VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2009

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STUDENT NUMBER

									Letter
Figures									
Words									

BIOLOGY

Written examination 2

Monday 2 November 2009

Reading time: 9.00 am to 9.15 am (15 minutes)
Writing time: 9.15 am to 10.45 am (1 hour 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	25	25	25
B	7	7	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.
- No calculator is allowed in this examination.

Materials supplied

- Question and answer book of 27 pages.
- Answer sheet for multiple-choice questions.

Instructions

- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- All written responses must be in English.

At the end of the examination

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

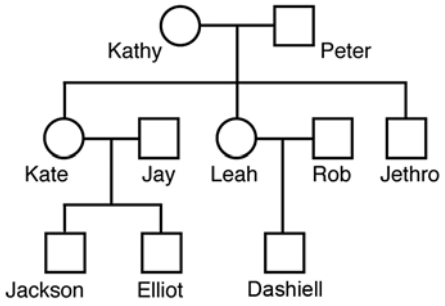
Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

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** for the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

The following pedigree is relevant for Questions 1 and 2.



Question 1

From an analysis of this pedigree, individuals with the same mitochondrial DNA (mDNA) include

A. Kathy and Peter.
B. Peter and Jethro.
C. Jay, Rob and Jethro.
D. Jackson, Elliot and Dashiell.

Question 2

Jackson is known to have the X^H allele.
It is reasonable to claim that the allele must be also present in

A. Kate.
B. Peter.
C. Elliot.
D. Jethro.

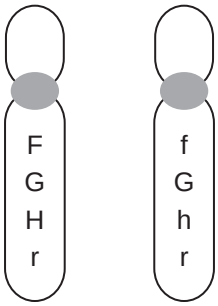
Question 3

Meiosis in human females

A. involves the separation of homologous chromosomes before DNA replication.
B. relies on contraction of protein fibres in the spindles formed within the cells.
C. results in four gametes for each cell that undergoes the process.
D. involves haploid cells giving rise to diploid cells.

Question 4

A pair of homologous chromosomes involved in normal meiosis in an ovary carries the alleles shown.



Chromosomes detected in eggs produced would include

A.

B.

C.

D.

Question 5

The gene locus in cats that controls tabby coat-patterns has three alternative alleles.

This kind of allelic system is referred to as

A. dominance.

B. recessiveness.

C. codominance.

D. multiple allelic.

Question 6

In domestic cats, two gene loci that control different aspects of coat colour have the following alleles.

Gene locus for black coat colour	**B** : black fur
	b : brown fur
Gene locus for white spotting	**S** : white spotting in fur
	s : no white spotting in fur

A cat that is heterozygous at the S locus has less fur that is white than a cat that is homozygous at that locus.

Two cats were mated. The cross was **BbSs** × **BBSs**.

With such a cross

A. kittens could be brown with white spots.

B. kittens have a one in two chance of having no white.

C. kittens could have far more white than either of the parents.

D. kittens would have a one in two chance of being homozygous dominant at both loci.

Question 7

In pigs, the number of teats and litter size are under genetic control. Each piglet must have ready access to a teat.

British breeds of female pigs (called sows) generally have 12 teats and 11 piglets each litter. Some of the traditional British breed of pigs have been crossed with the Chinese Meisham pig. Chinese Meisham sows have up to 18 teats and average 16 piglets each litter. This crossbreeding has produced a hybrid pig called the Manor Meisham.

With respect to these breeding experiments, it is most likely that

A. British farmers wanted to produce smaller-sized litters.

B. Chinese farmers wanted to produce larger-sized litters.

C. British sows were mated with Meisham males.

D. Meisham sows were mated with British males.

Question 8

Using gene therapy to treat a disease involves introducing

A. particular proteins into a person with the disease.

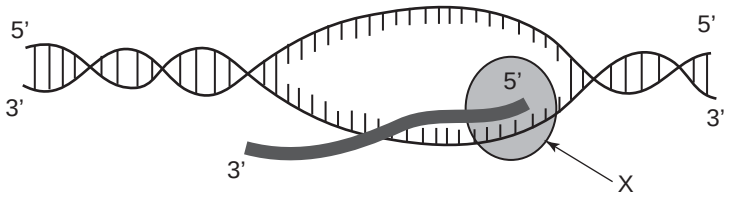
B. various types of blood into a person with the disease.

C. viruses that destroy certain cells of a person with the disease.

D. functional alleles into the cells of a person with the disease.

The following information is relevant for Questions 9 and 10.

Examine the following diagram.



