NSW GOVERNMENT

NSW Education Standards Authority

Centre Number

Student Number

2023 **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
- Write your Centre Number and Student Number at the top of this page

Total marks: 100

Section I – 20 marks (pages 2–14)

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

Section II – 80 marks (pages 17–44)

- Attempt Questions 21–35
- 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.

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1 A cochlear implant is a device that is used to assist with hearing loss.

What does the cochlear implant electrode array stimulate?

A. Hairs

B. Ossicles

C. Oval window

D. Auditory nerve

2 Which of the following is an advantage of internal fertilisation?

A. Decreases the risk of gamete dehydration

B. Increases the number of gametes released

C. Increases the number of zygotes at one time

D. Decreases the care provided to gamete and offspring

3 A Punnett square is shown.

	B	b
B	1	2
B	3	4

Which of the following options represents heterozygous offspring?

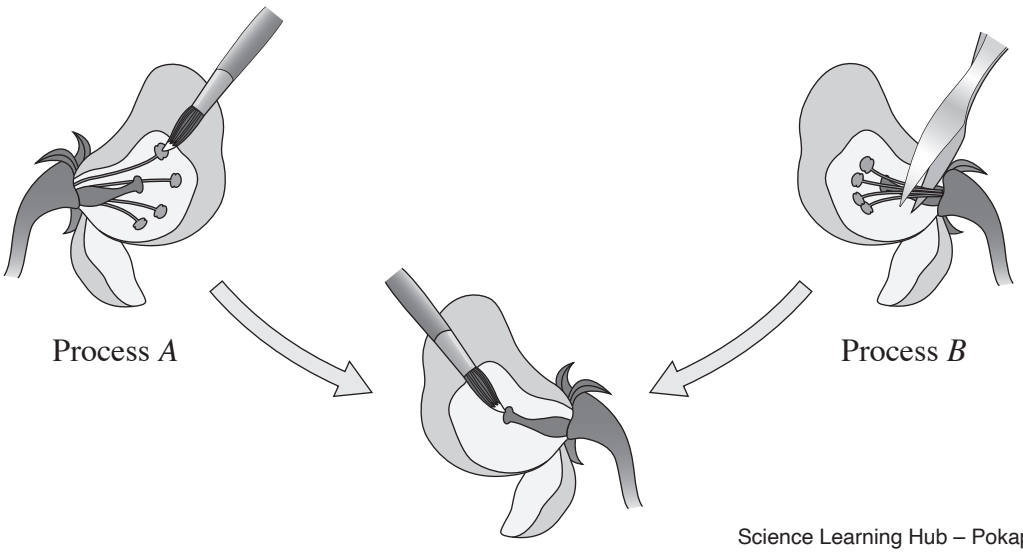
A. 1, 2

B. 1, 3

C. 2, 4

D. 3, 4

4 The following diagram shows a summary of the process of artificial pollination.



Science Learning Hub – Pokapū Akoranga Pūtaiao, University of Waikato, www.sciencelearn.org.nz

The purpose of Process *B* is to

A. produce seeds.

B. collect the pollen.

C. fertilise the flower.

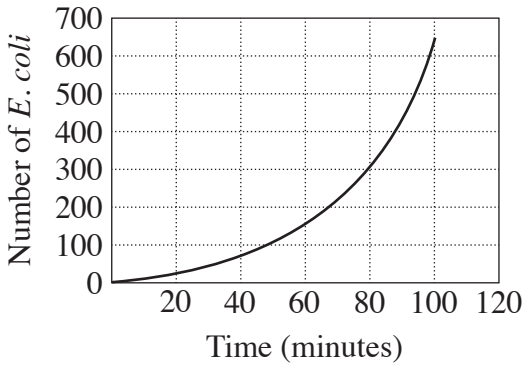
D. prevent self-pollination.

5 An experiment was conducted to investigate the rate of binary fission in *E. coli*. The results of the experiment are shown.

