INSIGHT

Trial Exam Paper

2010

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.
- Calculators are not permitted in this examination.

Materials provided

- The question and answer book of 25 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.

Question 1

The peony rose *Paeonia lactiflora* has a diploid number of 20.

At the end of mitosis, a cell of *Paeonia lactiflora* has 20 chromosomes. How many chromatids would be present in the G_2 phase of its next cell cycle?

A. It depends on whether it is undergoing mitosis or meiosis.

B. 10

C. 20

D. 40

Question 2

Pairs of homologous chromosomes

A. synapse during the S phase of cell cycle.

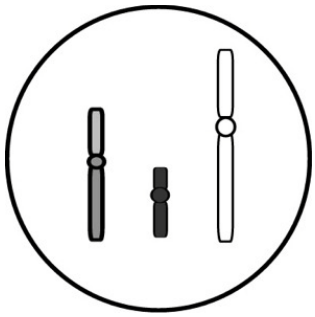
B. are found in gametes.

C. have genes for the same traits at the same loci.

D. have identical DNA sequences in their genes.

Question 3

Sexual reproduction contributes to an increase in variation within a species due to the contribution of genetic material (found in gametes) from both parents. Gametes arise though the process of nuclear division known as meiosis. The diagram shows a cell during a phase of meiosis.



The cell could be from an organism with a

A. haploid number of 6 during telophase I.

B. haploid number of 3 during telophase II.

C. diploid number of 6 during telophase I.

D. diploid number of 3 during telophase II.

Question 4

Mendel's law of segregation states that

A. the laws of probability determine gamete formation.

B. allele pairs separate in gamete formation.

C. there is a 50% probability that a gamete will get a dominant allele.

D. gene pairs segregate independently of other genes in gamete formation.

Question 5

Eye colour in humans can range from dark brown to light blue and is controlled by multiple genes.

Eye colour is an example of

A. multiple alleles.

B. codominance.

C. polygenic inheritance.

D. discontinuous variation.

Question 6

In the diagram shown below, there are

A. four chromatids and four molecules of DNA.

B. four chromosomes and two molecules of DNA.

C. two double-stranded chromatids and two molecules of DNA.

D. two double-stranded chromosomes and two molecules of DNA.

Question 7

Gene M has two alleles, M and m. Gene R has two alleles, R and r. Gene M and R are linked. An organism has the genotype $\frac{MR}{mr}$. Which of the following genotypes is **not** possible amongst the offspring of a test cross involving this organism?

A. $\frac{MR}{mr}$

B. $\frac{Mr}{mr}$

C. $\frac{mR}{mr}$

D. $\frac{Mr}{Mr}$

Question 8

A woman with type B blood has two children, one with type A blood and one with type O blood. Her partner has type O blood. What can be concluded from this information?

A. Neither the woman nor the man could be the biological parent of the child with type A blood.

B. The man could not be the biological father of either child.

C. The man could be the biological father of the child with type O blood, but not the child with type A blood.

D. The man must be the biological father of the child with type O blood and could be the biological father of the child with type A blood.

The following information relates to Questions 9 and 10.

In humans, androgenic alopecia (AGA), also known as male and female pattern baldness, occurs over many years and usually begins in males after puberty and in females any time after the age of twenty. The condition is controlled by a gene on the X chromosome.

Question 9

A man and woman both aged in their mid thirties and with no sign of hair loss are considering having a child. Both of their fathers have androgenic alopecia. The probability that their first child will develop AGA later in life is

A. 0

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

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

D. $\frac{1}{2}$

Question 10

If the couple have three children, what is the probability that they will have two children who will develop AGA and one child who will not?

A. 1

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

C. $\frac{3}{64}$

D. $\frac{5}{12}$

Question 11

The 5’ ⟶ 3’ nucleotide sequence on a complementary (noncoding) DNA strand is TAA.

5’ ⟶ 3’

TAA

The corresponding codon on mRNA and anticodon on tRNA would be

	mRNA	**tRNA**
A	AUU	UAA
B	UAA	AUU
C	AUU	TAA
D	TAA	AUU

Question 12

RNA polymerase

A. begins transcription at a promoter sequence, moves along the template strand of DNA, elongating an RNA molecule in a 5’ ⟶ 3’ direction.

B. begins transcription at a promoter sequence, moves along the template strand of DNA, elongating an RNA molecule in a 3’ ⟶ 5’ direction.