Question 9

The diagram is most likely to be of

A. translation.

B. transcription.

C. gene regulation.

D. DNA replication.

Question 10

The molecule labelled **X** represents

A. ligase.

B. a ribosome.

C. RNA polymerase.

D. DNA polymerase.

Question 11

A mutation is

A. a product of natural selection.

B. caused by immigration and emigration.

C. a change in an allele due to a change in DNA.

D. a random change in gene frequencies from one generation to the next.

Question 12

The 200th anniversary of the birth of Charles Darwin is celebrated in 2009.

In the development of his ideas on evolution, Darwin proposed that

A. all members of a species have an equal chance of survival.

B. offspring look more like their parents than they do to unrelated people.

C. individuals in a population have the same chance for reproductive success.

D. environmental changes that change the structure of individuals are transmitted to the next generation.

Question 13

Tay Sach's disease is a genetic condition that can be caused by mutations in the hexoseaminidase gene resulting in an abnormal enzyme.

The table below shows details for part of a normal and abnormal peptide sequence for hexoseaminidase.

	Codon position			
	4	**5**	**6**	**7**
Normal hexoseaminidase	thr ACU	ser UCU	val GUU	gln CAG
Abnormal hexoseaminidase	thr ACU	tyr UAC	ser UCU	val GUU

Using this information it is reasonable to say that the abnormal hexoseaminidase enzyme could have resulted from a change in the mRNA due to

A. a substitution of G for C at the beginning of codon 7.

B. a duplication of ACU at the beginning of codon 4.

C. an insertion of UAC at the beginning of codon 5.

D. deletion of UCU at the beginning of codon 6.

Question 14

A small population of copper-coloured butterflies was found in Eltham in 1938. The butterfly has since been found in one location in Castlemaine and six locations at Kiata. The butterfly lays its eggs on the native shrub sweet bursaria (*Bursaria spinosa*) and the larvae shelter in the nest of the Australian ant (*Notoncus emery*). After 1956 it was thought that the butterfly was extinct, but it was found again in 1986.

Map of Victoria

Extinction of the copper butterfly from all three areas would best be prevented by

A. moving the populations to one area to give greater genetic diversity.

B. planting more sweet bursaria in reservation areas at all locations.

C. burning off local undergrowth to remove competitive weeds.

D. removing the nests of all Australian ants.

Question 15

In 2006, two separate palaeontology laboratories were set up in the Sahara desert.

laboratory 1 uncovered a burial site that contained human remains. Over 200 human remains were found and they were dated from 10 000 to 4500 years ago.

laboratory 2 discovered a 110 million-year-old plant-eating dinosaur, *Nigersaurus*, in a nearby area in a different sedimentary layer.

To date the fossils accurately the two groups of palaeontologists would most likely have used

A. carbon-14 dating for both the human and dinosaur remains.

B. uranium-235 dating for both the human and dinosaur remains.

C. uranium-235 dating for the human remains and carbon-14 dating for the dinosaur remains.

D. carbon-14 dating for the human remains and uranium-235 dating for the dinosaur remains.

Question 16

In 1954, copper waste in the Finniss River killed numerous fish. This caused various species in the area to die out. However, one species, the black-banded rainbow fish, increased in numbers. The black-banded rainbow fish have modified gills that enable the fish to filter and remove the copper before it enters their body.

With respect to the black-banded rainbow fish it is reasonable to conclude that

A. a mutation occurred in their population in 1954.

B. the ability of their gills to remove copper already existed in 1954.

C. the high levels of copper in the water changed the structure of their modified gills.

D. their genomes are identical with those of the other species of fish that existed in 1954.

Question 17

The process of gene expression involves

A. translation followed by transcription.

B. exons carrying information required for protein synthesis.

C. identical action in every cell of the organism containing the particular gene.

D. tRNA molecules, each carrying four nucleotides that specify one amino acid.

Question 18

In humans, smooth chin and straight hairline are each inherited as autosomal recessive traits. The alleles for each of the genes involved are

chin line –	***S***	: cleft chin	hairline –	***W***	: widow's peak
	s	: smooth chin		***w***	: straight hairline

A mother and son each have a smooth chin and a straight hairline. The father of the boy has a cleft chin and a widow's peak.

The father's genotype must be

A. ***Ss Ww***.

B. ***SS WW***.

C. ***ss WW***.

D. ***ss ww***.

Question 19

Convergent evolution is

A. also known as adaptive radiation.

B. responsible for the development of analogous structures.

C. the splitting of an ancestral group into two different species.

D. the independent development of similar features in related species.

Question 20

Regulatory and structural genes differ in their arrangement in the genomes of prokaryotic and eukaryotic cells. In prokaryotic cells, regulatory genes are arranged side by side. This arrangement is known as an operon. In eukaryotic cells, the regulatory genes and structural genes may be located on different chromosomes.

