



NSW Education Standards Authority

2021 HIGHER SCHOOL CERTIFICATE EXAMINATION

Biology

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used

Total marks: 100

Section I – 20 marks (pages 2–11)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 13–36)

- Attempt Questions 21–33
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks

Attempt Questions 1–20

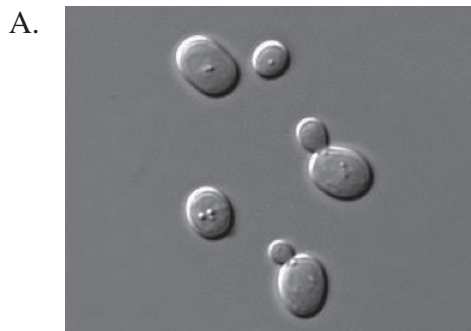
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

- 1 A patient felt tired, weak and had a swollen neck. After following the doctor's advice to eat more foods containing iodised salt, her symptoms disappeared.

What was the most likely cause of the patient's symptoms?

- A. Cancer
 - B. Genetic disorder
 - C. Nutritional deficiency
 - D. Environmental exposure
- 2 Which of the following photographs shows an example of sexual reproduction?



Yeast budding

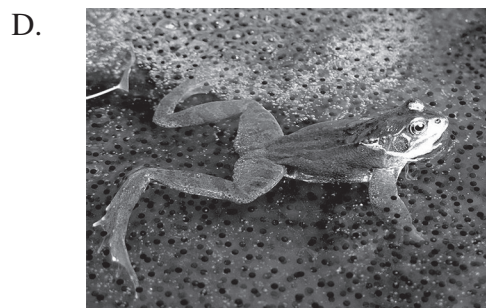


Bacteria – binary fission



Strawberry runners

Stack overflow



Frog spawning

Photo by Salimfadhley

- 3** A scientist transferred male gametes from one plant to another to achieve a desired characteristic in the offspring.

Which genetic technology was the scientist using?

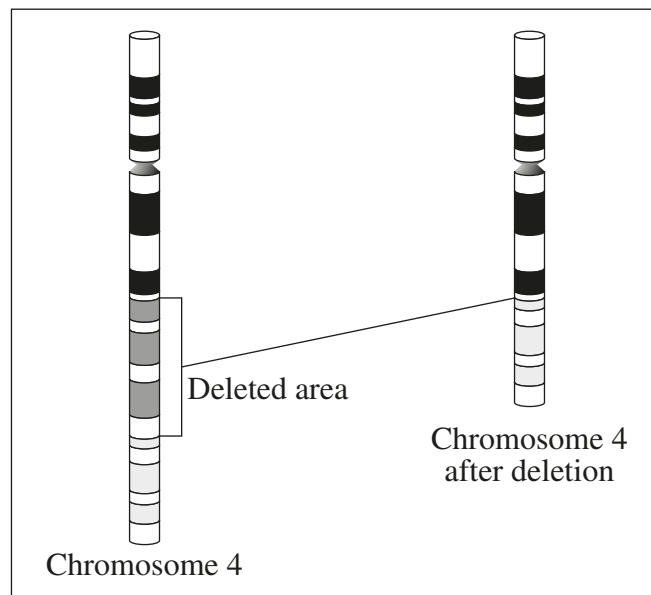
- A. Gene cloning
 - B. Artificial pollination
 - C. Artificial insemination
 - D. Whole organism cloning
- 4** Which is the most effective strategy for treating non-infectious diseases?
- A. Hygiene
 - B. Pharmaceuticals
 - C. Quarantine
 - D. Vaccination

- 5** Glucose levels are maintained by the hormones insulin and glucagon.

Which statement best describes the changes in hormone levels of a healthy human soon after a high glucose meal?

- A. Insulin levels fall and glucagon levels rise.
- B. Insulin levels fall and glucagon levels fall.
- C. Insulin levels rise and glucagon levels fall.
- D. Insulin levels rise and glucagon levels rise.

- 6 A mutation involving a DNA deletion is illustrated.



Courtesy of the National Human Genome Research Institute.
<https://www.genome.gov/genetics-glossary/deletion>

Which statement about the mutation is correct?

- A. It will have an effect on many genes.
 - B. It will have an effect on only one codon.
 - C. It may be the result of an error during translation.
 - D. It may be the result of an error during transcription.
- 7 Which of the following shows correct base pairing in DNA replication?

- A. A A T G T G C C A
U U A C A C G G U
- B. A A T G T G C C A
G G C A C A T T G
- C. A A T G T G C C A
T T A C A C G G T
- D. A A T G T G C C A
T T U C U C G G T

- 8 Howard Florey conducted a breakthrough experiment in the development and use of antibiotics. He infected eight mice with *Streptococcus* bacteria. Four mice were given penicillin and survived while the four untreated mice died.

What conclusion could be drawn from the data obtained?

- A. The experiment should be repeated with more mice.
 - B. The use of penicillin causes antibiotic resistance in mice.
 - C. Penicillin may be used on humans safely to treat bacterial infections.
 - D. Penicillin may have played a role in the survival of the four treated mice.
- 9 Streptomycin is an antibiotic that kills bacteria by interfering with the function of their ribosomes.

The primary effect of the antibiotic is that it prevents the bacteria from producing

- A. tRNA.
 - B. mRNA.
 - C. amino acids.
 - D. polypeptides.
- 10 Cystic fibrosis is an autosomal recessive disorder caused by mutations in the *CFTR* gene. Many different recessive alleles cause cystic fibrosis.

The four most common alleles of the *CFTR* gene and their frequencies in the Australian population are shown in the table.

<i>Allele</i>	<i>Frequency of allele (%)</i>
A	98.33
a1	1.13
a2	0.08
a3	0.07

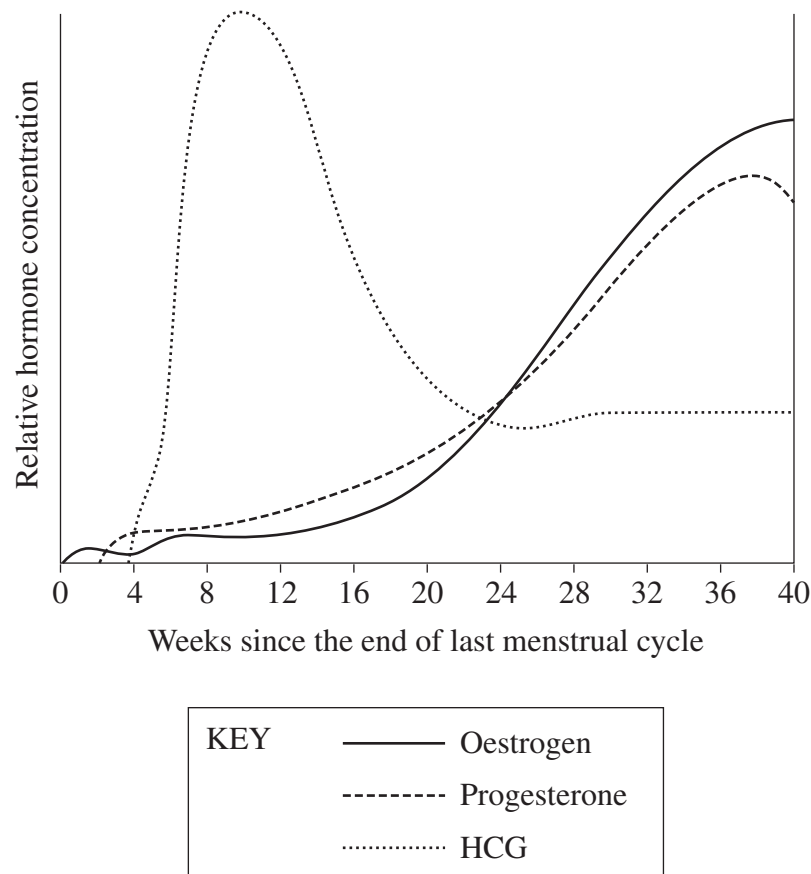
What will be the most common genotype of cystic fibrosis patients in Australia?

- A. a1/a1
- B. a1/a2
- C. A/a1
- D. A/A

- 11 Many transgenic crops have been genetically engineered to have traits such as herbicide resistance. In at least four different crops the transgene has been found in nearby wild plant relatives of the cultivated crops.

What is the most likely reason for this observation?

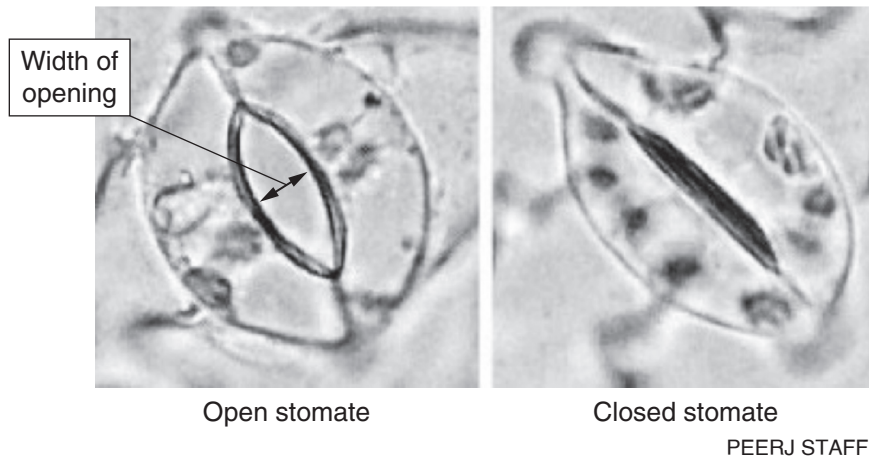
- A. Crossing over in the wild plants
 - B. Gene flow from the crops to the wild plants
 - C. Genetic drift from the crops to the wild plants
 - D. Mutations in the wild plants that match the transgenes
- 12 The graph shows the levels of three hormones, oestrogen, progesterone and human chorionic gonadotrophin (HCG), measured in the blood of a woman during her pregnancy.