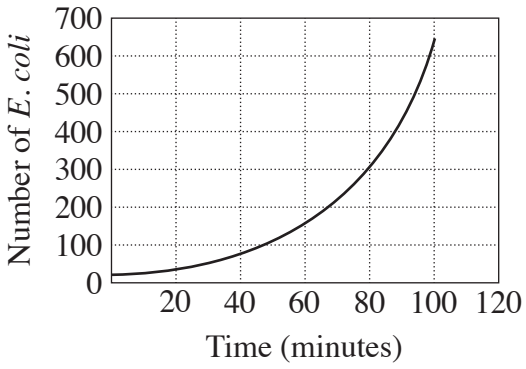
Time (minutes)	*Number of E. coli*
0	20
20	40
40	80
60	160
80	320
100	640

Which graph represents the data in the table?

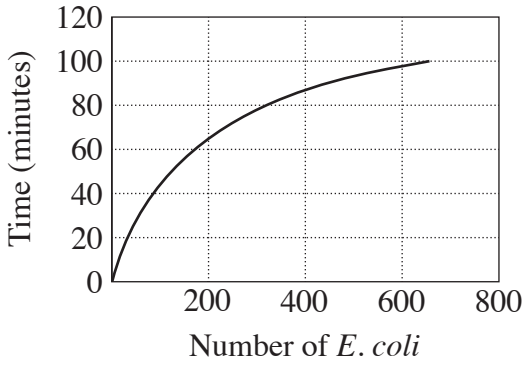
A.



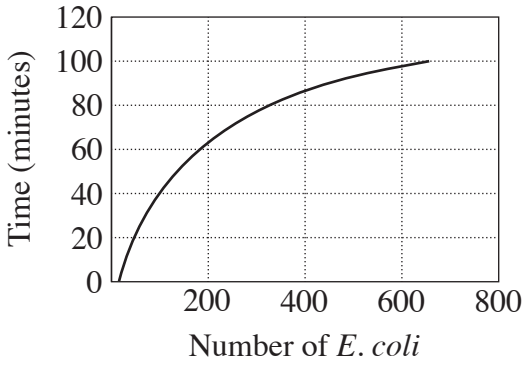
B.



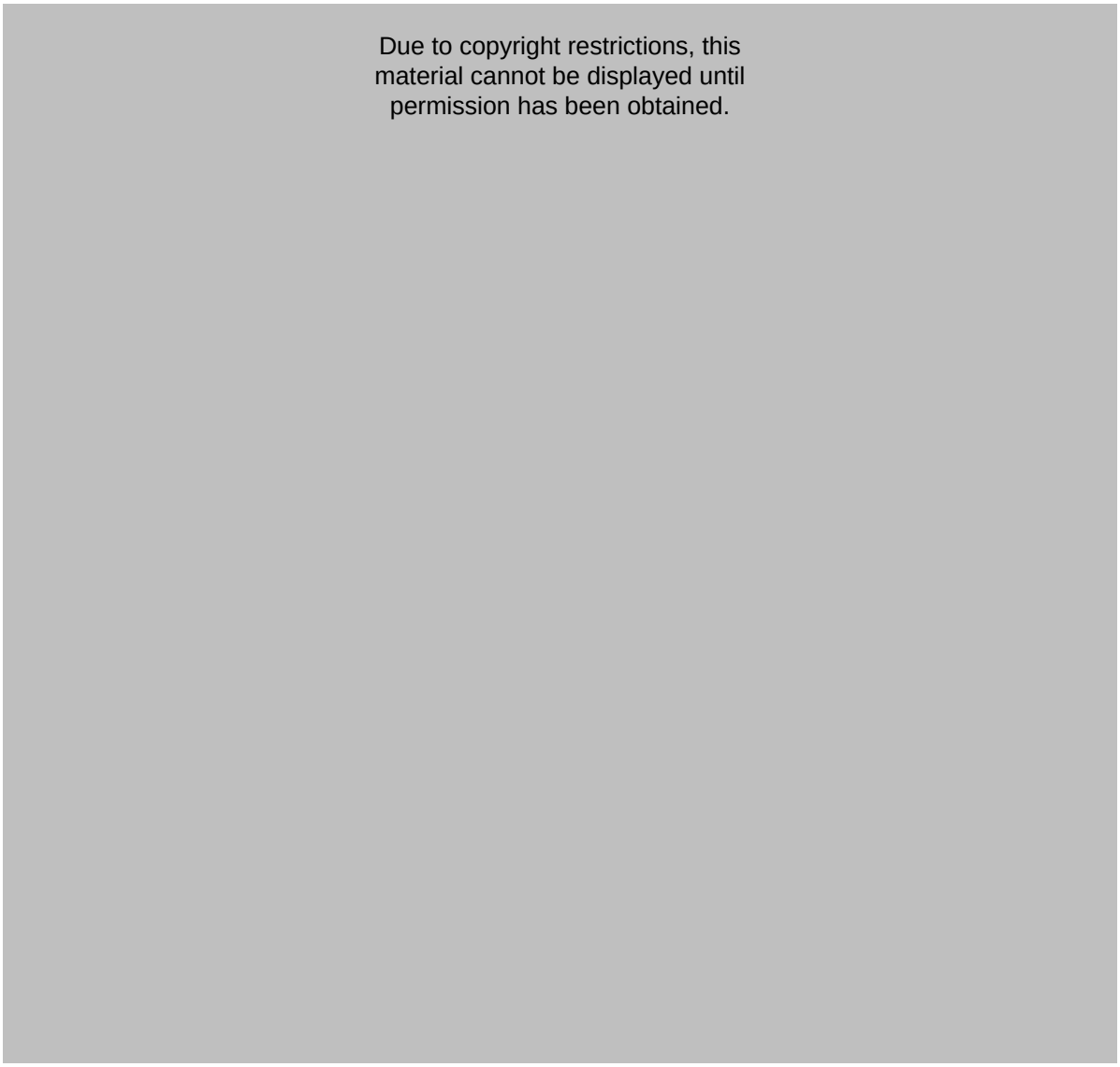
C.