Therefore, it would be reasonable to say that

A. eukaryotic stem cells have all genes switched on.

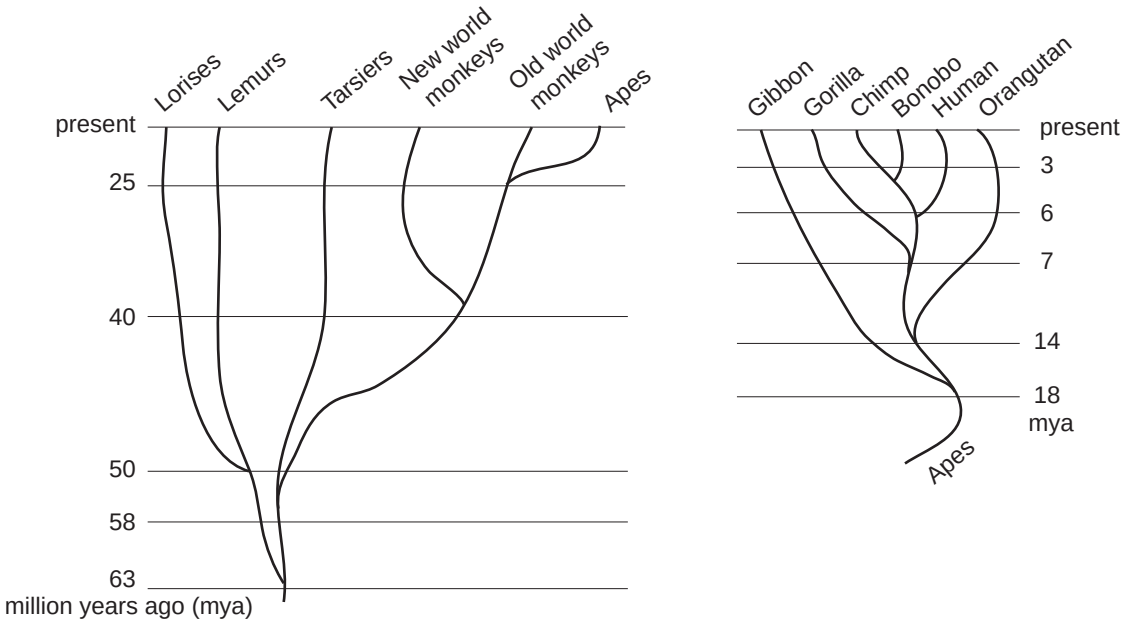
B. the environment has no impact on whether a gene is switched on or off.

C. all bacterial operons are located on a large circular chromosome within the cell.

D. mutations in distant regulatory genes will have no effect on their related structural genes in eukaryotic cells.

Question 21

Examine the following primate evolutionary tree.



Analysis of the evolutionary tree above shows that

A. gibbons and old world monkeys are unrelated.

B. lorises is the oldest group in the evolutionary tree.

C. the most recent group to evolve separately is humans.

D. chimps and humans are more closely related than gorillas and chimps.

Question 22

Scientific opinion was once evenly divided regarding the geographical origin of the modern human. Two hypotheses were put forward – the 'Out-of-Africa' hypothesis and the 'Multi-Regional' hypothesis. In general, researchers now accept that the Out-of-Africa hypothesis is better supported by current information.

Findings from worldwide human fossil sites which would best support the Out-of-Africa hypothesis include

A. dating of fossils by radioactive uranium.

B. the degree of decomposition of remains.

C. the present-day climate of the region.

D. variations in mitochondrial DNA.

Use the following information to answer Questions 23 and 24.

A scientist took a small population of 10 flowering plants and conducted an experiment to examine the change in allele frequencies over three generations. The plants were grown in identical conditions, in a controlled environment.

Within the flowering plants the presence of the **R** allele allows red flowers to be produced, while white flowers can only be produced when the **rr** genotype is present.