C. is the enzyme that forms hydrogen bonds between nucleotides on the DNA nontemplate strand and their complementary RNA nucleotides.

D. is the enzyme that unwinds the parental double helix at the replication forks during DNA replication.

The following information relates to Questions 13 to 15.

Forensic police attended the scene of a crime and collected samples of blood from the scene of the crime, the victim and two suspects. The samples were then subjected to a procedure known as Southern blotting in which the DNA found in the blood was treated with a restriction enzyme.

Question 13

The role of a restriction enzyme in DNA technology is to

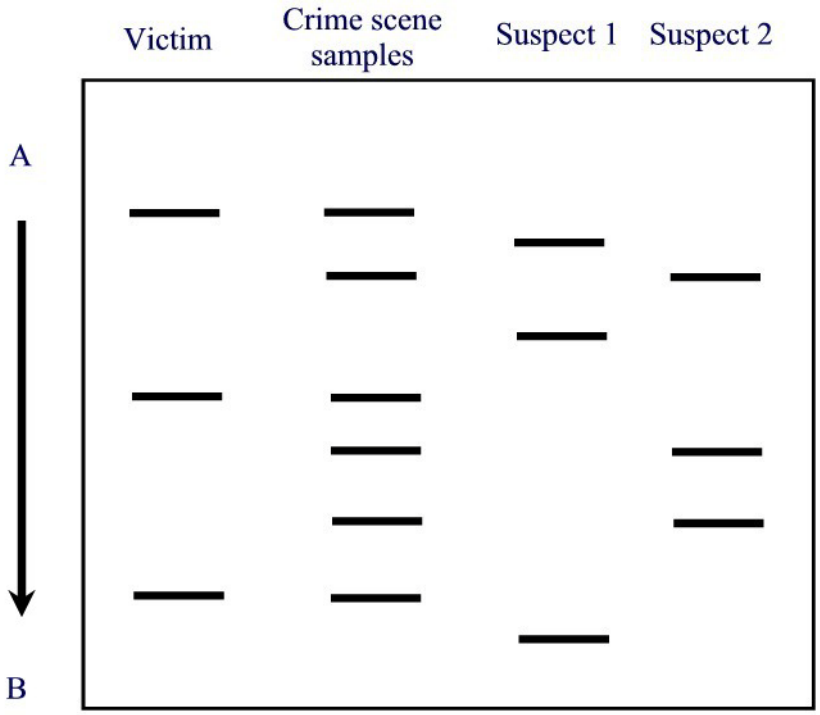
A. act as a vector for the transfer of recombinant DNA.

B. reseal 'sticky ends' after base pairing of complementary bases.

C. dissociate DNA into single strands to enable hybridisation with complementary sequences**.**

D. cut DNA at a specific nucleotide sequence.

An autoradiograph was produced from the blood samples. The diagram below shows the banding pattern displayed on the autoradiograph.



Question 14

The bands in the autoradiograph are most likely to represent

A. DNA molecules that have moved in the direction of A to B due to the positive charge of their phosphate groups.

B. DNA molecules that have moved in the direction of A to B due to the negative charge of their phosphate groups.

C. DNA molecules that have moved in the direction of B to A due to the positive charge of their phosphate groups.

D. DNA molecules that have moved in the direction of B to A due to the negative charge of their phosphate groups.

Question 15

As a result of the blood analysis, it is most likely that

A. neither Suspect 1 nor Suspect 2 will be charged with the crime.

B. both Suspect 1 and Suspect 2 will be charged with the crime.

C. Suspect 1 will be charged with the crime.

D. Suspect 2 will be charged with the crime.

The following information relates to Questions 16 and 17.

In 1859, Charles Darwin and Alfred Wallace made the claim that all the species present on Earth descended from a common ancestral species, and that the mechanism for evolution is natural selection.

Question 16

The claim that all the species present on Earth descended from a common ancestor is best supported with evidence from

A. comparative anatomy.

B. comparative embryology.

C. molecular biology.

D. the fossil record.

Question 17

The best description of natural selection is

A. the overproduction of offspring in environments with limited natural resources.

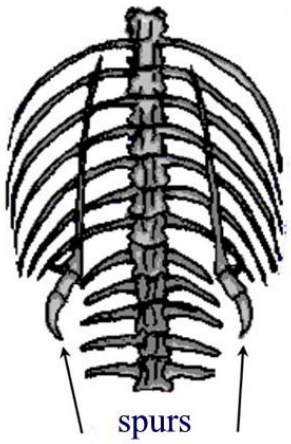
B. the reproductive success of the members of a population best adapted to the environment.