Which statement can be inferred from the graph?

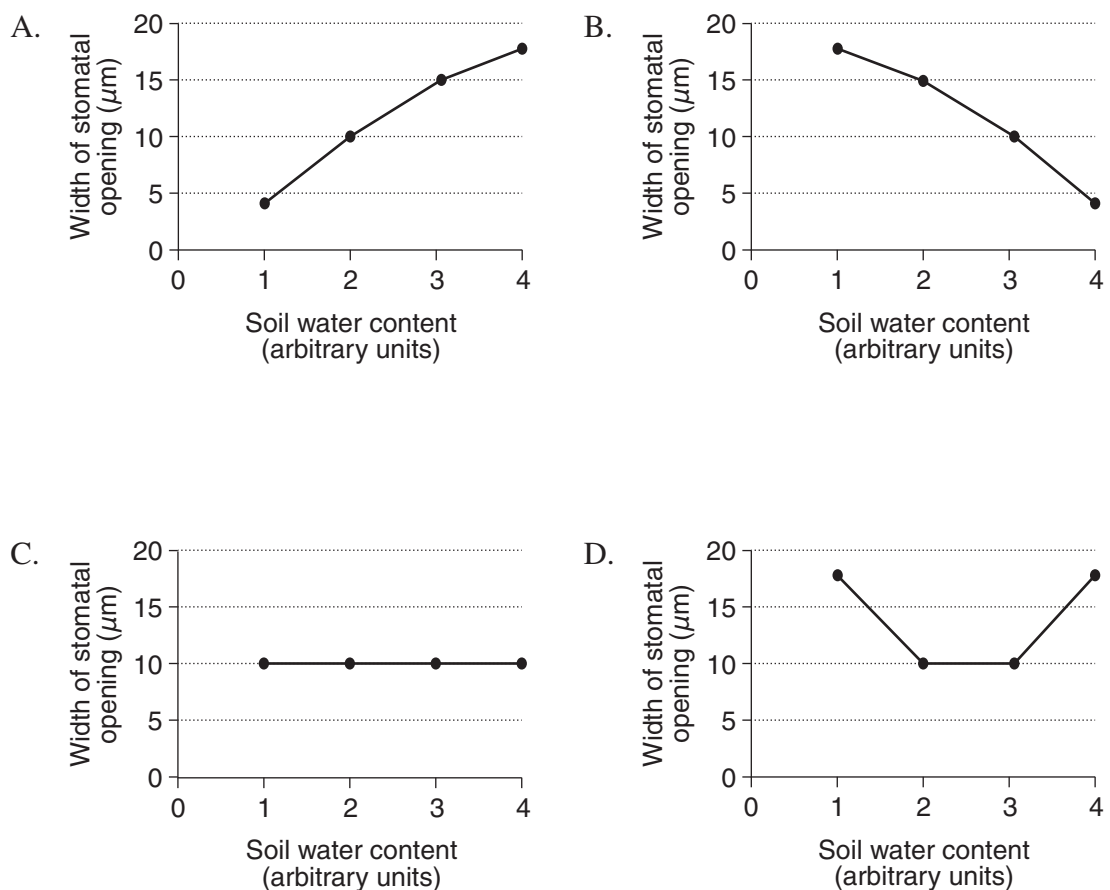
- A. Birth occurred about week 36.
- B. Fertilisation occurred at day 0.
- C. Implantation occurred about week 4.
- D. The placenta was formed about week 24.

- 13 The photographs show an open and a closed stoma on a leaf surface. When open, stomates allow water vapour to pass out of the leaf.



Regulating stomates is a mechanism by which plants maintain water balance.

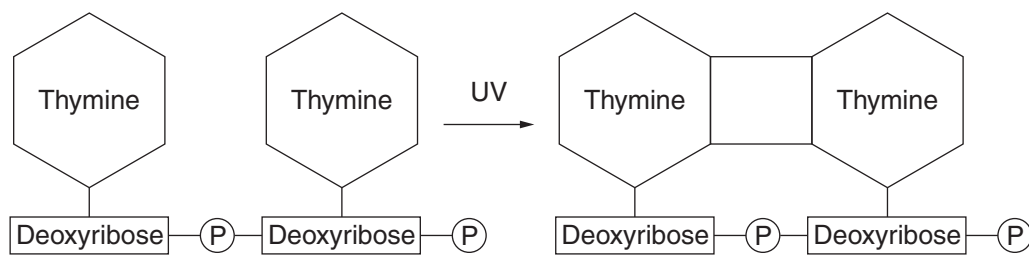
Which of the following graphs best illustrates this homeostatic mechanism?



- 14** The human *PRNP* gene codes for the prion protein. Misfolding of this protein may be the result of ingesting tissue that contains misfolded prion protein or a mutation. Accumulation of misfolded prion protein causes serious diseases such as Creutzfeldt–Jakob disease (CJD).

Which of the following statements best classifies CJD?

- A. It is both a genetic disease and an infectious disease.
 - B. It is a genetic disease only, since it is encoded by a gene.
 - C. It is not an infectious disease because the prion is non-cellular.
 - D. It is an infectious disease and the normal prion protein is the pathogen.
- 15** An example of the mutagenic effect of ultraviolet radiation (UV) on DNA is shown in the diagram.

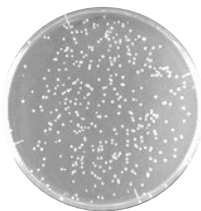
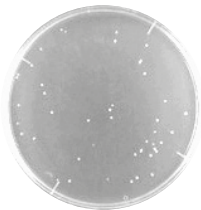
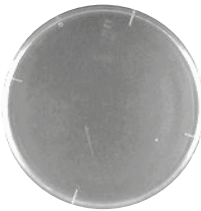


What is the mutagenic effect that is modelled?

- A. Thymine is duplicated.
- B. Bonds are formed between adjacent bases.
- C. Nucleotides form bonds in the backbone of DNA.
- D. Thymines on the two strands of DNA form bonds.

- 16 Scientists conducted an experiment to investigate the effectiveness of treating water from storage dams with UV radiation.

The experiment was conducted more than three times. The results are shown in the table.

<i>UV dose (mJ/cm²)</i>	<i>Agar plates after being inoculated with 5 mL of water and incubated at 25°C for 24 hours</i>	
	<i>Photo of agar plate</i>	<i>Average number of bacterial colonies counted</i>
0		365
1		55
6		2

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What conclusion may be drawn from the data obtained?

- A. The control plates are contaminated.
- B. High doses of UV eliminate all pathogens.
- C. Exposure to UV inhibits reproduction of bacteria.
- D. The presence of bacteria reduces the amount of UV.

- 17 The images show the sequence of changes in the chromosomes (stained black) during mitosis in plant cells.

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this material cannot be displayed

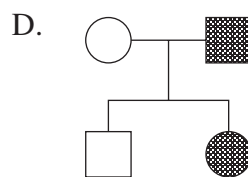
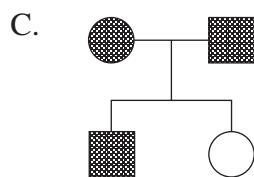
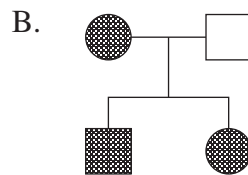
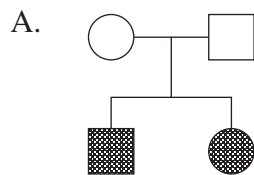
Please refer to <https://www.qwisd.us/vimages/shared/vnews/stories/4ebbe99bda63a/Onion%20Cell%20Mitosis%20Lab%20Instructions.pdf>

(Please refer to the 1st image/illustration on page 2, in green colour)

Which statement is true for mitosis?

- A. Crossing over occurs during prophase.
- B. Sister chromatids separate during anaphase.
- C. Two daughter cells are produced during telophase.
- D. Homologous pairs of chromosomes line up in metaphase.

- 18 Which human pedigree shows inheritance of a recessive, sex-linked characteristic?

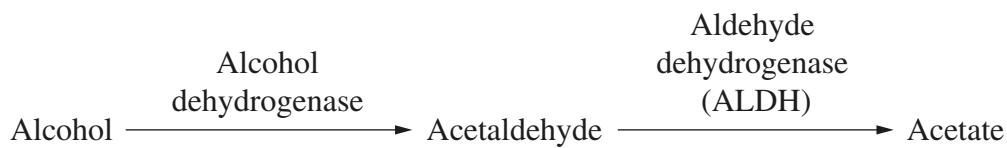


KEY

-  Unaffected female
-  Unaffected male
-  Affected female
-  Affected male

Use the following information to answer Questions 19–20.

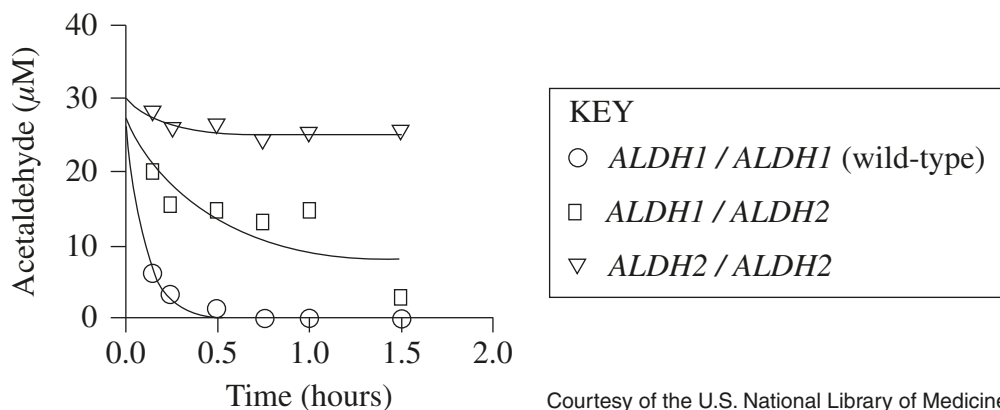
Alcohol that is consumed is broken down by the following pathway.



