis occurs on the ribosomes when:

- A. triplets of bases in DNA are translated
- B. sequences of three consecutive bases in mRNA are matched to complementary sequences in tRNA molecules
- C. amino acids are brought to the ribosome by mRNA molecules
- D. nuclear DNA has been transcribed into tRNA

Question 16

The codon AAU codes for the amino acid asparagine. It is reasonable to say that:

- A. other codons may also code for asparagine
- B. the DNA triplet on the template strand coding for asparagines is TTA
- C. the same codon may also code for other amino acids
- D. the anticodon corresponding to this codon is TTA

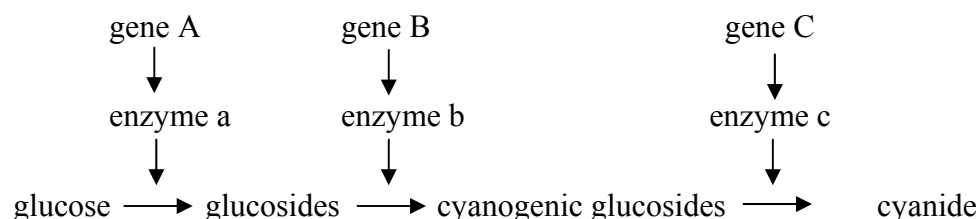
Question 17

The sequences in a eukaryotic gene which are not spliced out after transcription and are actually translated on ribosomes are called:

- A. introns
- B. codons
- C. anticodons
- D. exons

For Questions 18 – 20 use the following information.

Clover, *Trifolium repens*, sometimes produces cyanide in its leaves. This is released when leaf cells are ruptured by grazers or frost. The cyanide is produced by the following metabolic pathway.



Question 18

The production of cyanide is controlled by the following number of genes:

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

Question 19

A recessive mutation has occurred in gene B. In plants homozygous for the mutant allele, enzyme b can no longer be produced. It would be logical to predict that this mutant allele will become more common in clover populations:

- A. in sub-alpine habitats affected by frequent autumn and winter frosts
- B. in paddocks occupied by large numbers of sheep
- C. in habitats never affected by frost
- D. in paddocks which are never grazed

Question 20

The resulting increase in the frequency of the mutant allele in the population of clover would be an example of:

- A. genetic drift
- B. natural selection
- C. gene flow
- D. recombination

The following information relates to Questions 21 – 24

Samples of DNA were taken from two men, “P” and “Q”, who were suspects in a rape case. A sample of semen was also taken from the victim, and DNA was extracted from it. DNA was also obtained from the victim’s cheek cells. The various samples of DNA were compared using gel electrophoresis. DNA from a well-studied strain of yeast was used as a control. The region of human DNA of interest was a region called DS180, found on chromosome number 1. In this region, DNA sequences are repeated to a highly variable extent between individuals.