C. the struggle for existence.

D. the survival of the fittest.

Question 18

In September 2009 a woman claimed to have discovered a snake with a single clawed foot in her home in southwest China. Whilst the specific case is thought to be the result of a mutation, it is known that the skeletons of some snakes, including boas and pythons, show the remnants of pelvic and leg bones.



(Copyright by Jamie Love: www.synapses.co.uk/evolve)

The pelvic and leg bones appear externally on the snakes as bumps or spurs. Males use their spurs to stimulate females during mating. These remnants

A. provide evidence for the inheritance of acquired characteristics.

B. confirm that lizards evolved from snakes.

C. are homologous structures.

D. are vestigial structures.

The following information relates to Questions 19 and 20.

Ellis-van Creveld syndrome is a rare autosomal recessive genetic disorder that results in skeletal malformations such as polydactyly, congenital heart defects and prenatal tooth eruption. The condition is much more prevalent in the Amish people of Pennsylvania than in the general population. The Amish are religious isolates and do not usually marry out of their community. It is known that two members of the original community both had the recessive allele for Ellis-van Creveld syndrome.

Question 19

Ellis-van Creveld syndrome is considered to be an example of genetic drift. Genetic drift is most likely to be observed in a population that

A. has low numbers.

B. experiences changing environmental conditions.

C. has a high migration rate.

D. has a low mutation rate.

Question 20

The form of genetic drift observed in the Amish community is also known as

A. sympatric speciation.

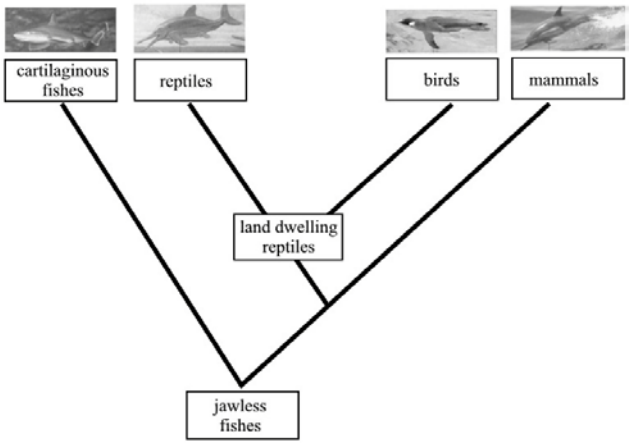
B. allopatric speciation.

C. a population bottleneck.

D. a founder effect.

The following information relates to Questions 21 and 22.

The phylogenetic tree shown below illustrates the evolutionary lineage of four groups of vertebrates. Life in an aquatic environment has produced a common streamlined body shape. When compared with Darwin's Galapagos finches, which have a known recent common ancestry, sharks (cartilaginous fish), ichthyosaurs (reptiles), penguins (birds) and dolphins (mammals) do not share a recent common ancestor.



The pattern of evolution described in the diagram is an example of

Question 21

A. parallel evolution.

B. convergent evolution.

C. divergent evolution.

D. co-evolution.

Question 22

Whilst the four vertebrate groups do not share a recent common ancestor, they all show variations of the pentadactyl limb which enables propulsion through water. This is most similar to the development of

A. the eye for detecting light, in mammals and the octopus.

B. wings for flight, in bees and birds.

C. legs for walking, in spiders and horses.

D. wings for flight in bats and birds.

Question 23

Current data support the view that *Homo sapiens* appeared in Africa around 195 000 years ago. There are many characteristics that distinguish hominins from other primates. The distinguishing characteristic believed to have emerged first is

A. larger brain.

B. bipedalism.

C. reduction in jaw bones and musculature.

D. manufacture and use of tools.

Question 24

Fossils are the preserved remains, impressions or traces of once-living organisms. Which of the following is NOT a requirement for successful fossilisation?