ALDH is the product of the *ALDH* gene. The normal allele is *ALDH1* but many people have the *ALDH2* allele, which is associated with an increased risk of cancer.

Scientists have used mouse models to study the effects of *ALDH2*. They used wild-type mice with *ALDH1* alleles and genetically-engineered mice with one or two copies of the *ALDH2* allele.

The mice were given a dose of alcohol and the response was measured. The results are shown.



19 The *ALDH* alleles differ in their

- A. genome location.
- B. location in gametes.
- C. effect on phenotype.
- D. amino acid composition.

20 What do the data show about the effect of the *ALDH2* allele?

- A. Enzyme activity is highest in homozygous mice.
- B. Enzyme activity decreases if *ALDH2* is present.
- C. Enzyme activity increases if *ALDH2* is present.
- D. Enzyme activity is lowest in wild-type mice.

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Centre Number

Biology

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Student Number

Section II Answer Booklet

80 marks

Attempt Questions 21–33

Allow about 2 hours and 25 minutes for this section

Instructions

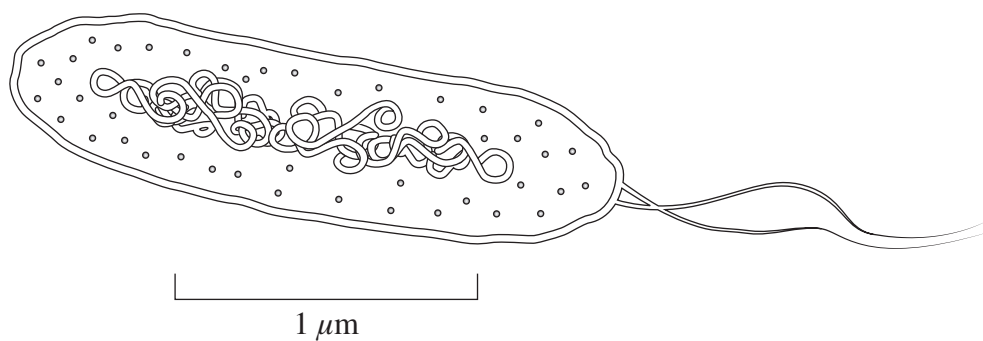
- Write your Centre Number and Student Number at the top of this page.
- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (7 marks)

- (a) Label TWO features on the diagram below that would help to classify this pathogen as a bacterium.

2



Question 21 continues on page 15

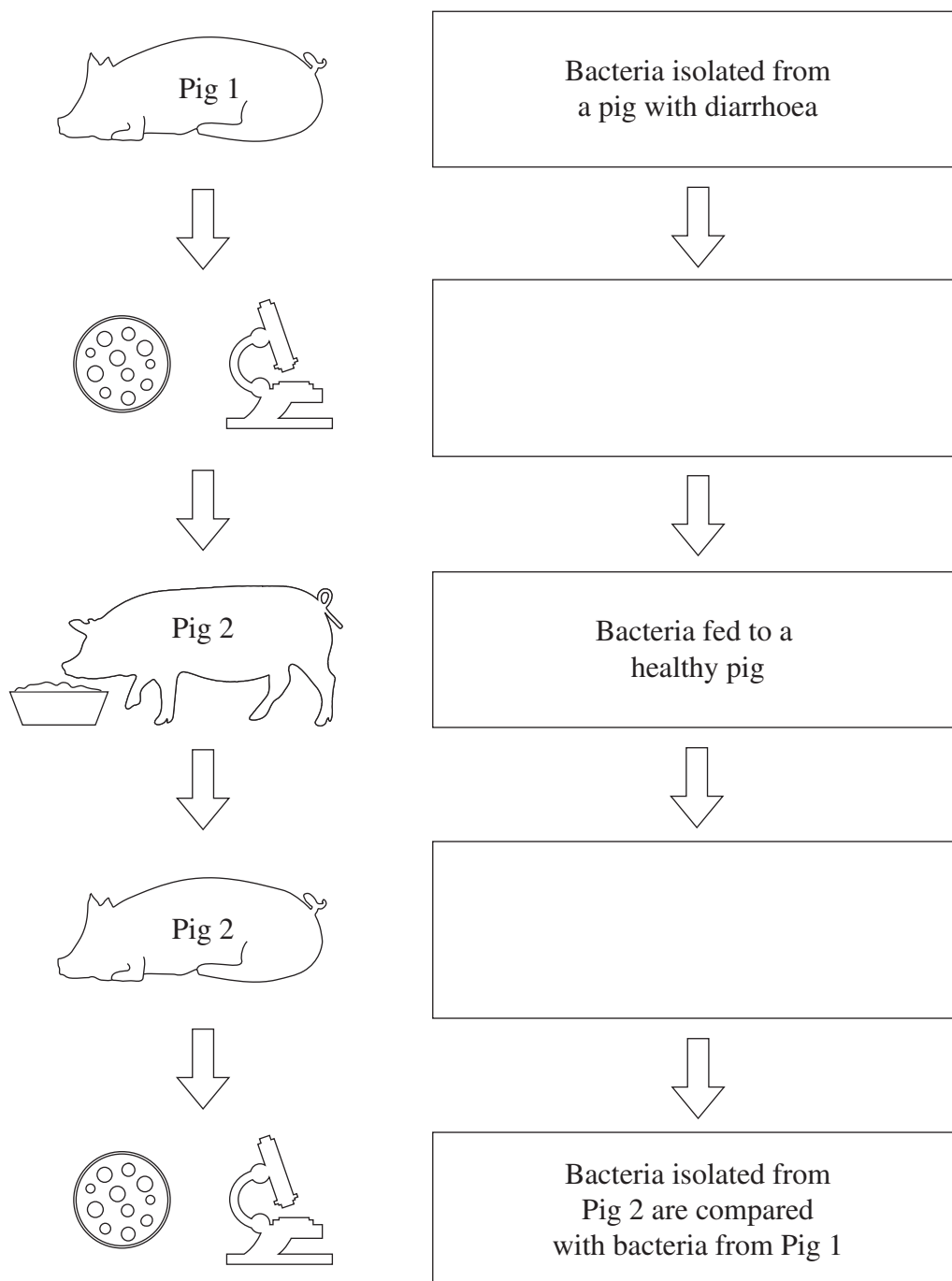
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Question 21 (continued)

- (b) A scientist followed Koch's postulates to confirm that this bacterium was causing diarrhoea in pigs on a local farm.

2

Complete the boxes in the flowchart provided to show the steps taken by the scientist.



Question 21 continues on page 16

Question 21 (continued)

- (c) Two pig farmers on neighbouring farms noticed that their pigs were suffering from diarrhoea and gradually losing weight. The farmers each adopted a different strategy to deal with this disease, as shown in the table.

3

<i>Farm</i>	<i>Strategy</i>	<i>Result</i>
1	Treatment with antibiotics	All pigs recovered after two weeks
2	Elimination of rats and mice from pig sheds to improve hygiene	Decrease in number of sick animals over three months

Outline ONE benefit and ONE limitation of the strategies used on each farm.

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Question 22 (3 marks)

In a population of rabbits, black fur colour is dominant over white fur. A black rabbit, whose mother has white fur, mates with a white rabbit.

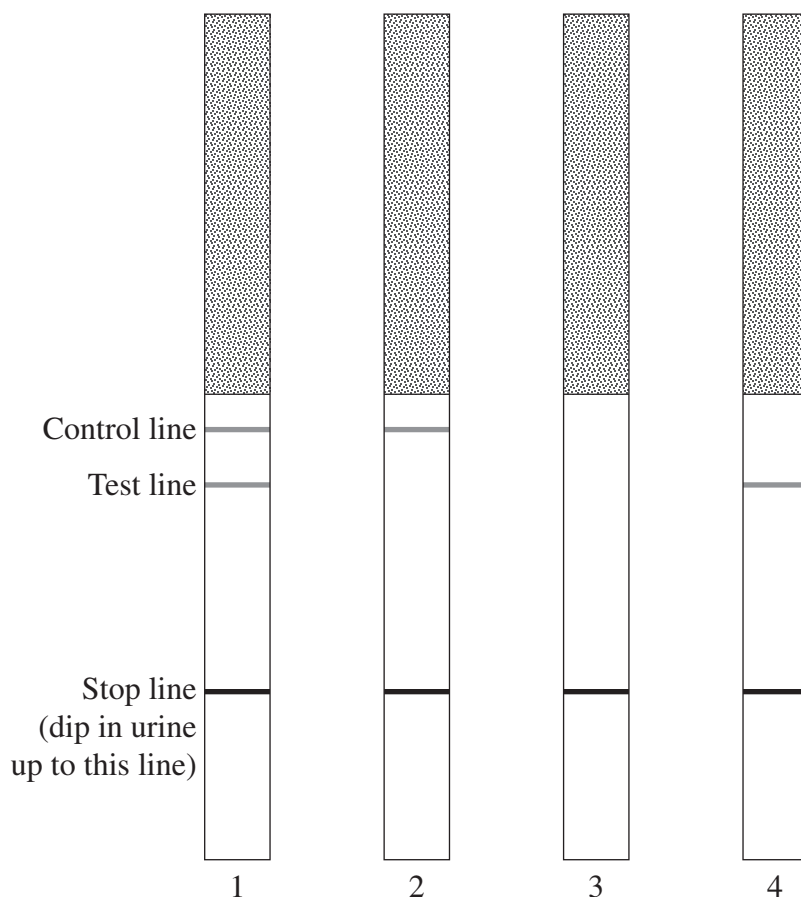
3

Predict the phenotypic ratio for the offspring of this cross. Show your working.

Question 23 (3 marks)

Ovulation in women is associated with a rapid increase in luteinising hormone (LH). Test strips can be used to detect high levels of LH in urine. Once a test strip is used, a control line should appear and the presence of a test line indicates high levels of LH in urine. The image below represents four different results that were obtained.

3



Which of the results indicates a valid test which shows that ovulation is NOT occurring? Justify your answer.