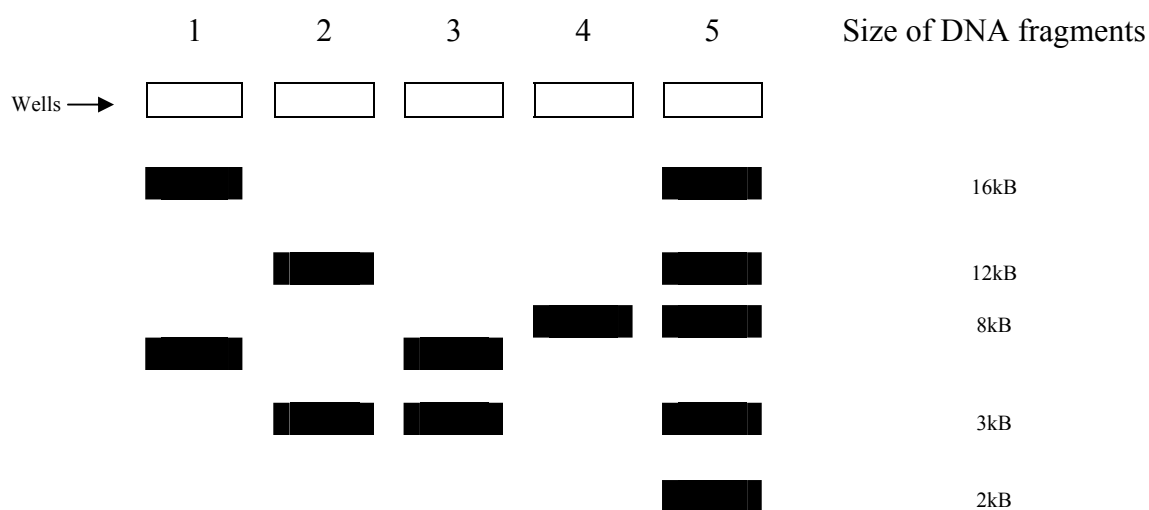
Question 21

The term used to describe a sequence of bases, in the same region of DNA, which is variable between individuals is:

- A. alleles
- B. continuous variation
- C. loci
- D. tandem repeats

The results of the DNA analysis are shown on the gel below.

1 – “Q”, 2 – “P”, 3 – semen sample, 4 – victim’s cheek cells, 5 - control



Question 22

From the evidence on the gel, which suspect appears to be responsible for the rape?

- A. Q
- B. P
- C. both
- D. neither

Question 23

The most likely reason for the victim's DNA only showing one band on the gel is that:

- A. she is heterozygous at the DS180 locus
- B. the restriction enzyme used to prepare the DNA fragments has not cut the DNA from the victim
- C. the restriction enzyme used to prepare the DNA fragments has cut her DNA into fragments of exactly equal length
- D. she is homozygous at the DS180 locus

Question 24

What is the **main** purpose of the control DNA?

- A. to eliminate the possibility that the rapist's DNA has been contaminated by DNA from the victim's vaginal microflora
- B. to ensure that the gel electrophoresis is being "run" correctly and is satisfactorily separating the DNA fragments
- C. to enable the size of the DNA fragments to be measured
- D. to allow comparisons to be made between human and fungal DNA

Question 25

In preparing a recombinant plasmid for the insertion of a selected gene into a bacterium, it is **most** important to:

- A. cut the plasmid using a restriction enzyme which produces "sticky ends" which are complementary to those acted upon by DNA ligase
- B. cut the plasmid with the same type of restriction enzyme that was used to cut the gene out of the "donor" DNA, so that complementary "sticky ends" are produced
- C. use a restriction enzyme to make an initial "blunt end" cut which changes the plasmid from a ring of DNA into linear DNA
- D. choose a plasmid which contains antibiotic resistance genes

SECTION B- Short answer questions

Specific Instructions for Section B

Answer all questions in the spaces provided.

You should spend approximately 60 minutes on this section

Question 1

The honey bee, *Apis mellifera*, has three different types of adult insect: diploid queen bees with 32 chromosomes, sterile diploid females, and haploid male drones. Sterile females are called workers. Workers clean the hive and take care of the larvae. Some also remove dead larvae from the hive. The task of removing dead larvae involves two separate actions. Firstly, the compartment (or cell) containing the dead larva is opened. Next, the dead larva (carcass) is picked up and carried from the hive. Some workers carry out both actions, some can perform only one, while others can perform neither. Each action is under the control of a single gene, and the two genes are found on different autosomes. The alleles of each gene are as follows:

Gene 1	D	cannot open the cell
	d	opens the cell
Gene 2	R	cannot remove carcass
	r	removes carcass

a. i What is meant by the term *diploid*?

1 mark

ii How many chromosomes are there in a somatic cell of an adult male bee?

1 mark

iii What is an *autosome*?

1 mark

b. A queen bee lays thousands of eggs. A queen, heterozygous for each of the two genes, mates with a male that produces sperm containing the alleles **d** and **r**.

i Write the genotypes of these two bees.