D.



6 Liver fluke is a disease caused by parasites that infect grazing animals, including sheep. The life cycle of the liver fluke is shown.



How could the transmission of this disease to humans be prevented?

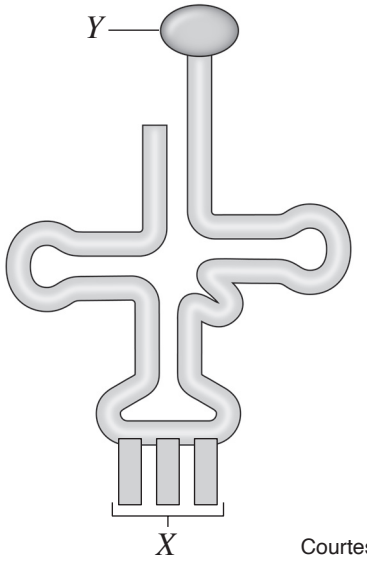
A. Eradicating the snails

B. Administering antibiotics to sheep

C. Wearing gloves when handling sheep

D. Regularly spraying fields with herbicides

7 The diagram shows the structure of a molecule of tRNA.

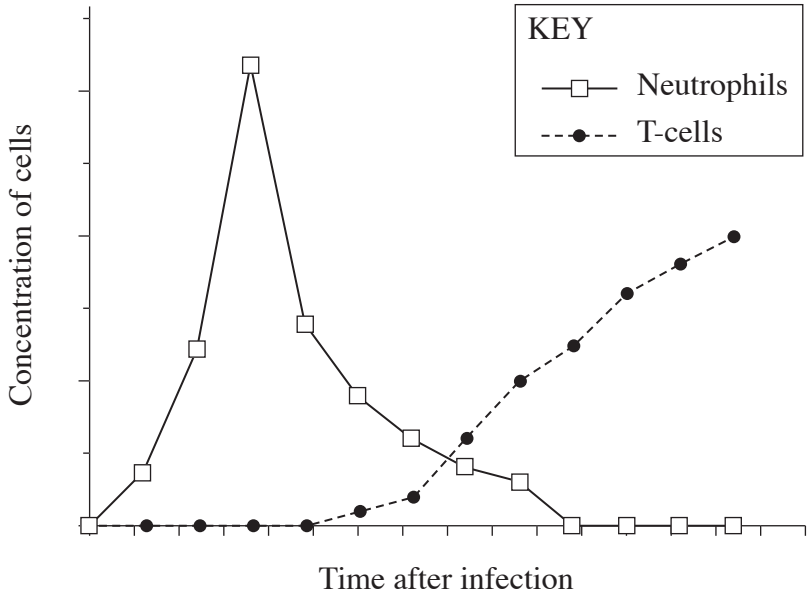


Courtesy of Medic Mind Ltd

Which row of the table correctly identifies *X* and *Y*?