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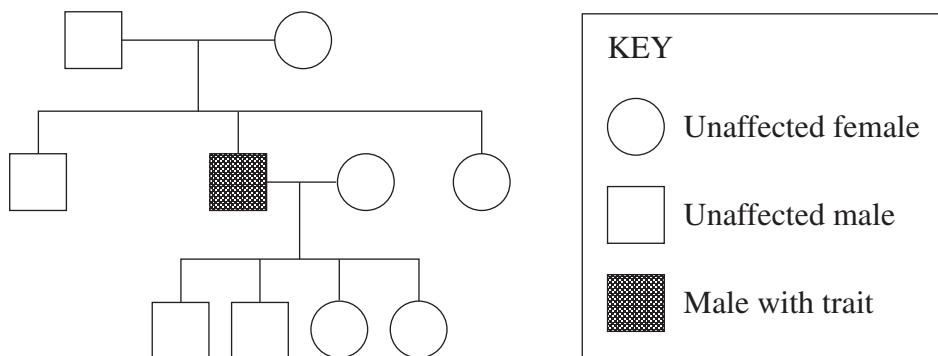
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Question 24 (7 marks)

An incidence of an autosomal dominant trait is shown in the pedigree.



- (a) Is this trait likely to be the result of a somatic or a germ-line mutation? Justify your answer.

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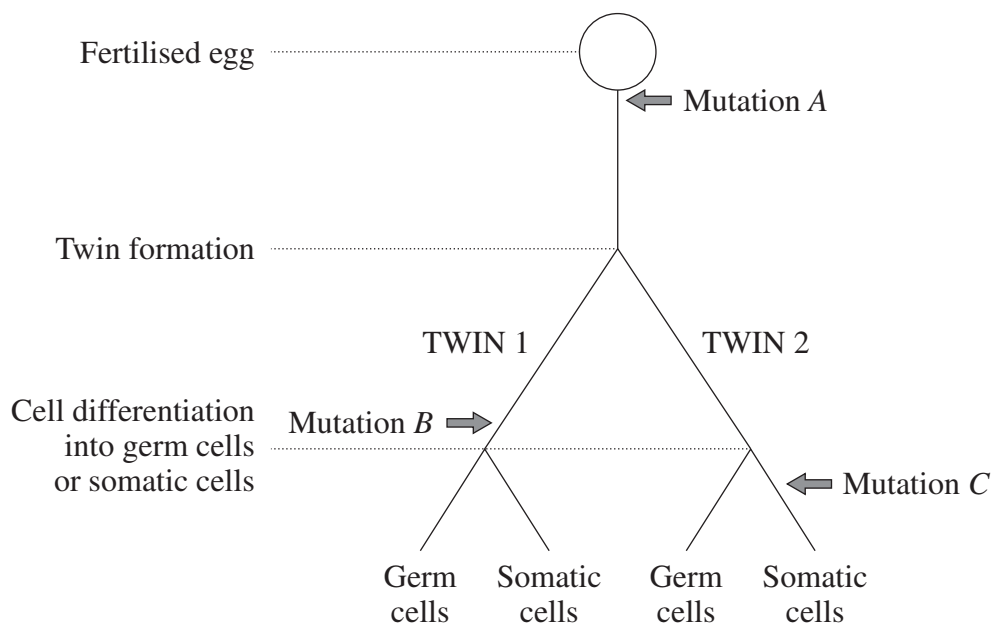
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Question 24 continues on page 19

Question 24 (continued)

- (b) The diagram shows the early stages of embryonic development from a fertilised egg. The developing ball of cells has split and monozygotic (identical) twins have formed. Mutations can occur at different times during embryonic development, for example Mutation A would result in both twins having the mutation in all their cells.

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Explain the effects of Mutation B and Mutation C on each twin and on any offspring that they may have.

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End of Question 24

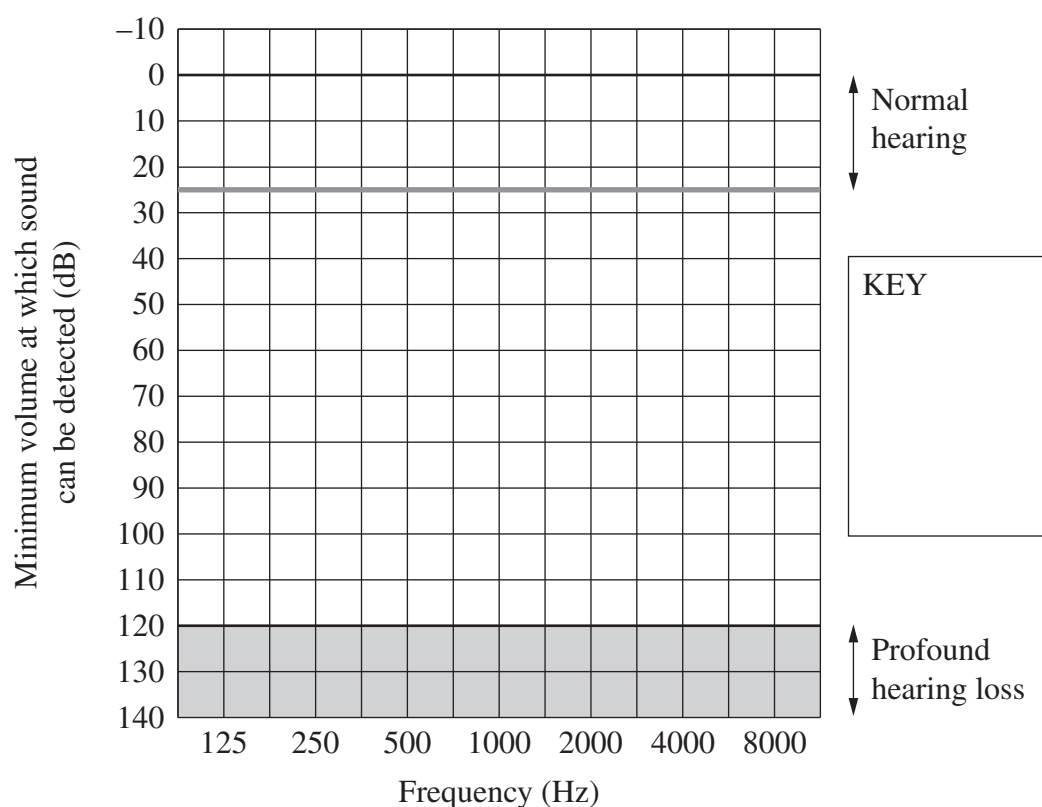
Question 25 (8 marks)

A patient visited an audiologist for a hearing test. The audiologist tested both ears at specific frequencies. The volumes at which each frequency could be heard are shown.

Frequency (Hz)	Minimum volume at which sound could be detected (dB)	
	Right ear	Left ear
250	5	55
500	9	60
1000	9	75
2000	5	75
4000	9	80
8000	20	100

- (a) Plot the data on the grid provided and include a key.

3



Question 25 continues on page 21

Question 25 (continued)

- (b) What conclusions can be drawn about the patient's hearing? 2

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- (c) It is discovered that there is a complete and permanent blockage of the outer ear, 3
but the cochlea is still fully functional.

Justify the use of a suitable technology to assist the patient's hearing.

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End of Question 25

Question 26 (4 marks)

Zebra populations are suffering from a reduction in their gene pools due to habitat destruction and increasing isolation. This has led to an increase in the number of offspring born with coat patterns different to that of their parents. An example is shown.

4

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due to copyright issues.

<https://www.forbes.com/sites/grrlscientist/2019/09/26/rare-zebra-foal-with-polka-dots-spotted-in-kenya/?sh=b39b7a344bd4>

Explain possible reasons for the increase in these offspring.

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Question 27 (3 marks)

3

Sickle cell anaemia is a genetic disorder. In a family, the parents are both known to be heterozygous for the mutation that causes sickle cell anaemia. The couple has two unaffected children and is now expecting a third child. They have had an allele screening test to determine whether the child will have sickle cell anaemia.

A part of the DNA profile is shown. It shows the alleles present.

<i>Mother</i>	<i>Father</i>	<i>Child 1</i>	<i>Child 2</i>	<i>Child 3</i>
████████	████████		████████	████████
████████	████████	████████	████████	

Use the DNA profile provided to justify whether Child 3 will have sickle cell anaemia.

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Question 28 (8 marks)

- (a) Describe the role of mRNA in human cells.

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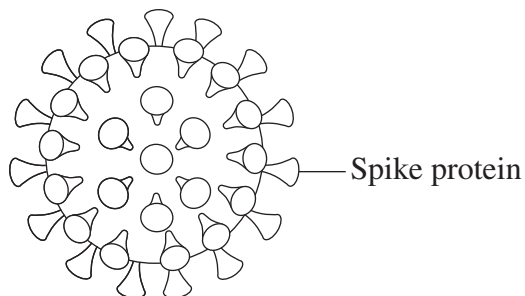
Question 28 continues on page 25

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Question 28 (continued)

- (b) An mRNA vaccine has been developed in order to immunise people against a virus. The vaccine contains modified mRNA which codes for the spike protein on the surface of the virus.

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Explain how this vaccine can lead to active immunity to the virus.