	Genotype numbers		
	Generation 1	Generation 2	Generation 3
RR	6	3	0
Rr	2	3	4
rr	2	4	6
Total alleles	**20**	**20**	**20**

Question 23

The most likely reason for the population of flowering plants having more **rr** genotypes and white-flowered phenotypes after only three generations is

A. genetic drift.

B. natural selection.

C. divergent evolution.

D. convergent evolution.

Question 24

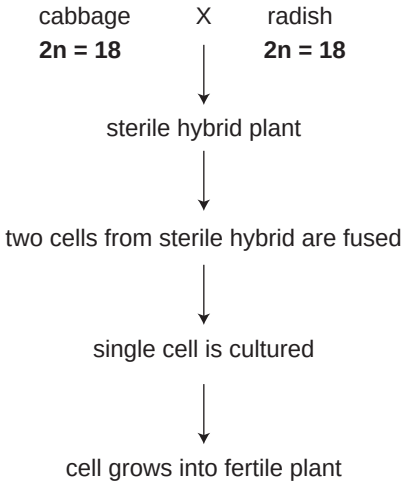
The allele frequency of the **r** allele changed during the course of the experiment.

Allele frequencies for the **r** allele in Generation 1 and Generation 3 are

	Generation 1	**Generation 3**
A.	0.3	0.8
B.	0.8	0.3
C.	0.7	0.3
D.	0.3	0.7

Question 25

Cabbage, *Brassica oleracea,* and radish, *Raphanus sativus*, are both members of the Brassicaceae family. The cells of each type of plant have 18 chromosomes. When these plants are crossed, a sterile hybrid is produced. Two cells from a sterile hybrid plant are fused and the single cell that is formed is cultured. This is summarised in the following diagram.



From this information, it is reasonable to conclude that

A. cabbage and radish have identical chromosomes.

B. the fused cell has 18 pairs of homologous chromosomes.

C. the sterile hybrid has nine pairs of homologous chromosomes.

D. gametes from the fertile plant will be identical with those of the cabbage or the radish.

END OF SECTION A

CONTINUED OVER PAGE

SECTION B – Short answer questions

Instructions for Section B

Answer this section in pen.

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

Question 1

a. Describe binary fission.

1 mark

Diagram **X** outlines a mitotic cell cycle. Image **D** shows the appearance of a chromosome during one of these cycles.

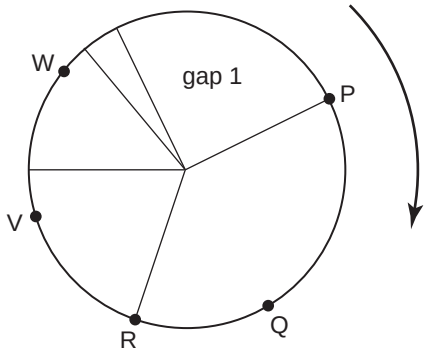


Diagram **X**: Outline of the mitotic cell cycle

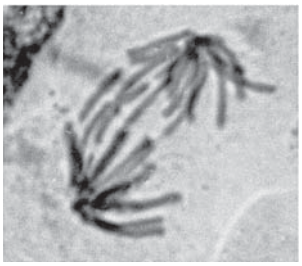


Image **D**

b. Explain at which labelled point (P, Q, R, V, W) in the cycle image **D** would be found.

1 mark

c. Explain why apoptosis sometimes occurs during the cell cycle represented in the above diagram.

1 mark

Translation occurs within the cytosol of a cell.

d. Outline the steps that normally occur in translation. Use specific terms and names of the molecules involved. Name the final product of the process.

3 marks

Total 6 marks

Question 2

Diagram **W** shows part of a metabolic pathway involving the amino acids phenylalanine and tyrosine. One or more enzymes are involved at each step in such a pathway.

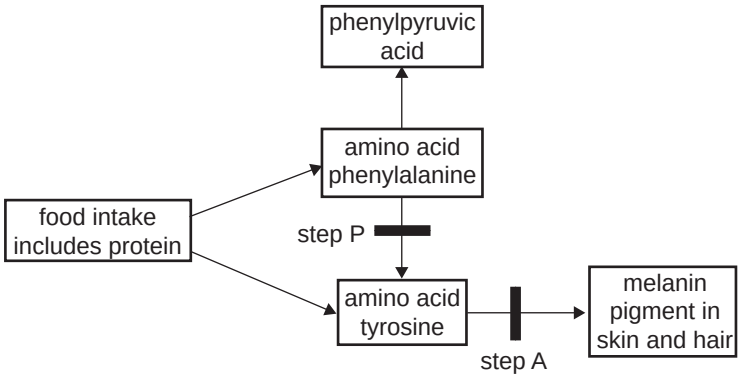


Diagram **W**

Two steps have been highlighted, step P and step A. Each is under the control of a single gene.