	X	*Y*
A.	Anticodon	Ribonucleotide
B.	Codon	Ribonucleotide
C.	Codon	Amino acid
D.	Anticodon	Amino acid

8 Neutrophils and T-cells are cells of the human immune system. After an infection, the concentration of these types of cells in infected tissue was plotted as a function of time.



Based on the data provided, neutrophils are part of which human immune system?

A. Acquired

B. Adaptive

C. Innate

D. Primary

9 Sheep have 54 chromosomes, while goats have 60 chromosomes. The hybrid offspring of a sheep-goat pairing is called a geep.

During fertilisation, an egg from the sheep is fertilised by a sperm from the goat, resulting in a geep.

Which of the following will be correct for the geep?

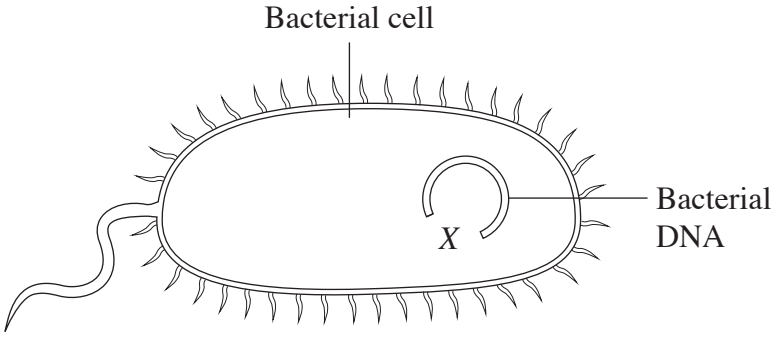
A. $n = 29$ chromosomes

B. $n = 52$ chromosomes

C. $2n = 57$ chromosomes

D. $2n = 114$ chromosomes

10 The diagram shows a bacterial cell that will be used to produce a protein.



Which component would be inserted into gap *X*?

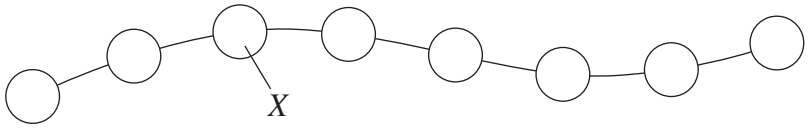
A. A cell

B. A gene

C. An amino acid

D. A chromosome

11 The diagram shows part of a protein molecule.



Which row of the table is correct?

	X	*Level of protein structure*
A.	Amino acid	Primary
B.	Amino acid	Secondary
C.	Polypeptide	Primary
D.	Polypeptide	Secondary

12 The following diagram shows the regulation of blood calcium (Ca^{2+}) levels in the body.

A blood test shows a person has a blood calcium level of 6 mg/100 mL.

What will occur in the body to restore homeostasis?

A. Calcium will be deposited in the bones.

B. Calcium will be removed from the bone matrix.

C. The thyroid gland will release the hormone thyroxine.

D. The thyroid gland will release the hormone calcitonin.

13 Australian native plants can be infected by fungal and viral pathogens.

Which of the following is an active plant response to infection by pathogens?

A. Phagocytosis

B. Programmed cell death

C. Formation of powdery spots

D. Development of small stomata

14 Minamata Disease is caused by regular consumption of contaminated fish and shellfish. The symptoms include numbness in the hands and feet, muscle weakness, and damage to vision, hearing and speech.