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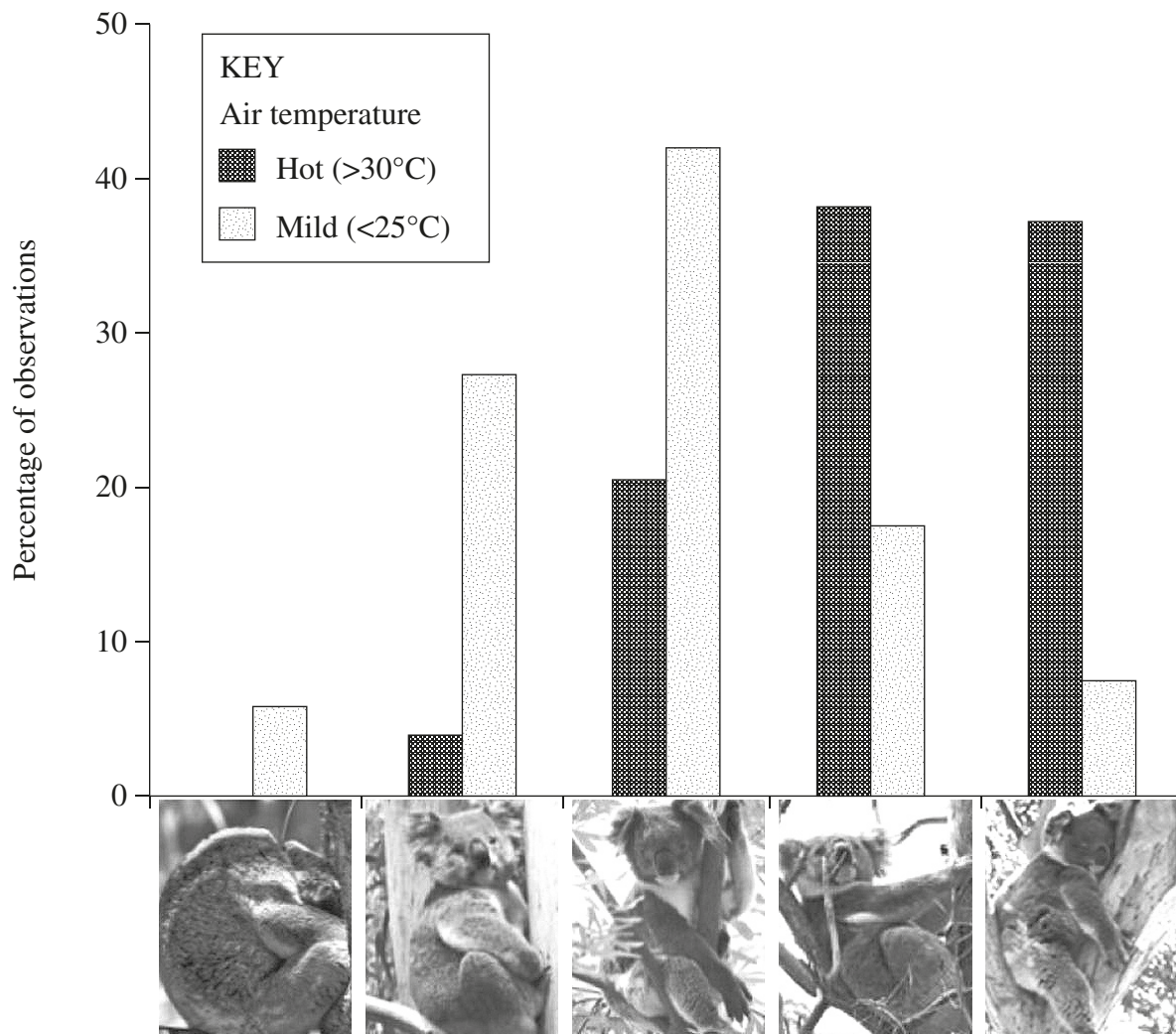
Question 29 (4 marks)

The koala is a mammal that maintains a stable body temperature of close to 36.6°C.

4

A study was conducted. Koalas were observed in natural forests in south-eastern Australia. Their posture in the tree and the ambient temperature were recorded. Ambient temperatures were divided into two categories, hot and mild.

The graph shows the posture of koalas observed.



Koala posture

By Briscoe N, Handasyde K, Griffiths S, Porter W, Krockenberger A, and Kearney M
Reproduced with permission of the Licensor through PLSclear

Additional data showed that the temperature of some tree trunks and large branches was up to 9°C cooler than air temperature during hot conditions.

Question 29 continues on page 27

Question 29 (continued)

Explain the adaptations used by the koalas in this study to maintain a stable body temperature. Make reference to the stimulus provided.

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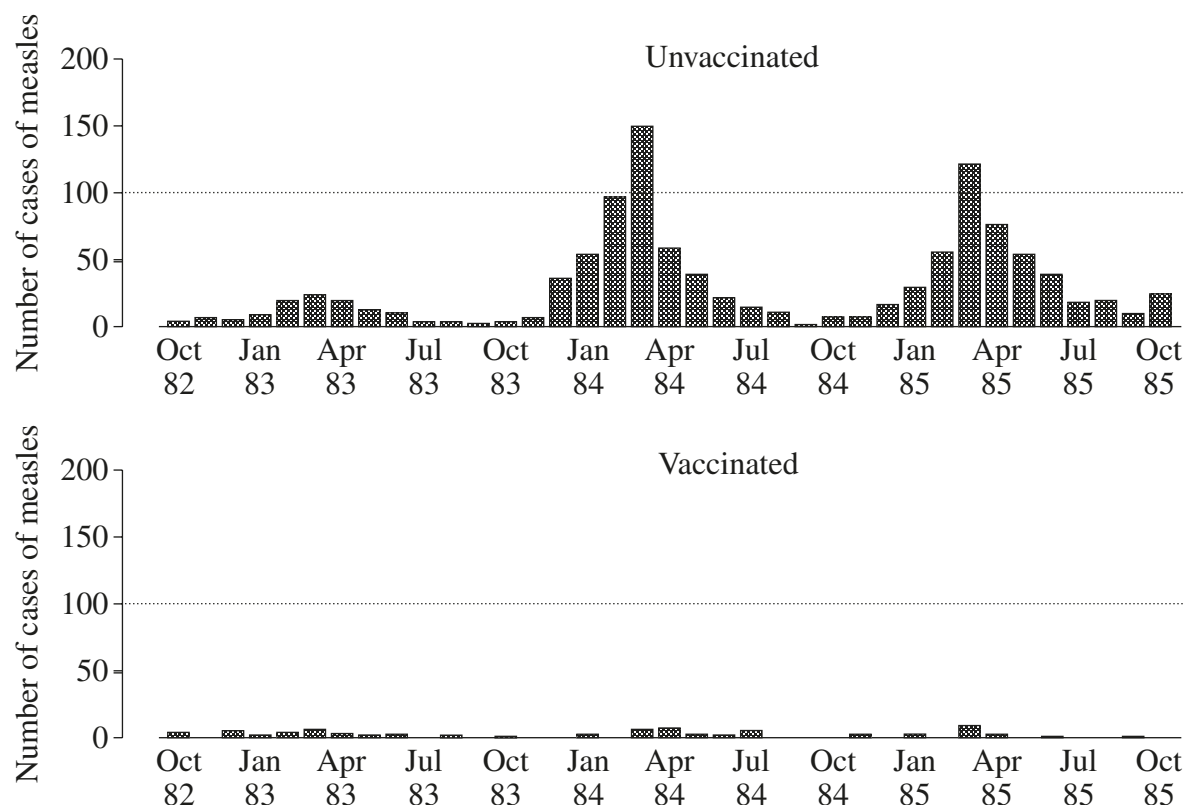
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End of Question 29

Question 30 (7 marks)

A study compared the incidence of disease and survival of 8134 children who had received the measles vaccine with 8134 children from a neighbouring area who remained unvaccinated against measles. Children in each group were matched for age, sex, size of dwelling, number of siblings and maternal education. The graphs show the number of measles cases among the two groups over three years.

7



Aaby, P, Bhuiya, A, Nahar, L, Knudsen, K, de Francisco, A & Strong, M 2003, 'The survival benefit of measles immunization may not be explained entirely by the prevention of measles disease: a community study from rural Bangladesh', International Journal of Epidemiology, vol. 32. Reproduced by permission of Oxford University Press on behalf of the International Epidemiological Association.

The table compares the cause of death and number of deaths of the two groups over the same three years.

Cause of death	Number of deaths	
	Children vaccinated against measles	Children unvaccinated against measles
Measles	2	40
Diarrhoea and dysentery	85	156
Oedema (swelling due to fluid in the tissues)	6	21
Fever	22	25
Total	115	242

Question 30 continues on page 29

Question 30 (continued)

‘A vaccine only protects the community against a specific disease.’

Analyse the data with reference to this statement.

[illegible]

End of Question 30

– 29 –

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Question 31 (6 marks)

6

Millions of people around the world take drugs known as statins, which have been shown to reduce the incidence of heart attacks and strokes in vulnerable patients. However, up to 20% of people stop taking statins due to side-effects such as muscle aches, fatigue, feeling sick and joint pain.

A recent study at a public hospital focused on 60 patients who had all stopped taking statins in the past due to severe side-effects. Patients took statin tablets for four months, placebo tablets for four months and no tablets for four months.

Every day for the year the patients scored, from zero to 100, how bad their symptoms were. The results are shown.

<i>Four month treatment</i>	<i>Average score symptoms / 100</i>
Statin tablets	16.3
Placebo tablets	15.4
No tablets	8.0

Evaluate this study and its results.