A. rapid burial and entombing with sediment.

B. anaerobic conditions.

C. soil or environment with low pH.

D. hard parts and unchanging temperature conditions.

Question 25

Recent comparisons of mitochondrial DNA have provided strong support to the theory that *Canis lupus*, the grey wolf, is the ancestor of domestic dogs. There are over 400 different breeds of dog which have come about as a result of artificial selection. Which one of the following statements about artificial selection is CORRECT?

Artificial selection is

A. a form of directional selection.

B. capable of maintaining phenotypes in a population that would be selected against under natural conditions.

C. dependent on the existence of some genetic variability within a chosen population.

D. a continuation of a natural evolutionary process.

END OF SECTION A

SHORT ANSWER QUESTIONS

Instructions for Section B

Answer this section in pen.

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

Question 1

In the Bengal tiger (*Panthera tigris tigris*), normal coat colour is orange-brown or dark yellow with dark brown, grey or black stripes (Y). A recessive allele (y) can produce cubs with creamy white coats, pink noses and blue crossed eyes. The recessive allele is not found in any other tiger species, nor is it sex-linked.

1a. How many recessive alleles would be present in the somatic cells of Bengal tigers heterozygous for the condition?

_____

1 mark

1b. What is the term used to describe the position occupied by an allele on a chromosome?

_____

1 mark

1c. If two normal tigers that are heterozygous for this condition mate, what is the expected phenotypic ratio of their offspring? Show your working.

3 marks

In the wild, the likelihood of producing a white, crossed-eyed Bengal tiger is 1 in every 10,000, an approximation based on documented observations of white cubs in their natural habitat. There are very few adult white tigers in the wild. When bred in captivity, mortality rates of cubs are in excess of 80%. The recessive allele that produces white, cross eyed tigers is also linked with other, often fatal characteristics including immune deficiency, scoliosis (curvature) of the spine, cleft palates and early death.

1d. **i.** What is the name of the event that has produced the recessive allele in the Bengal tiger?

_____

1 mark

1d. **ii.** Other than congenital abnormalities, suggest another explanation for the extremely low numbers of adult white tigers in the wild.

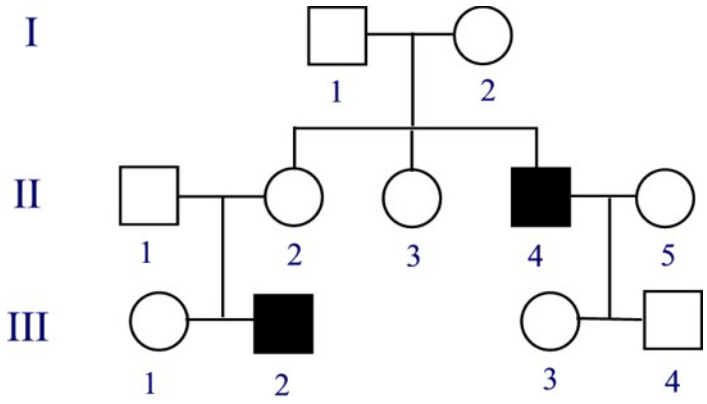
_____

_____

1 mark
Total 1+1+3+1+1= 7 marks

Question 2

Becker muscular dystrophy (BMD) is an inherited disorder in humans that usually affects only males. The condition is characterised by slow progressive muscle weakness of the legs and pelvis. The pattern of symptom development is similar to that of Duchenne muscular dystrophy (DMD), however the mean age of onset is 12 years. The pedigree shows an inheritance pattern for Becker muscular dystrophy within a family over three generations. The individuals in generation III are all under the age of 10 years.



2a. What is represented by the shading?

_____

1 mark

On the basis of the information provided in the pedigree it has been suggested that BMD is inherited as an X-linked recessive condition.

2b. Use the information from the pedigree to demonstrate how the suggestion can be supported.

_____

_____

_____

_____

2 marks

2c. Assign allelic symbols for BMD.

_____

1 mark

2d. State the genotypes of individual III – 3.

_____

1 mark

Duchenne muscular dystrophy (DMD) is a condition closely related to BMD; both occur as a result of a mutation in the gene that codes for the production of dystrophin, which is a protein made up of 3700 amino acids. In DMD, abnormal dystrophin, a smaller protein made up of 2500 amino acids, is produced leading to the degradation of muscle fibres. Abnormal dystrophin is known to be missing an exon.

2e. **i.** What is an exon?

_____

1 mark

2e. **ii.** Explain how the absence of an exon could lead to the production of the abnormal dystrophin protein.