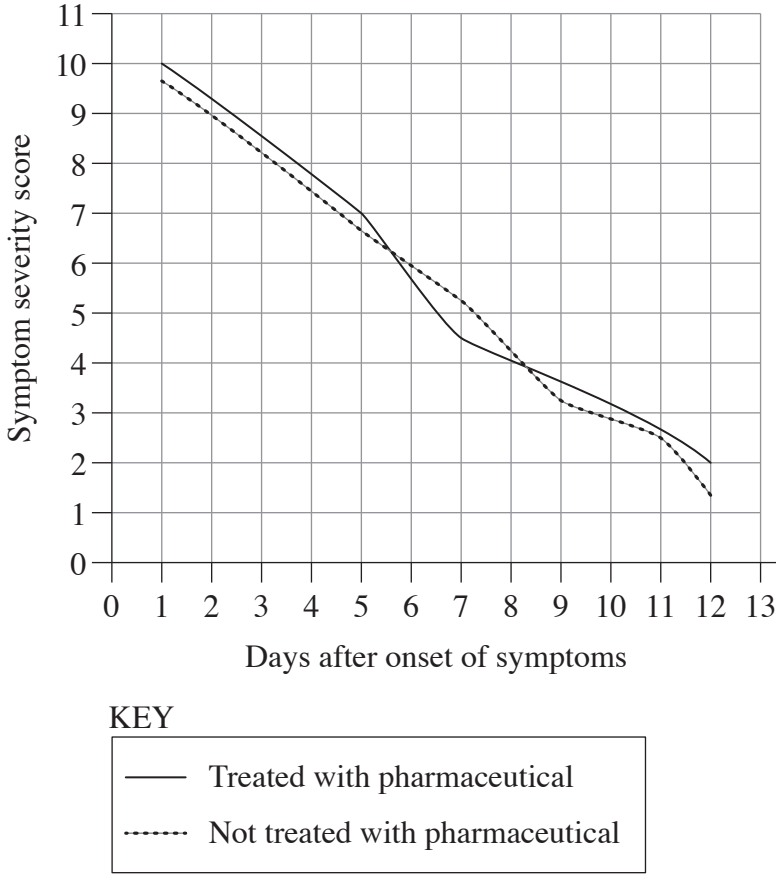
Pellagra is a disease which causes delusions or mental confusion, diarrhoea, weakness and loss of appetite caused by insufficient levels of iron and niacin.

Wildervanck Syndrome is a condition that affects the bones in the neck, the eyes and the ears, and occurs primarily in females.

Given the information above, which row in the table correctly identifies the classification of these diseases?

	Minamata Disease	*Pellagra*	*Wildervanck Syndrome*
A.	Genetic	Nutritional	Environmental
B.	Genetic	Environmental	Nutritional
C.	Environmental	Genetic	Nutritional
D.	Environmental	Nutritional	Genetic

15 A pharmaceutical was tested for its effectiveness in treating a viral infection. A symptom severity score of zero indicates no symptoms.



What conclusion can be drawn from the graph?

A. The pharmaceutical tested had no antiviral properties.

B. The pharmaceutical tested did not reduce the severity of symptoms.

C. The pharmaceutical tested increased symptoms in patients in the study.

D. Pharmaceuticals do not reduce symptoms in patients suffering from viral infections.

16 Mesothelioma is a non-infectious environmental disease caused by exposure to asbestos. The table shows the number of new cases, existing cases and deaths caused by Mesothelioma in Australia in 2020.

	New cases	*Existing cases – five year survival*	*Deaths*
Males	499	801	590
Females	143	239	206
Total	642	1040	796

In 2020 the Australian population was 26 million.

What is the incidence rate for Mesothelioma in 2020 as a percentage?

A. 0.000025%

B. 0.000040%

C. 0.0025%

D. 0.0040%

17 In humans, blood groups are produced by combinations of three alleles I^A, I^B and i.

Blood type	*Genotype(s)*
A	$I^A\ I^A$ or $I^A\ i$
B	$I^B\ I^B$ or $I^B\ i$
AB	$I^A\ I^B$
O	$i\ i$

A mother has blood type O and her child has blood type A.

Which of the following includes all possible genotype(s) of the father?