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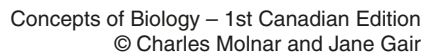
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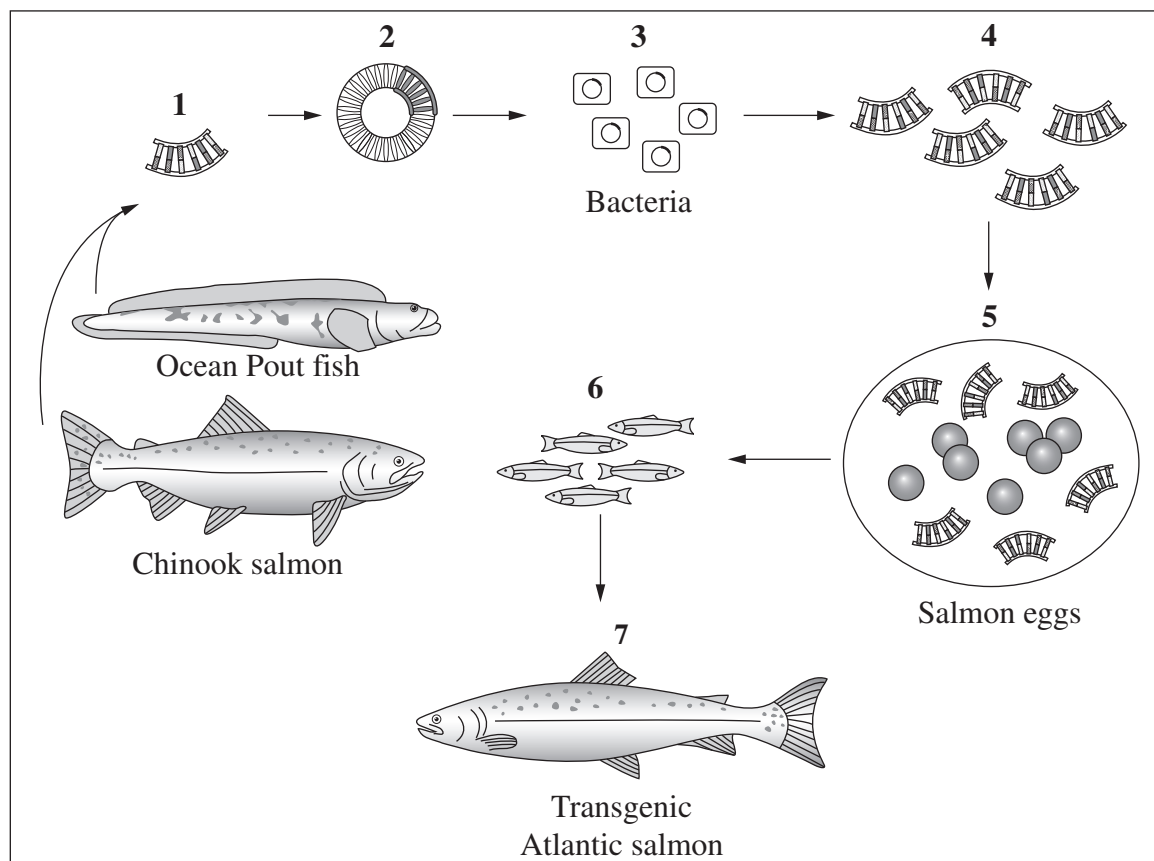


Explain the changes that would occur in the testes of a male athlete continuously taking anabolic steroids. Support your answer with reference to the flow chart.

[illegible]

Question 33 (15 marks)

Genetically engineered Atlantic salmon have been produced and approved for aquaculture in the US. These salmon have a transgene that includes a protein-coding sequence from a Chinook salmon's growth hormone gene and the promoter region of an Ocean Pout's antifreeze protein gene. The following diagram provides an overview of the production of the transgenic salmon.



- (a) Explain the processes shown in steps 1–4.

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Question 33 continues on page 33

Question 33 (continued)

- (b) The graph summarises the growth of standard salmon and transgenic salmon.

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Explain ONE potential benefit of using transgenic salmon in aquaculture. Support your answer with data from the graph.

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Question 33 continues on page 34

Question 33 (continued)

- (c) Transgenic fish can reproduce and pass on the dominant transgene (T).

9

Reproduction for aquaculture is strictly controlled using a variety of techniques in order to protect and preserve biodiversity.

Some of these techniques are outlined below.

1. Homozygous (TT) female (XX) breeding stock are kept in quarantine.
2. The female fish undergo hormone treatment that results in sex reversal and the development of male sex organs and sperm.
3. The sperm produced is collected and used to fertilise eggs obtained from wild-type, non-transgenic salmon.
4. The eggs are treated with pressure shock to prevent the completion of meiosis II. As a result, offspring are triploid (three copies of each chromosome).

All offspring are transgenic female fish and have XXX (XXX fish cannot develop sex organs).

5. Offspring are transported to inland aquaculture tanks to be grown to market size.

Analyse how these techniques protect and preserve biodiversity.

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Question 33 continues on page 35

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– 35 –

Section II extra writing space

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2021 HSC Biology Marking Guidelines

Section I

Multiple-choice Answer Key

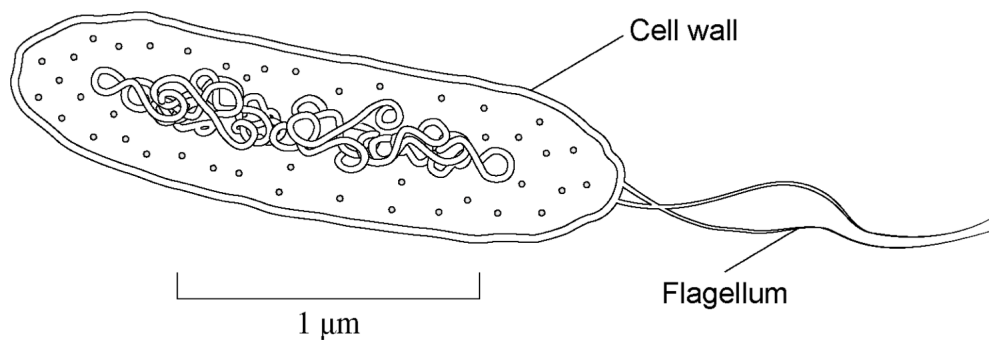
Question	Answer
1	C
2	D
3	B
4	B
5	C
6	A
7	C
8	D
9	D
10	A
11	B
12	C
13	A
14	A
15	B
16	C
17	B
18	D
19	C
20	B

Section II

Question 21 (a)

Criteria	Marks
• Correctly labels TWO features of the diagram	2
• Correctly labels ONE feature on the diagram	1

Sample answer:



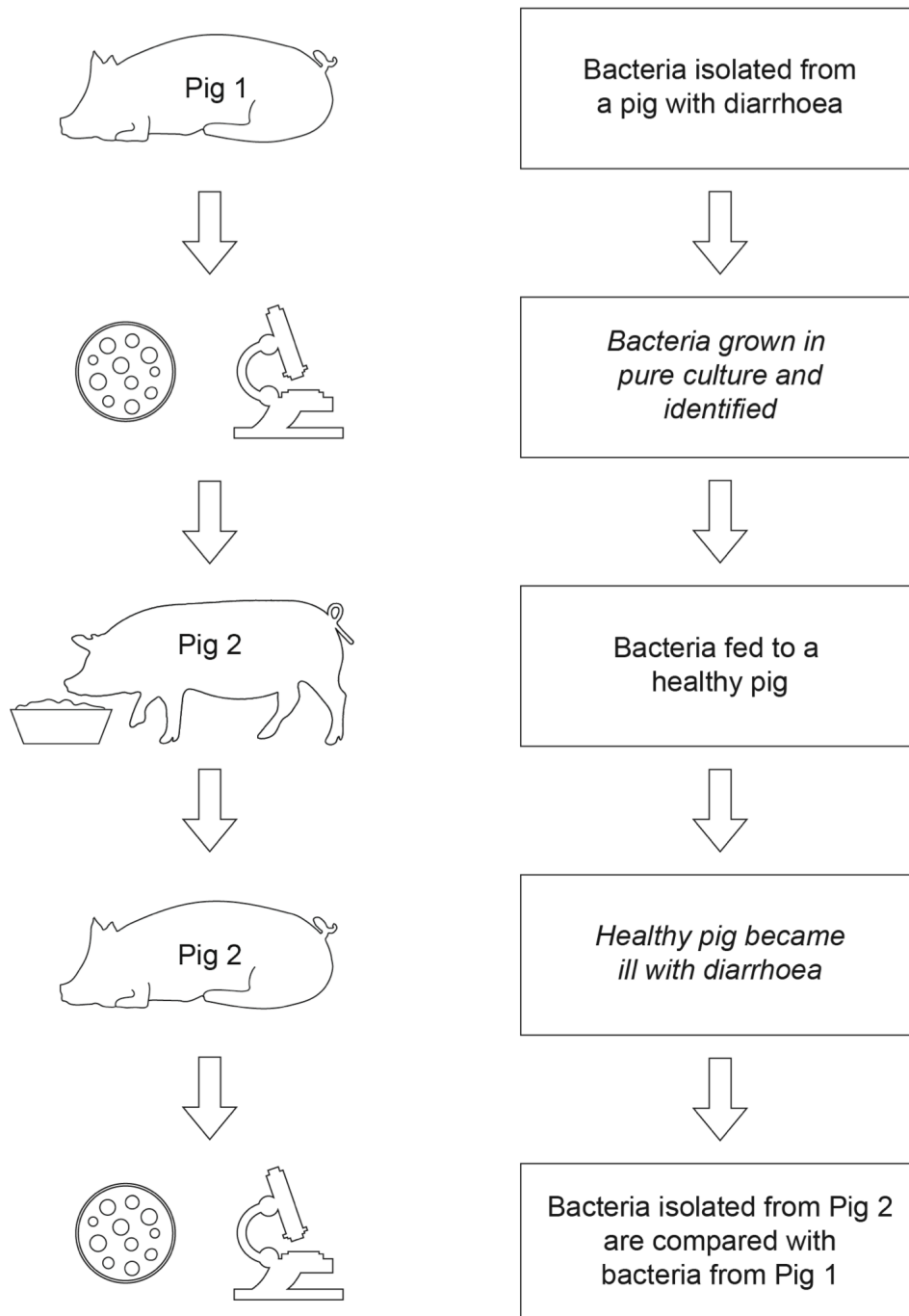
Answers could include:

- Plasma membrane
- Absence of membrane bound organelles
- DNA.

Question 21 (b)

Criteria	Marks
• Completes TWO boxes in the flowchart correctly	2
• Provides some relevant information	1

Sample answer:



Question 21 (c)

Criteria	Marks
• Outlines a benefit and a limitation of the strategies	3
• Outlines a benefit or limitation OR • Identifies a benefit and a limitation OR • Identifies benefits or limitations	2
• Provides some relevant information	1

Sample answer:

The use of antibiotics on Farm 1 eliminates the disease quickly but may induce resistance in the bacteria with longer term use so the strategy will become less effective.

On Farm 2, improved hygiene including removal of rats and mice is slow to eliminate the disease but provides a long-term solution that will prevent future outbreaks.