2 marks

- ii Four different groups of workers with respect to phenotype were produced by the queen as a result of this mating. Complete the following table to predict the phenotypes and genotypes of these offspring.

Worker group	Phenotype of worker	Genotype	Expected phenotype ratio
1			
2			
3			
4			

4 marks

- c. Workers that carry out both actions necessary to remove dead larvae from the hive are called *hygienic* females. Workers that carry out only one or neither of the actions are *non-hygienic*. If the workers in the four groups in part **b ii** above were reclassified into *hygienic* and *non-hygienic*, what would the new phenotypic ratio be?

1 mark

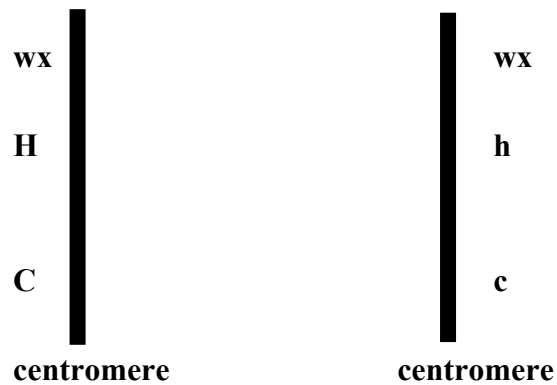
Total 10 marks

Question 2

Several pairs of alleles found in maize are involved in controlling the nature of the endosperm (the starchy food reserve in the seed). These genes are found on the same pair of homologous chromosomes.

C	-	coloured	c	-	colourless
Wx		non-waxy	wx		waxy
Yg		yellow-green	yg		green
Sh		shrunk	sh		round
H		hard	h		soft

The diagram below shows the loci of three of these genes on a pair of chromosomes, together with their positions relative to the centromere.



a. i What term is used to describe this arrangement of genes?

1 mark

ii Crossing over would be most likely to occur between which two gene loci?

1 mark

- b.** Study this cross carefully. Predict the genotypes and phenotypes of the F2 offspring by completing the table below:

P CW_x x cwx
 CW_x cwx

F1 CW_x
 cwx
 (coloured, non-waxy)

F1 CW_x x cwx
 cwx cwx

F2	Phenotype	Genotype	Number of offspring
			1542
			747
			739
			1510

4 marks

- c. i** The distance between gene loci on the same chromosome (*map units*) can be calculated from the frequency of “crossing-over” of alleles from one homologous chromosome to the other during meiosis. This is also called the *recombination frequency*. In the form of an equation, show how you would be able to calculate the cross-over value for these two genes.

1 mark

- ii** The cross-over value for the genes **C** and **W_x** is 33 map units. Use the following information to complete a chromosomal map of the likely positions of the genes **C**, **W_x**, **Yg**, and **Sh**.

<u>Genes</u>	<u>Map units apart</u>
C and W_x	33
Yg and W_x	52
C and Sh	3
W_x and Sh	30
Sh and Yg	22

centromere



3 marks

Total 10 marks

Question 3

Until 1970 it was believed that there was only one known species of platypus, living or extinct. It was also believed that Australia was the only place where platypuses were found. It was thought that the platypus had evolved in Australia within the last 38 million years since the separation of Australia from the continents of Antarctica and South America.

However, in 1984, a platypus jaw with three large teeth was discovered in sedimentary rocks in New South Wales that were 120 million years old. Furthermore, in 1992, three more fossil platypus teeth were found in sedimentary rocks 62 million years old in South America. These South American teeth were sufficiently distinct from those found in New South Wales that scientists concluded that they were from a different and larger species.

A whole platypus skull, found in 15 million year old limestone in Queensland, indicates that the modern platypus is much smaller than both the fossil species. It also indicates that platypuses evolved horny grinding pads to replace teeth between 38 and 15 million years ago.

- a. i** Explain why teeth are more likely to become fossilized than some other parts of the body.

2 marks

- ii** Describe two ways in which the age of fossil teeth could be established.