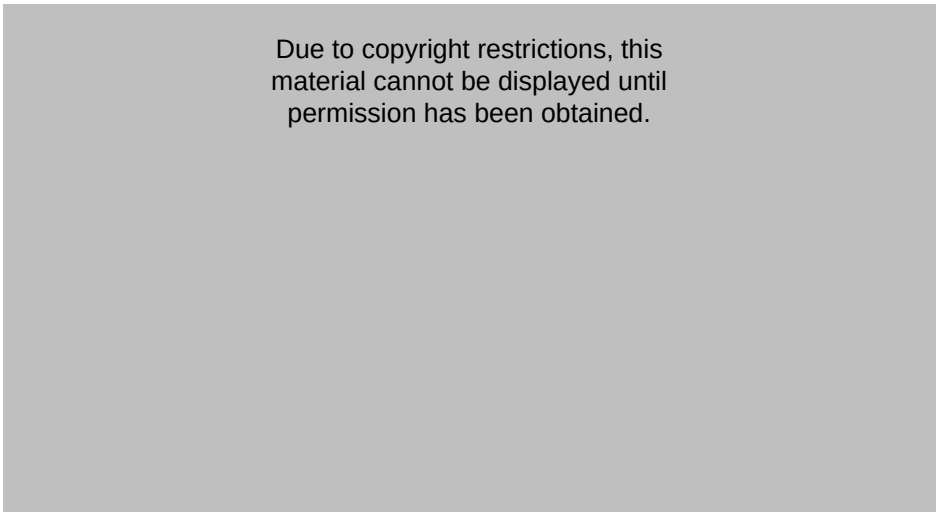
A. $I^A\ I^A$

B. $I^A\ I^A$ or $I^A\ i$

C. $I^A\ I^A$ or $I^A\ i$ or $I^A\ I^B$

D. $I^A\ I^A$ or $I^A\ i$ or $I^A\ I^B$ or $i\ i$

18 The graph shows the increase in the global yield of wheat from 1800–2020. Genetically modified organisms (GMOs) are not currently used to grow wheat commercially.



What row in the table correctly identifies biotechnologies that have contributed to the increase in wheat yields and could be adapted to enhance commercial production in the future?

	Past (until 1960)	*Present* (1960–2023)	*Future* (2023 onward)
A.	Selective breeding Embryo transfer	GMO production Gene sequencing	CRISPR Recombinant DNA technologies
B.	Selective breeding Embryo transfer	Selective breeding Gene sequencing	CRISPR Stem cell engineering
C.	Selective breeding Hybridisation	Artificial insemination Recombinant DNA technologies	CRISPR Stem cell engineering
D.	Selective breeding Hybridisation	Selective breeding Gene sequencing	CRISPR Recombinant DNA technologies

19 The following are the five steps in the process of gene cloning.

1. Selection of organisms containing recombinant DNA sequences
2. Creation of recombinant DNA joined using DNA ligase
3. Introduction of recombinant DNA into host organism
4. Extraction and amplification of DNA to be cloned
5. Choice of host organism and cloning vector

Which is the correct order for this process?