Question 22

Criteria	Marks
• Predicts the correct phenotypic ratio of the offspring • Provides parental genotypes and suitable working out	3
• Predicts the correct phenotypic ratio of the offspring • Provides some correct working OR • Identifies correct parental genotypes • Provides appropriate working out OR • Provides parental genotypes • Provides appropriate working out and relevant phenotypic ratio	2
• Provides some relevant information	1

Sample answer:

Bb × bb

	b	b
B	Bb	Bb
b	bb	bb

Ratio — Black : White
1 : 1

Question 23

Criteria	Marks
- Correctly identifies the valid result - Provides a suitable justification - Includes reference to test line and control line	3
- Correctly identifies a negative result - Provides a justification	2
Provides relevant information about the test	1

Sample answer:

Strip 2 is the only valid negative result. The control line is present therefore indicating that the test itself has worked. No LH surge line has been detected in strip 2 therefore it is a negative result (unlike test 3 and 4 which have no control line, making those results invalid). Ovulation is not occurring according to test 2.

Question 24 (a)

Criteria	Marks
- Identifies the type of mutation - Justifies the type of mutation with reference to the information provided	3
- Identifies the type of mutation - Provides a reason for the type of mutation	2
Provides some relevant information	1

Sample answer:

It is a somatic mutation because it is a dominant trait but not present in the parents or the offspring of the affected male. If it were a germ-line mutation which occurs in the cells that form gametes, it is most likely it would be seen in the offspring.

Question 24 (b)

Criteria	Marks
Explains the effects of the mutations on the twins and their offspring	4
Explains some effects of the mutations on the twins and/or their offspring	3
Demonstrates some understanding of the effect(s) of the mutation(s)	2
Provides some relevant information	1

Sample answer:

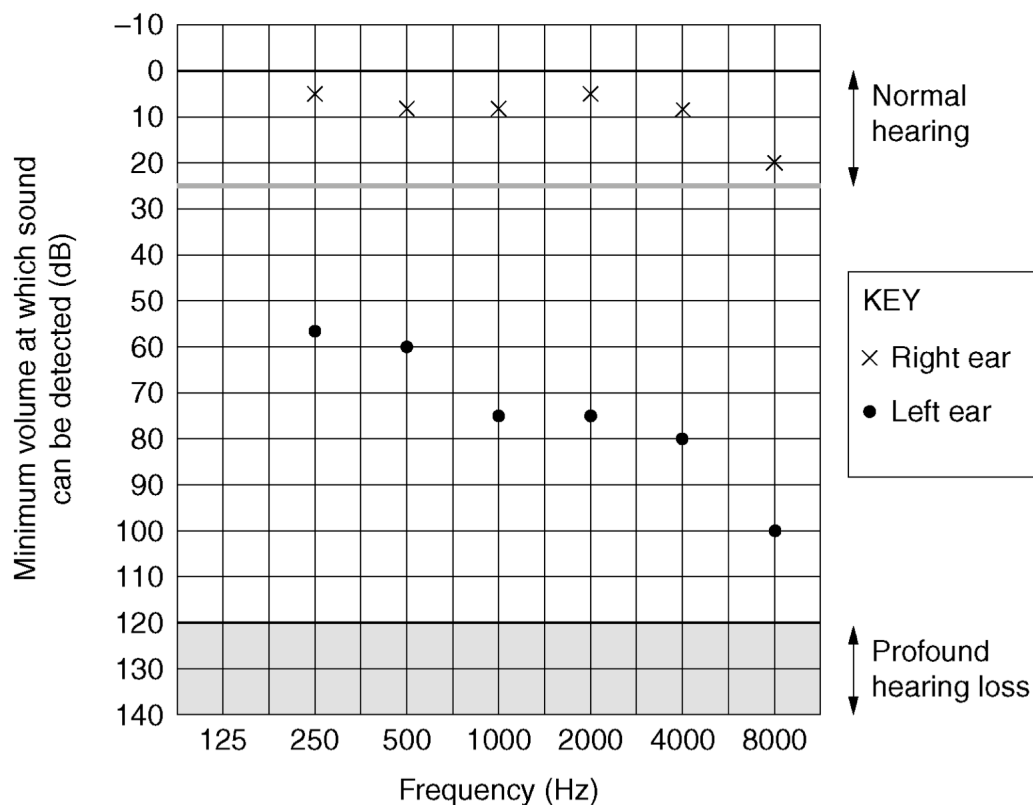
Mutation *B* occurred after twin formation, therefore affecting only Twin 1. Because it occurred prior to formation of the germ cells it will be evident in both the germ cells and the somatic cells of Twin 1 and through the germ cells may be passed to the offspring.

Because Mutation *C* occurs in the cells leading to somatic cells in Twin 2 only, it will be evident in the somatic cells of Twin 2 but not in the germline cells and can't be passed on to offspring.

Question 25 (a)

Criteria	Marks
- Data for right and left ear plotted correctly - Appropriate key provided	3
- All data plotted accurately OR - Most data plotted correctly and includes an appropriate key	2
Plots some data	1

Sample answer:



Question 25 (b)

Criteria	Marks
Draws correct conclusions about the hearing level in both left and right ears	2
Provides some appropriate information about the hearing	1

Sample answer:

Right ear has normal hearing.
Left ear has a deficit/cannot hear at a normal level.

Question 25 (c)

Criteria	Marks
• Justifies the use of a suitable technology to assist hearing	3
• Outlines a relevant hearing technology	2
• Provides relevant information on any hearing technology	1

Sample answer:

Bone conduction implants would be the most suitable technology for this patient. The blocked outer ear needs to be completely bypassed, and bone conduction works by detecting sound waves via a microphone, and relaying it to a sound processor that converts the waves into vibrations. These vibrations are transferred directly to the cochlea in order to hear the sound and so improve the patient's hearing.

Question 26

Criteria	Marks
- Explains reasons for the changing phenotypes with reference to recessive alleles and gene pools in populations - Relates concentration of recessive alleles to offspring being different to parents	4
• Explains a reason for the changing phenotypes showing a sound knowledge of gene pools in populations	3
• Demonstrates some understanding of inheritance in populations	2
• Provides some relevant information	1

Sample answer:

A reduction in gene flow occurs as populations become smaller and more isolated. This results in inbreeding, a reduction in the gene pool and the accumulation of mutations. Many mutations are recessive and when offspring receive two copies of a mutation it is expressed (and offspring will appear different to their parents). Inbreeding with close relatives results in increased risk of phenotype being affected by mutations.

Question 27

Criteria	Marks
- Provides correct phenotype for Child 3 - Justifies it using the DNA profile	3
- Provides correct phenotype for Child 3 - Provides some justification	2
Provides some relevant information	1

Sample answer:

The third child will have sickle cell anaemia because the mother, father and child two are all heterozygous/unaffected (Aa) and this is depicted by the 2 bands on the DNA profile. Child one is unaffected and displays only 1 band therefore must be homozygous normal (AA). Child 3 displays one band in a different location to child one but is a common band to the heterozygous family member therefore must be (aa) recessive and will have sickle cell anaemia.

Question 28 (a)

Criteria	Marks
Demonstrates a thorough knowledge of the role of mRNA	3
Describes a feature of the role of mRNA OR	2
Identifies features of the role of mRNA	
Provides some relevant information	1

Sample answer:

mRNA carries a complementary copy of a section of DNA that codes for a polypeptide to the ribosomes. At the ribosomes mRNA provides a template. Each codon (three nucleotides) on the mRNA results in the addition of a correct amino acid to form a polypeptide chain.

Question 28 (b)

Criteria	Marks
- Provides a comprehensive explanation of how the vaccine results in active immunity - Applies knowledge of mRNA and protein to the production of active immunity	5
- Provides a sound explanation of how the vaccine results in active immunity - Links mRNA and protein to the production of active immunity	4
- Demonstrates a sound knowledge of vaccination and the development of active immunity OR - Links mRNA and protein to the production of active immunity	3
- Outlines how a vaccine could provide immunity OR - Demonstrates an understanding of active immunity	2
Provides some relevant information	1

Sample answer:

The vaccine's mRNA enters cells and provides instructions for the production of the spike protein. The mRNA is translated at the ribosomes and the viral spike protein is produced and released into the body.

The protein will be an antigen in the body as it is foreign (not coded for by the human genome). This will trigger a specific response by B and T lymphocytes that match the antigen. Once the viral protein has been removed, memory B and T cells for the spike protein will remain, providing active immunity that allows for a rapid future response.

If the person is later exposed to the virus, the spike protein molecules on the virus's surface will trigger a rapid, large response by the memory cells.

Question 29

Criteria	Marks
• Demonstrates a thorough understanding of adaptations to maintain stable body temperature • Relates the answer to the stimulus provided • Explains the relevant adaptations in the koala	4
• Demonstrates a sound understanding of adaptations to maintain stable body temperature • Links the answer to the stimulus provided • Describes adaptations in the koala	3
• Describes an adaptation to maintain stable body temperature • Refers to the stimulus provided	2
• Provides some relevant information	1

Sample answer:

The posture of the koala on the tree is associated with the category of hot or mild air temperatures. Posture is a behavioural adaptation that changes the surface area of the skin exposed to the air. In mild conditions koalas were sometimes observed to curl up, minimising the surface area exposed and therefore minimising heat loss, a behaviour which was never observed in hot conditions. Maximising the surface area of ventral skin exposed by leaning back on a branch occurred much more frequently in hot conditions than in mild.

Hugging of tree trunks was observed more often in hot conditions. Since the tree trunk temperatures have been shown to be lower than air temperatures in hot conditions, this is also a behavioural adaptation by the koala to expose its ventral surface to the cool trunk and use it as a heat sink.

Answers could include:

Reference to physiological adaptation of directing blood flow to the koala's belly to make contact with the tree trunk.