Method 1

Method 2

2 marks

- b. i** Name the process which describes the geological separation of Australia from Antarctica and South America.

1 mark

ii Explain how two new pieces of evidence, described in the passage, support the hypothesis that the platypus evolved **before** the separation of these continents.

Evidence 1

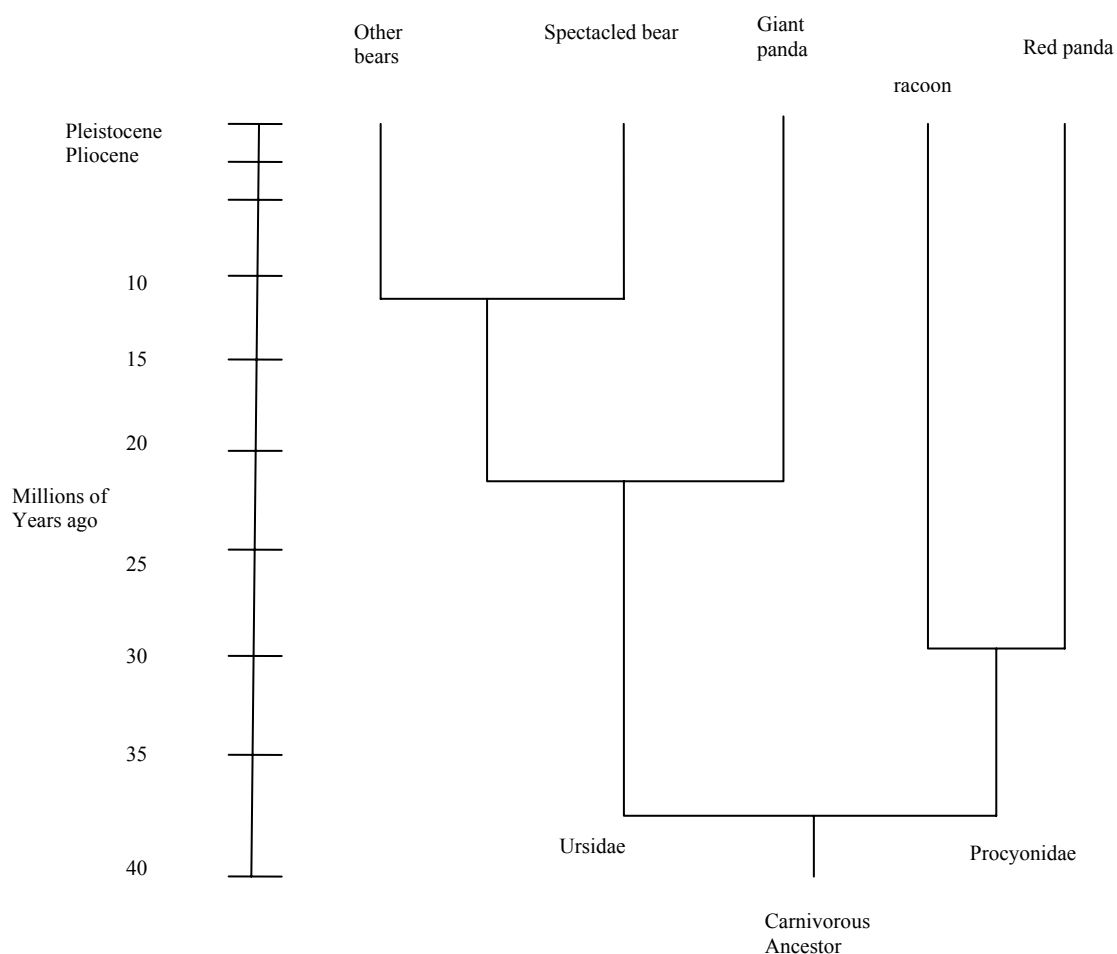
Evidence 2

2 marks

Total 7 marks

Question 4

There have been differences of opinion over the years as to how the pandas should be classified. Some biologists believed the giant panda to be related only to the red panda. Others believed both pandas were members of the raccoon family (Procyonidae). Others concluded that the giant panda was related to the bears (Family Ursidae). DNA hybridisation experiments have now confirmed that the giant panda is closely related to modern bears, while the red panda is closely related to the raccoons. As shown in Figure 1 below, the giant panda and the red panda are only related through the common carnivorous ancestor that gave rise to both the bears and the raccoons about 35-40 million years ago. In DNA hybridisation, heat is used to separate the two strands in the DNA molecules of the two species under investigation. The single strands from each of the two species are then mixed together. The strands will join together (or hybridise) if their bases are complementary.



- a. i Explain what is meant by “the strands will join together (or hybridise) if their bases are complementary”. Give an example.

2 marks

- ii What name is given to the changes in the DNA of an ancestral species which leads to differences in the DNA of later species?

1 mark

- b. A study was made of the base sequences of the same part of a template strand (also known as the “sense” or “coding” strand) of DNA from the common carnivorous ancestor and each of the five descendant species in Figure 1. The results are shown below. Three of the sequences have been identified. Each of the remaining sequences belongs to one of the remaining species.

Carnivorous ancestor	T	A	C	A	G	A	G	T	A	C	C	A	T	T	A	C	G	C	T	G	G
Spectacled bear	T	A	C	A	T	A	G	C	A	T	C	A	T	T	A	C	G	C	T	G	G
Red panda	T	A	C	A	G	A	G	T	A	C	C	A	T	T	A	C	G	C	A	C	G
Sequence One	T	A	C	A	G	A	G	T	A	C	C	A	T	T	A	C	G	C	A	T	G
Sequence Two	T	A	C	A	T	A	G	C	A	G	C	A	T	T	A	C	G	C	T	G	G