_____

_____

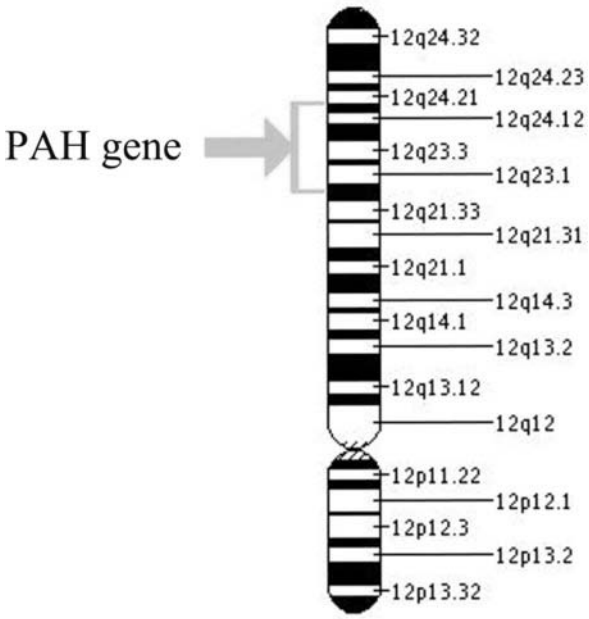
_____

_____

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

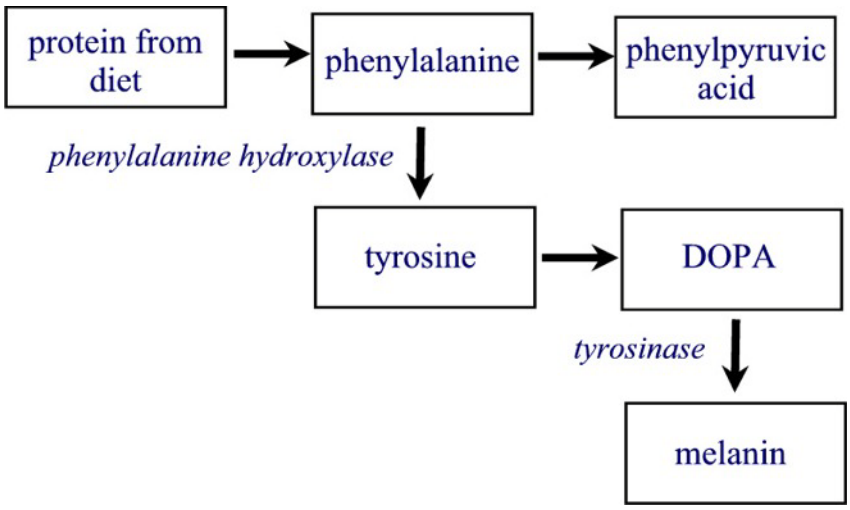
Question 3

Phenylketonuria (PKU) is an autosomal recessive disorder characterised by a deficiency in the enzyme phenylalanine hydroxylase (PAH). PAH is produced by the PAH gene which is located on chromosome 12 (base pairs 101 756 233 to 101 835 510) and is essential in the conversion of the amino acid phenylalanine to tyrosine.



(source: U.S. National Library of Medicine)

The abnormal form of PAH shows a very low level of enzyme activity. If it is produced, phenylalanine is converted to phenylpyruvic acid (also known as phenylpyruvate) which can build up to toxic levels in the body. Nerve cells in the brain are sensitive to phenylalanine levels and excessive amounts impair the development of the nervous system, resulting in severe brain damage. Phenylalanine is an essential amino acid which is obtained through food.



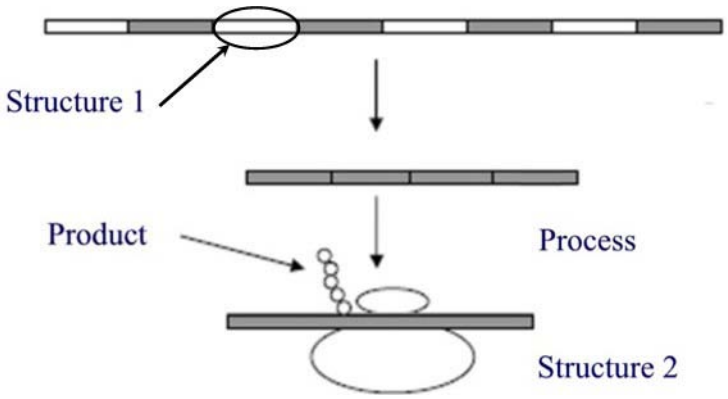
There are more than 500 known mutations in the PAH gene. Most mutations involve a change in a single amino acid in phenylalanine hydroxylase. One of the most common PAH mutations amongst European Caucasians involves a change at codon 408 where CGG is replaced by TGG.