Question 30

Criteria	Marks
- Provides a comprehensive analysis and interpretation of scientific data reference to the statement - Provides arguments for and against the statement	7
- Provides a sound analysis and interpretation of scientific data - Provides argument(s) for and against the statement	6
Interprets scientific data to support arguments for and/or against the statement	4–5
Demonstrates some understanding of the information provided and/or the role of vaccines in the control of infectious disease	2–3
Provides some relevant information	1

Sample answer:

The measles vaccine protects children against contracting measles. The graph shows that the incidence of measles in vaccinated children is very low, sometimes zero, compared with unvaccinated children. Since these children are matched for age and other social factors, it is likely that the vaccine is responsible for the differences. The table supports this conclusion in that only two vaccinated children died of measles compared with 40 in the unvaccinated group. Therefore the data supports the statement that the measles vaccine protected the community against measles.

The table provides data that suggests the measles vaccine protects children against dying from diseases other than measles and therefore contradicts the statement that a vaccine targets a specific disease. Children vaccinated against measles died at about half the rate of unvaccinated children from diarrhoea and dysentery, and less than one third the rate from oedema. However, numbers dying of oedema are small so this conclusion needs further study. If all other variables were taken into account then the vaccine appears to have non-specific beneficial effects, especially for diarrhoea. However, only small differences between the groups with respect to fever suggest that the protection of the vaccine is for selected diseases only. Since it is likely the vaccine targeted specific antigens for the measles virus, the mechanism for this wider protection is not clear.

Overall the vaccinated group showed about half the mortality of the unvaccinated group supporting the conclusion that the vaccine was protective in a more general way. The results in the table question the specificity of the measles vaccine and therefore the statement requires qualification.

Question 31

Criteria	Marks
- Evaluates the validity of the design of the study - Provides a suitable interpretation of the data - Provides a suitable judgement	6
- Demonstrates an understanding of the validity of the study - Provides an interpretation of the data - Provides a judgement	5
Outlines suitable points about the validity of the study and/or the data	3–4
- Identifies several suitable points about the study and/or the data OR - Outlines one suitable point about the study or the data	2
Provides relevant information	1

Sample answer:

The study results show that when patients were in the 'no tablet' period they still displayed the symptoms of side effects (score 8). Taking placebo tablets doubled the severity of side effects (from 8 to 15.4) even though no active ingredients were present. Statin tablets and placebo tablets had very similar results (16.3 and 15.4). These data seem to indicate that side effects in patients taking statins may not be due to the active ingredients in statins but other factors.

However these results cannot be regarded as valid as only 60 patients were involved (millions of people take statins). Also, symptoms were monitored and recorded by the patients themselves in a qualitative way and cannot be regarded as reliable measurements. The study should also have included a control group that could be used for comparison.

The study and its results cannot be regarded as valid. However, it is valuable as it indicates it would be worthwhile following this up with a large randomised control trial to confirm that statins do not cause side effects in most people.

Question 32

Criteria	Marks
- Explains changes that would occur in the testes in response to anabolic steroids - Demonstrates a comprehensive knowledge and understanding of negative feedback loops - Correctly interprets the diagram	5
- Describes changes that would occur and provides a reason for the proposed changes - Demonstrates an understanding of negative feedback loops - Correctly interprets some steps in the diagram	4
- Identifies change(s) that would occur and/or provides a reason for the proposed change(s) - Demonstrates some understanding of negative feedback loops and/or relates answer to the diagram	2–3
Provides some relevant information	1

Sample answer:

In a normal male as shown in the diagram, the hypothalamus releases Releasing Hormone which stimulates the anterior pituitary to produce hormones that stimulate the testes to produce sperm and the hormones testosterone and inhibin. Testosterone stimulates sperm production also. When a large dose of an anabolic steroid that is like testosterone is taken, while this may initially increase sperm production and the associated hormone inhibin, the testosterone effect of negative feedback on both the hypothalamus and the anterior pituitary cause less stimulatory hormones to be released so that the testes produce less sperm and less inhibin and less testosterone. Although less inhibin would mean a smaller negative feedback on the anterior pituitary caused by this hormone, the ongoing dose of testosterone would ensure a large overall negative feedback effect. In time, the testes would lose their normal function.

Question 33 (a)

Criteria	Marks
• Explains the processes in the steps	3
• Outlines the process of gene cloning	2
• Provides relevant information	1

Sample answer:

The transgene is inserted into a plasmid by using enzymes. The plasmid is then placed into a bacterial host. As the host reproduces the plasmid is copied and so is the transgene (gene cloning). This is done in order to produce multiple copies of the gene.

Question 33 (b)

Criteria	Marks
• Explains a benefit of the use of transgenic salmon in aquaculture • Links answer to data in the graph	3
• Describes a benefit of the transgenic species OR • Identifies a benefit of the transgenic salmon and links it to the data	2
• Provides relevant information	1

Sample answer:

Transgenic salmon has a higher rate of growth in the first two years than standard salmon. Transgenic salmon reaches market size in the second year whereas the standard salmon takes five months longer. This saves money in producing the fish for market as there are lower feed and maintenance costs.

Question 33 (c)

Criteria	Marks
• Demonstrates extensive knowledge and understanding of biotechnology, reproduction and biodiversity • Provides scientific analyses for the techniques used • Relates analyses to protecting and preserving biodiversity	9
• Demonstrates thorough knowledge of biotechnology, reproduction and biodiversity • Provides scientific analyses for the main techniques used • Links techniques to maintaining biodiversity	7–8
• Demonstrates sound knowledge of biotechnology and reproduction • Applies knowledge to explain technique(s) used • Links technique(s) to effect(s) on biodiversity	5–6
• Demonstrates a sound knowledge of biotechnology/techniques and/or reproduction and/or biodiversity OR • Demonstrates basic knowledge of biotechnology/techniques and makes a link to biodiversity	3–4
• Provides relevant information	1–2

Sample answer:

Biodiversity is the variety in gene pools of species as well as the variety of species in ecosystems. Transgenic salmon carries the risk of reducing biodiversity and has the potential to do great harm.

Physical isolation techniques 1 and 5 prevent transgenic salmon from escaping into the environment. They may have a survival advantage, and pass the transgene onto offspring. This may reduce biodiversity as wild-type fish become less common and the gene pool is reduced. Transgenic salmon could outcompete other species, potentially reducing species biodiversity.

Reproductive techniques such as the hormone treatment in technique 2 allow sperm to be produced that only carries X chromosomes as the parents are genetically female. This sperm is used to fertilise eggs from wild-type salmon, and all offspring are female as none of the sperm have a Y chromosome. They will all have a copy of T from the sperm – only one T is needed as it is dominant. Technique 4 prevents meiosis II and results in diploid eggs being fertilised by haploid sperm. This produces infertile, triploid offspring that have three copies of each type of chromosome. These techniques prevent the transgene from being passed on.

Using eggs from wild-type salmon is crucial to preserving biodiversity as it prevents inbreeding of transgenic fish stock and ensures hybrid vigour in the offspring, preventing the accumulation of mutations.

Physical isolation, reproductive technologies and the introduction of hybrid vigour are crucial in protecting biodiversity in ecosystems as well as within the transgenic salmon population.

2021 HSC Biology Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Mod 8 Causes and Effects	BIO12-15
2	1	Mod 5 Reproduction	BIO12-12
3	1	Mod 6 Biotechnology	BIO12-13
4	1	Mod 8 Epidemiology	BIO12-15
5	1	Mod 8 Homeostasis	BIO12-15
6	1	Mod 6 Mutation	BIO12-13
7	1	Mod 5 Cell Replication	BIO12-12
8	1	Mod 7 Prevention, Treatment and Control	BIO12-5, BIO12-14
9	1	Mod 7 Prevention, Treatment and Control	BIO12-14
10	1	Mod 5 Genetic Variation	BIO12-15, BIO12-12
11	1	Mod 6 Biotechnology	BIO12-13
12	1	Mod 5 Reproduction	BIO12-5, BIO12-12
13	1	Mod 8 Homeostasis	BIO12-5, BIO12-15
14	1	Mod 7 Causes of Infectious Disease	BIO12-14
15	1	Mod 6 Mutation	BIO12-13
16	1	Mod 7 Causes of Infectious Disease	BIO12-5, BIO12-14
17	1	Mod 5 Cell Replication	BIO12-4, BIO12-12
18	1	Mod 5 Genetic Variation	BIO12-5, BIO12-12
19	1	Mod 8 Causes and Effects	BIO12-5, BIO12-15
20	1	Mod 8 Causes and Effects	BIO12-5, BIO12-15

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	2	Mod 7 Causes of Infectious Disease	BIO12-14
21 (b)	2	Mod 7 Causes of Infectious Disease	BIO12-14
21 (c)	3	Mod 7 Prevention, Treatment and Control	BIO12-6, BIO12-14
22	3	Mod 5 Genetic Variation	BIO12-6, BIO12-12
23	3	Mod 5 Reproduction	BIO12-2, BIO12-12
24 (a)	3	Mod 5 Genetic Variation	BIO12-5, BIO12-12
24 (b)	4	Mod 6 Mutation	BIO12-6, BIO12-13
25 (a)	3	Mod 8 Technologies and Disorders	BIO12-4, BIO12-7, BIO12-15
25 (b)	2	Mod 8 Technologies and Disorders	BIO12-5, BIO12-15
25 (c)	3	Mod 8 Technologies and Disorders	BIO12-15
26	4	Mod 5 Genetic Variation	BIO12-12
27	3	Mod 5 Inheritance Patterns in Populations	BIO12-12

Question	Marks	Content	Syllabus outcomes
28 (a)	3	Mod 5 DNA and Polypeptide Synthesis	BIO12-12
28 (b)	5	Mod 7 Immunity	BIO12-14
29	4	Mod 8 Homeostasis	BIO12-5, BIO12-15
30	7	Mod 7 Prevention, Treatment and Control	BIO12-5, BIO12-6, BIO12-14
31	6	Mod 8 Epidemiology	BIO12-2, BIO12-5, BIO12-15
32	5	Mod 8 Homeostasis	BIO12-5, BIO12-6, BIO12-15
33 (a)	3	Mod 6 Genetic Technologies	BIO12-5, BIO12-13
33 (b)	3	Mod 6 Genetic Technologies	BIO12-5, BIO12-6, BIO12-13
33 (c)	9	Mod 6 Biotechnology	BIO12-5, BIO12-6, BIO12-7, BIO12-13