Step P is controlled by **gene P** which has the alleles

P : phenylalanine hydroxylase produced

p : no enzyme

Step A is controlled by **gene A** which has the alleles

A : tyrosinase produced

a : no enzyme

A couple, each heterozygous at the **P** and **A** loci, have a daughter, Emily.

a. With reference to these two genes, what is the chance that Emily has the same genotype as her parents?

_____

1 mark

The couple also have twin sons, Jack and Tom. Their genotypes are

Jack **Pp aa**

Tom **PP Aa**

b. Are Jack and Tom identical twins or non-identical twins? Explain.

Type of twins _____

Explanation _____

_____

1 mark

Another son, Max, has the genotype **pp Aa**.

c. With reference to their genotype for the pathway shown in Diagram **W**, outline two phenotypic differences that would exist between Max and Jack.

2 marks

In corn, brittle stalk **(b)** is recessive to normal stalk **(B)** and green **(g)** is recessive to yellow **(G)**. A claim was made that a particular plant was heterozygous at both loci.

d. **i.** Outline a cross you would carry out with the particular plant. Suggest results that would support the claim.

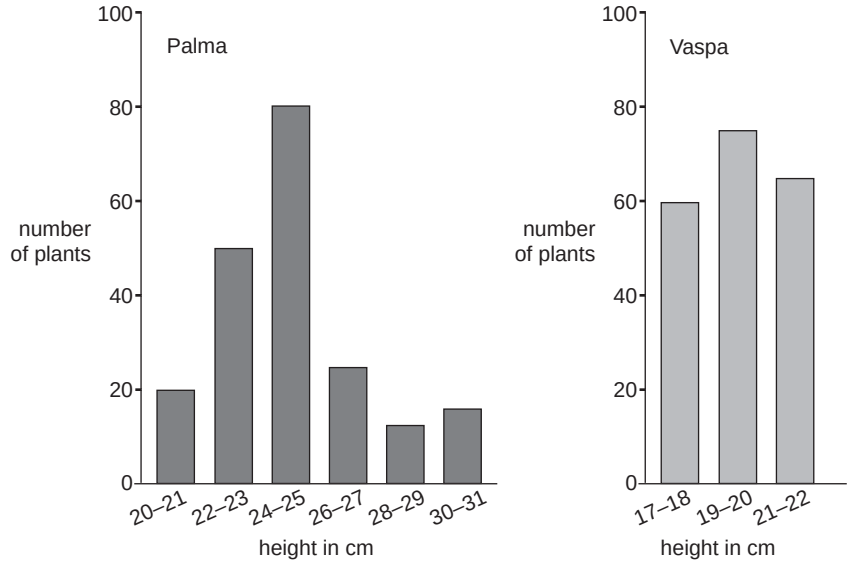
ii. Explain whether the results of your cross would enable you to decide if the genes involved were on the same or different chromosomes.

2 + 1 = 3 marks

Total 7 marks

Question 3

An experiment was set up to investigate the growth of two varieties of pea plants, Palma and Vaspa. Two hundred plants of each variety were grown from seed for 10 weeks. The histograms below show the heights of the plants (measured to the nearest whole number) at the end of 10 weeks.



a. **i.** Name the independent variable (also known as the experimental variable) in this experiment.

_____

ii. Equal numbers of each type of seed were grown for the same amount of time.
State one environmental variable that should be controlled in this experiment.

_____

_____

1 + 1 = 2 marks

b. What difference in height exists between the tallest Palma and tallest Vaspa plants?

_____

1 mark

c. Is height in pea plants controlled by one or many genes? Circle your answer and justify your choice.

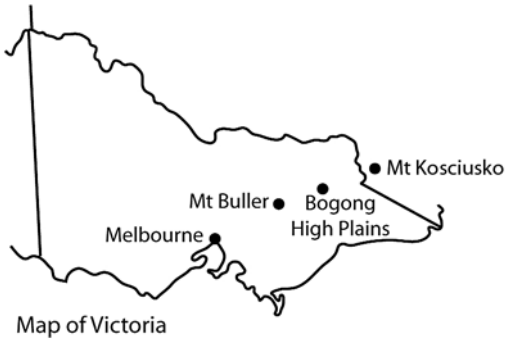
one gene many genes

_____

_____

2 marks

The endangered pygmy possum (*Burramys parvus*) lives in three restricted alpine areas, Mt Buller, Bogong High Plains and Mt Kosciusko.



Map of Victoria

About 2000 individuals remain in the wild. Studies show that there is a lot of genetic diversity between the three populations. Due to the isolation of these populations, scientists think that each population has a separate gene pool.

d. Explain what is meant by gene pool.