3a. What is the name given to this type of mutation?

_____

1 mark

3b. The diagram shows the stages that occur from the gene to the product. Identify the process, the product and each structure.



Process: _____

Product: _____

Structure 1: _____

Structure 2: _____

2 marks

The holly-leafed grevillea, *Grevillea infecunda*, is a rare and endangered species of endemic plant found in a small area around Anglesea in Victoria. Even though it flowers regularly every year, it has low fertility, producing no seeds. Instead, it reproduces asexually through root suckering.

The genetic variation between individual plants and between populations was tested by conservation biologists. A few leaves were sampled from every plant in the known populations and DNA was extracted from those leaves. The DNA was cut into fragments and then amplified using PCR.

3c. **i.** What do the letters PCR represent?

_____

1 mark

3c. **ii.** What are the four ingredients required for PCR?

Ingredient 1: _____

Ingredient 2: _____

Ingredient 3: _____

Ingredient 4: _____

2 marks

3c. **iii.** The process of PCR can be summarised in 3 steps. Identify and briefly outline the 3 steps.

Step 1: _____

Description: _____

_____

_____

Step 2: _____

Description: _____

_____

_____

Step 3: _____

Description: _____

_____

_____

3 marks
Total 1+2+1+2+3= 9 marks

Question 4

Within any organism there are many genes which can be classified by function. The genes that appear to be evolving the most rapidly are those that code for transcription factors. Transcription factors are responsible for the control of gene expression. A particular transcription factor which has shown evidence of rapid change in the human lineage is FOXP2, which is thought to be one of the principal genes associated with vocalisation in vertebrates, as well as the development process in mammals for a number of organ systems and exists at high levels in foetal brain tissue. The FOXP2 gene which is located on chromosome 7 is expressed in the brains of songbirds when they are learning their songs and in humans. Severe speech and language impairment is observed if a mutation occurs in the gene.

4a. **i.** What is the name given to a gene, such as FOXP2, that controls other genes?

_____

1 mark

4a. **ii.** Briefly explain how FOXP2 would regulate the genes for vocalisation in vertebrates.

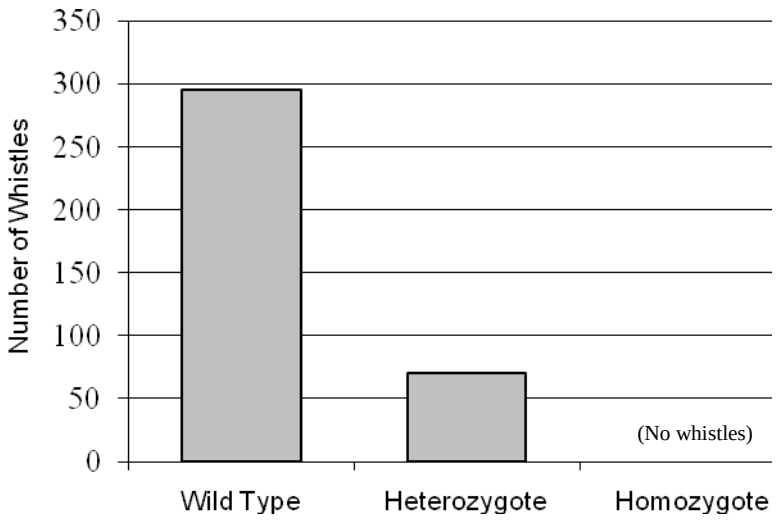
_____

_____

_____

1 mark

In a study designed to test the function of FOXP2, mice, organisms in which genes can be easily 'knocked out', were used as representatives of vocalising vertebrates. Mice use ultrasonic squeaks to communicate stress. Genetic engineering techniques were used to produce mice in which one or both copies of the FOXP2 genes were disrupted. An outline of the two experiments in the study is shown in the table below.