Sequence Three	T	A	C	A	T	A	G	T	T	C	C	A	T	T	A	C	G	C	T	G	G

- i. Which of the sequences, one to three is most likely to be from the raccoon? Explain your choice.

2 marks

- ii. Which of the sequences, one to three is most likely to be from the giant panda? Explain your choice.

2 marks

- iii.** Only very small quantities of DNA could be extracted from the fossil remains of the carnivorous ancestor. Describe how sufficient DNA could be prepared from this to do the DNA hybridisation experiments.

2 marks

- iv.** A hybridization test was conducted on DNA from two giant pandas. Explain whether you would expect the DNA to match exactly.

2 marks

- c. i.** What is convergent evolution?

1 mark

- ii.** Based on the most recent classification of the giant panda and the red panda, explain whether their evolution has been convergent.

1 mark

- iii.** The giant panda has an opposable thumb, which is a sixth digit which has developed from a bone in the wrist. In primates, the opposable thumb is a modified fifth digit. Explain whether the opposable thumbs in these two species are analogous or homologous structures.

2 marks

Total 15 marks

Question 5

The mortality of newborn human babies is related to birth weight. In an analysis of a large sample of hospital deliveries, the mortality of babies with different birth weights was recorded, and these data are shown in the table below.

Weight (kg)	Mortality (%)
1.0	80
1.5	30
2.0	12
2.5	4
3.0	3
3.5	2
4.0	3
4.5	7
5.0	15
5.5	26

- a. Using information from the table, describe the relationship between mortality rate and birth weight.

1 mark

- b. i Two trends in hominid evolution were the development of a bipedal gait and a steady increase in brain volume. Suggest two selective advantages of bipedalism to early hominids.

2 marks

- ii Describe two features of a hominid skeleton that would clearly indicate bipedalism.

2 marks

- iii Explain how increasing brain size in hominids might be the result of natural selection.

3 marks



Figure 1

- c. Figure 1 shows how the size of the baby's head and the diameter and shape of the birth canal are the two crucial factors in determining whether a normal delivery is possible. Suggest how these factors may have limited the evolution of brain size in humans.

2 marks

Total 10 marks

END