1 mark

e. Explain how exchange of genetic material may be beneficial in the survival of endangered species like the pygmy possum.

2 marks

Total 8 marks

Question 4

In 1877, German workers found a slab of stone containing the fossil of an ancient bird form.

Fossil

The fossil bird was called *Archaeopteryx*.

a. **i.** Describe how this fossil could have been formed.

ii. Scientists use information gained from sedimentary rock to arrange animal and plant fossils into some kind of evolutionary sequence over time.

Explain how such sequencing is possible.

1 + 2 = 3 marks

b. **i.** Name one isolation barrier involved in allopatric speciation.

ii. Explain how isolation may result in speciation.

1 + 3 = 4 marks

Total 7 marks

Question 5

Some people prefer to eat Wagyu cattle because of the high level of marbling (fat) in the meat. Four separate DNA markers are used to test for marbling in an animal. Tested cattle are scored on a scale of zero to eight, eight indicating the highest degree of marbling.

a. What does the use of four markers suggest about the inheritance of this characteristic?

1 mark

A Wagyu breeder discovered a small number of individuals in her elite herd that were suffering from Chediak-Higashi Syndrome (CHS). CHS is an autosomal recessive condition that can affect species other than cattle. The breeder required further information.

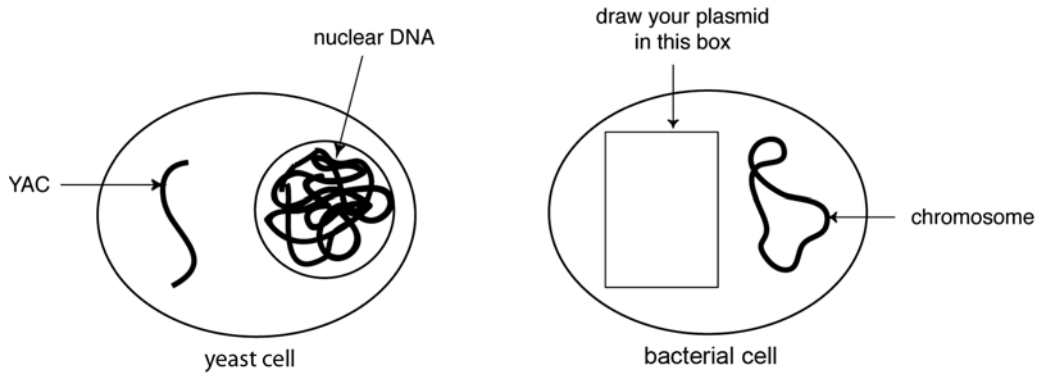
Gene probing was used to target *CHS1*, the allele responsible for the condition. The genetic probes for the Wagyu CHS locus were derived from human alleles.

b. Given that the gene probe for a human works for the Wagyu, what can you infer about the chemical code for this allele?

1 mark

The Wagyu *CHS1* allele was isolated and given a fluorescent tag. It was introduced into a yeast cell as a large, independent, cytoplasmic chromosomal segment called a Yeast Artificial Chromosome (YAC). In addition to the allelic DNA, a YAC includes a centromere and a replication sequence. The yeast cells are then incubated in the presence of growth stimulants and given time to replicate.

This procedure is similar to genetic engineering of bacterial plasmids, however the YAC is able to contain much larger pieces of DNA than a plasmid.



c. **i.** In the bacterial cell **above**, **draw** a plasmid in the **blank box**.

ii. Bacterial plasmids lack a centromere. Why are YACs made with a centromere?

iii. What term describes the process of copying a gene?

1 + 1 + 1 = 3 marks

A test was developed to identify each of the normal and mutant alleles. Two cows were chosen for testing.

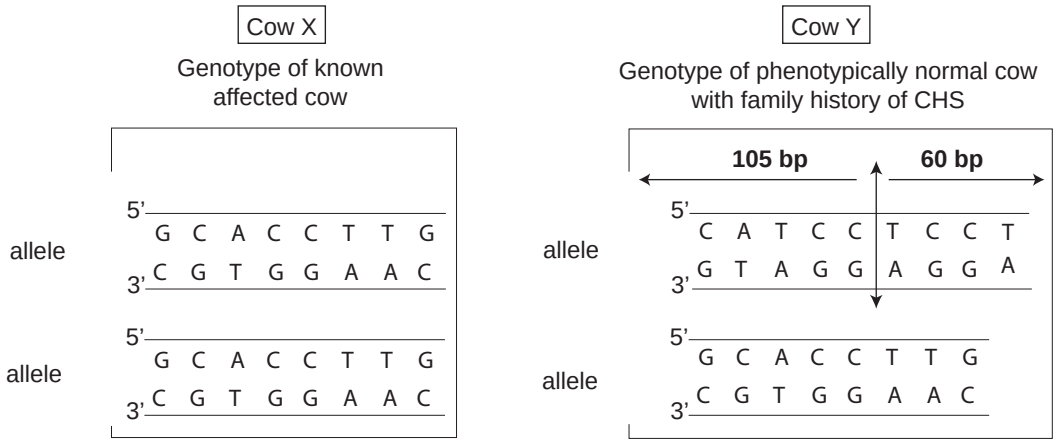
Cow X – a cow known to have the autosomal recessive disease CHS