	WILD TYPE two normal copies of FOXP2	HETEROZYGOTE one copy of FOXP2 disrupted	HOMOZYGOTE both copies of FOXP2 disrupted
Experiment 1 Thin sections of brain visualised under UV fluorescence microscope	Brain cells well organised	Brain cells mildly disorganised	Brain cells severely disorganised
Experiment 2 Newborn pups separated from their mothers. Number of ultrasonic whistles made by pups recorded.			

The mice used in this study are referred to as 'knock out' mice.

4b. Explain the meaning of the term 'knock out'.

_____

_____

1 mark

4c. **i.** Using the diagram, describe the results of Experiment 2.

_____

_____

_____

_____

2 marks

4c. **ii.** What conclusion can be drawn from the results of Experiment 2?

_____

_____

1 mark

FOXP2 is one of the 5% most conserved proteins in mammals, and two amino acid substitutions have remained fixed in the human lineage since the divergence from the chimpanzee common ancestor. The amino acid substitutions occur at positions 911 and 977 in exon 7 and change threonine to aspartic acid and arginine to serine. Analysis and comparison of the mitochondrial DNA of Neanderthals and modern humans has revealed that they carry a FOXP2 gene that is identical to that of present-day humans.

4d. Identify **two** difficulties likely to be experienced by paleoanthropologists in the analysis and comparison of the mitochondrial DNA during their study of the FOXP2 gene.

_____

_____

2 marks

Whilst academic speculation continues over whether Neanderthals and humans interbred, there has been no definite evidence to support the theory that gene flow is the mechanism by which identical changes to the FOXP2 gene appeared in modern humans and late Neanderthals.

4e. In the absence of gene flow, what is the most likely explanation for the occurrence of identical FOXP2 genes in Neanderthals and modern humans?

_____

_____

1 mark
Total 1+1+1+2+1+2+1 = 9 marks

Question 5

Developments in DNA technology have been of enormous benefit to the pharmaceutical industry. Advances in genetic research have enabled the production of drugs for the treatment of medical conditions. Protein based pharmaceutical products can be produced in large volumes using cells or multicellular organisms.

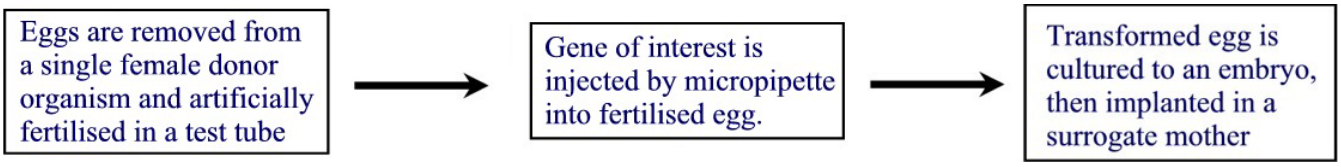
5a. What is an example of a manufactured pharmaceutical product used in the treatment of human disease?

_____

1 mark

When animals are used to produce large quantities of protein, they are referred to as transgenic or 'pharm' animals.

The diagram outlines the steps involved in creating a transgenic animal.



5b. What is the name given to the 'gene of interest' which is introduced to the egg from the donor organism?

_____

1 mark

5c. How many 'parents' are associated with a transgenic animal? Circle the correct answer and justify your choice.

one two three

_____

_____

2 marks

The gene that codes for the production of the human blood protein antithrombin can be inserted into the genome of goats, sheep and cows and is expressed in the milk. The protein is extracted by purifying the milk. Other animals used in transgenic production of protein include pigs, chickens and rabbits. In some circumstances, the human proteins produced by transgenic animals may differ in some ways from the naturally produced human proteins and are rigorously tested before commercial release.

5d. Identify a problem that could occur with transgenic protein products.

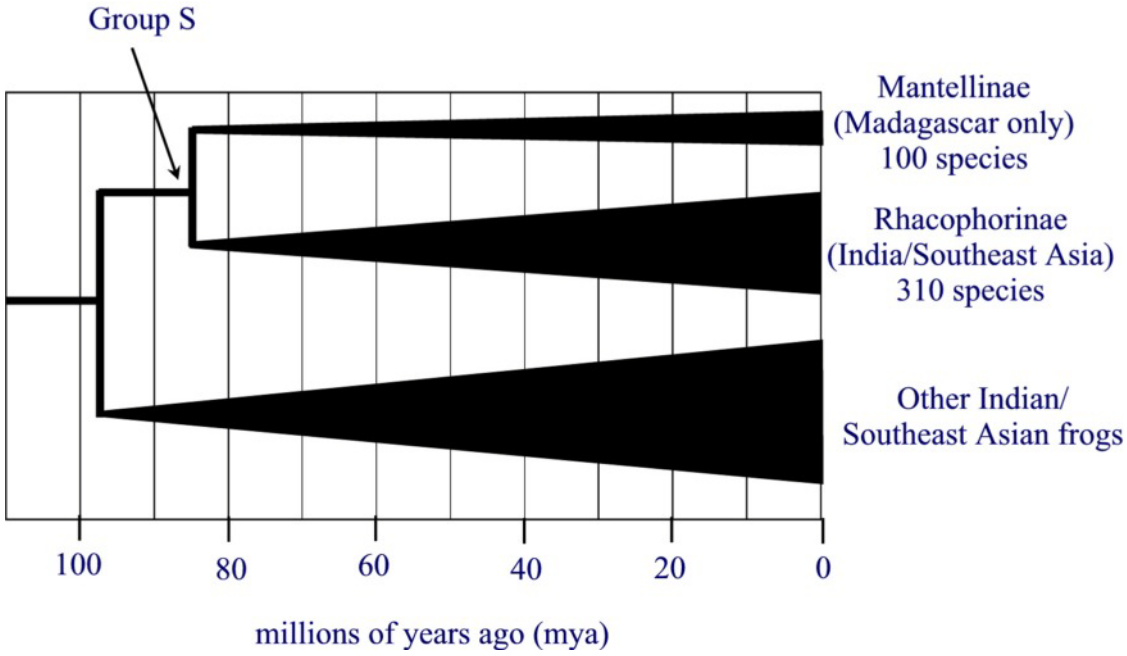
_____

1 mark

Total 1+1+2+1=5 marks

Question 6

Madagascar is an island that broke away from India around 88 million years ago when it began to move north toward Asia. Presently, in Madagascar the 100 frog species are grouped into the subfamily Mantellinae, whilst in India and Southeast Asia, the 310 frog species are grouped into the subfamily Rhacophorinae.



6a. What criteria would have been used to determine the existence of the 100 species of Malagasy frog?

_____

_____

_____

2 marks

6b. From the diagram, what is the relationship between Group S and the subfamilies Mantellinae and Rhacophorinae?

_____

1 mark

6c. Identify the type of speciation that has occurred within each of the frog subfamilies.

_____

1 mark

6d. Explain how speciation amongst Malagasy frogs is likely to have occurred.

_____

_____

_____

_____

_____

_____

_____

_____

3 marks
Total 2+1+1+3=7 marks

Question 7

In 2003, the partial skeleton of an 18 000 year old fossil was discovered at the Liang Bua limestone cave site on the Indonesian island of Flores and was given the name *Homo floresiensis*. The single near-complete skeleton, known as LB1, was fully bipedal, demonstrated a reduced tooth size, a receding forehead and no chin. On the basis of tooth wear, it was aged at about 30 years. The brain size of the adult female was 380cc which is significantly smaller than that of *Australopithecus afarensis* (400–500cc). Stone tools were found throughout the cave site.

7a. What absolute dating technique could have been used to date the fossil found at Liang Bua?

_____

_____

1 mark

7b. Suggest **two** forms of evidence that could have been used to place *Homo floresiensis* (the 'Hobbit') into the genus *Homo*.

Evidence 1: _____

Evidence 2: _____

2 marks

More fossilised skeletal fragments have been found since 2003, and the species is now represented by around six to nine individuals. Continued research by Peter Brown, the paleoanthropologist who first described *H. Floresiensis*, has led to the theory that the 'Hobbit's' lineage left Africa some time before the evolution of the genus *Homo*. Brown's most recent theory challenges the 'regional continuity' hypothesis.

7c. Suggest how paleoanthropologists might, if conditions for fossilisation were appropriate, determine the existence of six to nine individuals using only fragments.

_____

_____

1 mark

7d. Why is Brown's theory a challenge to the 'regional continuity' hypothesis?

_____

_____

_____

_____

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

END OF QUESTION AND ANSWER BOOK