Cow Y – a phenotypically normal cow with a family history of CHS

The CHS locus was isolated from each, amplified and then treated with *FokI* restriction enzyme which recognises the nucleotide sequences

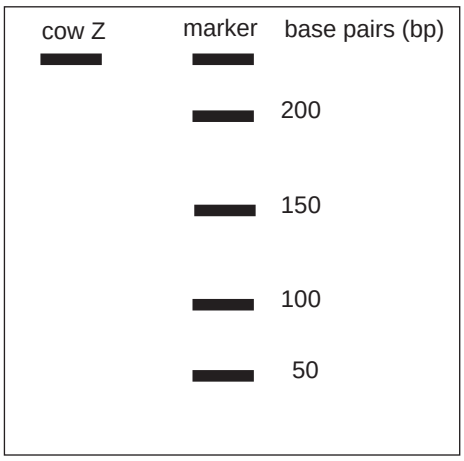
5' – G G A T G – 3' and 5' – C A T C C – 3'

The genotypes at the CHS locus for the two cows are shown in the following figure.



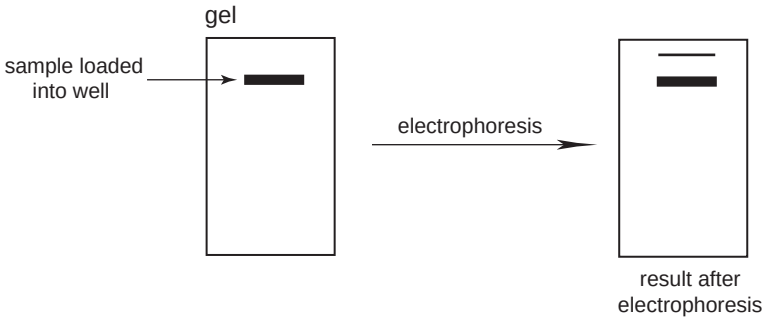
d. **i.** Explain whether Cow Y is heterozygous or homozygous at the CHS locus.

ii. On the electrophoretic gel diagram below, draw in the band(s) that would accurately show a profile for an unaffected cow Z with no history of CHS in the family.



1 + 2 = 3 marks

A farmer suspected that one of his cows was a CHS carrier. He sent a sample of the cow's hair follicles for testing. A technician ran a gel of DNA sequences from the hair follicles and obtained the following result.



e. What mistake must the technician have made in his procedures to obtain this result?

_____

_____

1 mark

Total 9 marks

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Question 6

The press recently reported:

'Anthropologists have uncovered ancient fossil footprints in Kenya dating back 1.5 million years, the oldest evidence that indicates our ancestors walked like present-day humans . . .'

a. Give one significant feature of the footprints that would have led anthropologists to this conclusion.

_____

_____

1 mark

The pictures below show views of skulls from *Homo erectus* and *Homo sapiens*.

skull set 1

skull set 2

b. With reference to two structural features of the skull, which skull set represents *Homo erectus*? Justify your choice.

Skull set _____

Justification _____

_____

_____

_____

_____

_____

2 marks

According to one interpretation of the hominid fossil record, *Homo habilis* is thought to have existed about 2 million years ago.

c. What kind of discoveries have been made at *Homo habilis* sites that have increased our understanding of the technological evolution of hominids?

_____

_____

1 mark

'The rate of technological evolution has been increased by cultural evolution of *Homo sapiens*.'

d. **i.** Describe one example of the effect that cultural evolution has had on the rate of technological evolution.

_____

_____

_____

Cultural evolution depended on the development of physical capabilities of the Homo genus.

ii. What physical feature has played the most important role in this advancement?

How has this feature developed over evolutionary time?

Feature _____

Development _____

_____

_____

Arguably, modern *Homo sapiens* has taken the manipulation and control of the environment to its highest level in history.

iii. Does this mean that our species will no longer physically evolve by the mechanism of natural selection? Justify your answer.

_____

_____

_____

1 + 1 + 1 = 3 marks

Total 7 marks

Question 7

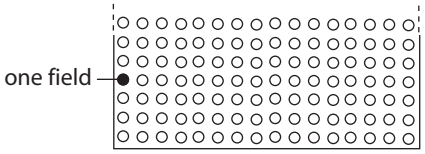
Many techniques in molecular biology require the use of probes.

a. What is a probe?

1 mark

DNA microarray technology, also known as DNA chip technology, allows screening to detect mutations.

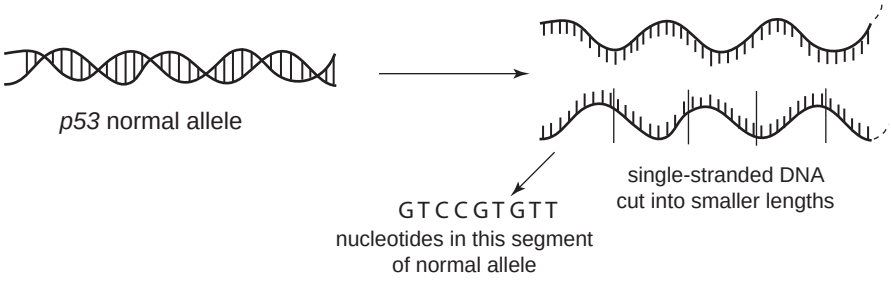
A DNA chip is made of glass and can contain thousands of fields. Each field is like a tiny well in which reactions can occur.



DNA microarray technology has been used to survey the *p53* gene because a mutation of this gene is present in about 60% of all cancers. The position of a mutation in the *p53* gene of a patient, Patient **X**, who has breast cancer, can be determined.

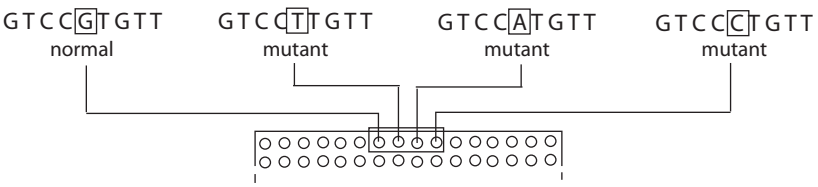
Steps in the screening procedure are outlined below.

Step 1 Treat a normal allele of *p53* to break it down into nucleotide sequences.



Step 2 Each segment must be tested, one nucleotide at a time. Tests for the first segment of the allele are outlined below.

Consider nucleotide five [G] in the normal sequence. Sequences of this section are manufactured so that all possible mutants of base five are formed. Each of these sequences is placed in a different field.



Step 3 Two solutions are added to each of the fields.
These solutions contain

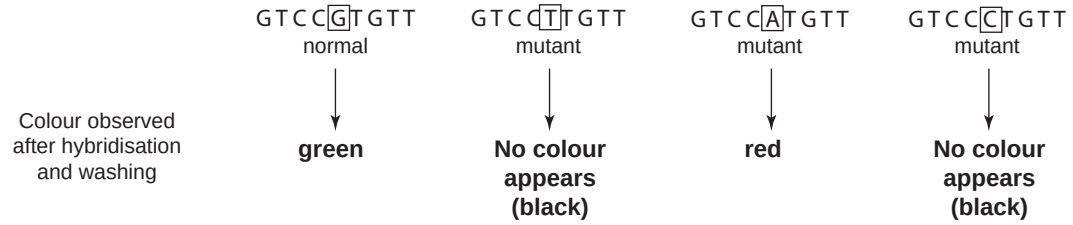
Solution I Complementary normal strand, labelled with green fluorescent dye

Solution II Complementary strand from DNA of person with breast cancer, labelled with red fluorescent dye.

Step 4 Allow time for hybridisation of strands and then wash the DNA chip to remove excess dyes.

Step 5 Examine fields under UV light to distinguish colours remaining. Interpret results.

The results for Patient **X** are shown below.



b. What is the function of each of the two different fluorescent dyes used?

2 marks

c. What does hybridisation mean?

1 mark

d. What mutation resulted in Patient **X** having breast cancer?

1 mark

A daughter of Patient **X** was also tested for the first segment of the allele.

e. Would you expect the result of her test to be green, red or black? Explain your answer.

1 mark

Total 6 marks

END OF QUESTION AND ANSWER BOOK