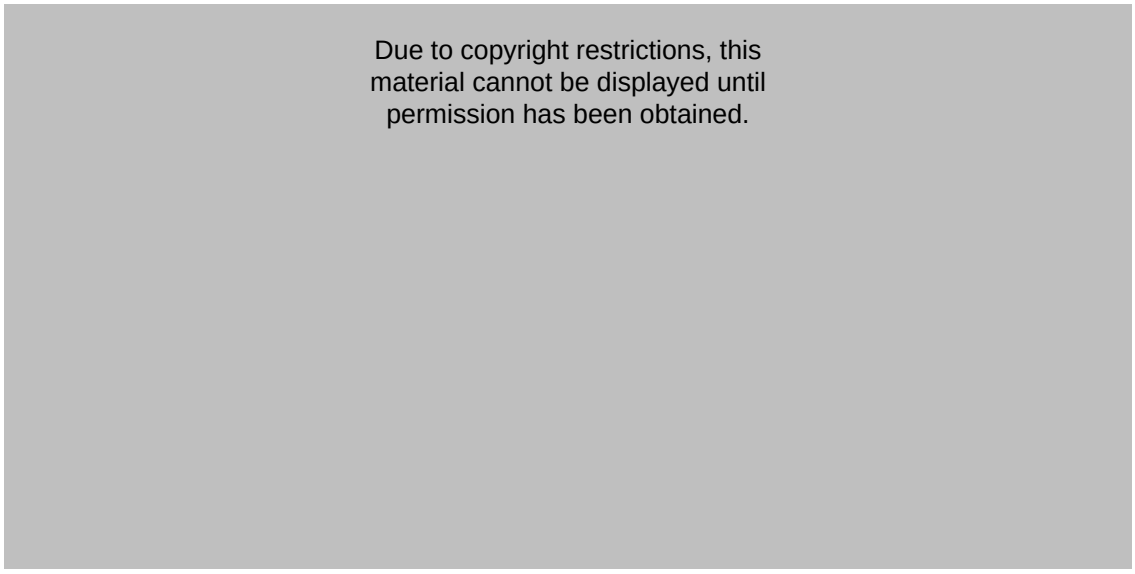
A. 5, 2, 1, 3, 4

B. 5, 4, 2, 3, 1

C. 3, 2, 4, 5, 1

D. 4, 5, 1, 2, 3

20 The diagram shows the karyotype of a normal female Tasmanian devil cell and the karyotype of a Tasmanian devil facial tumour cell.



M1, M2, M3 and M4 are marker chromosomes. These are chromosomes of unknown origin additional to the normal chromosomes found in the cells of Tasmanian devil facial tumour disease.

What can be deduced from the karyotypes?

A. The karyotype of the tumour cells shows trisomy.

B. The karyotype of tumour cells contains multiple chromosomal inversions.

C. The karyotype of tumour cells contains both chromosomal insertions and deletions.

D. The karyotype of the tumour cells contains more chromosomes than the karyotype of the normal Tasmanian devil cells.

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2023 HIGHER SCHOOL CERTIFICATE EXAMINATION

Centre Number

Student Number

Biology

Section II Answer Booklet

80 marks
Attempt Questions 21–35
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 (3 marks)

(a) Identify the components of a nucleotide. **1**

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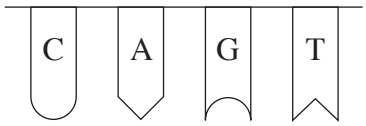
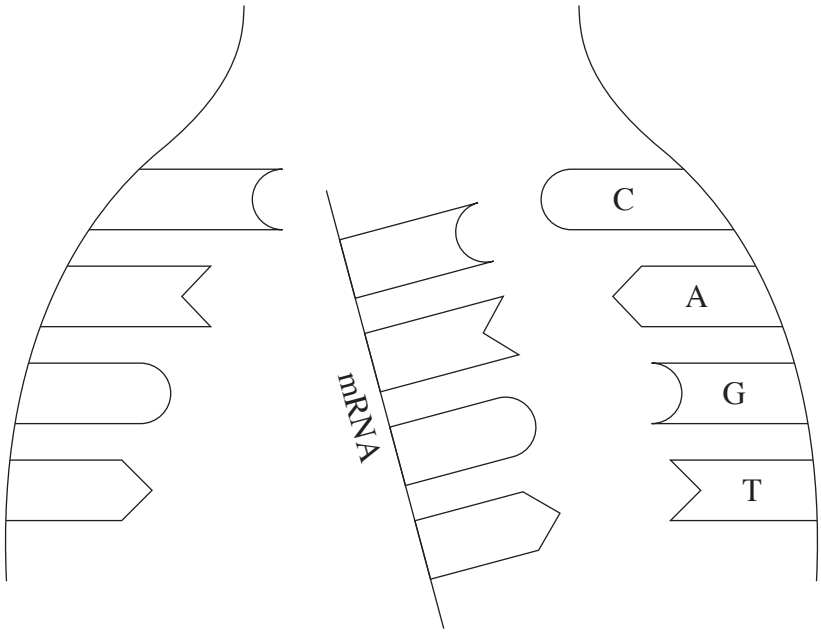
(b) A section of a leading strand of DNA has a sequence of CAGT. **2**



Complete the diagram by labelling the complementary mRNA strand which is formed during the transcription of DNA.



Question 22 (6 marks)

(a) Describe how phagocytes help protect against pathogens. **2**

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(b) Explain how antibodies are produced in response to the entry of a pathogen. **4**

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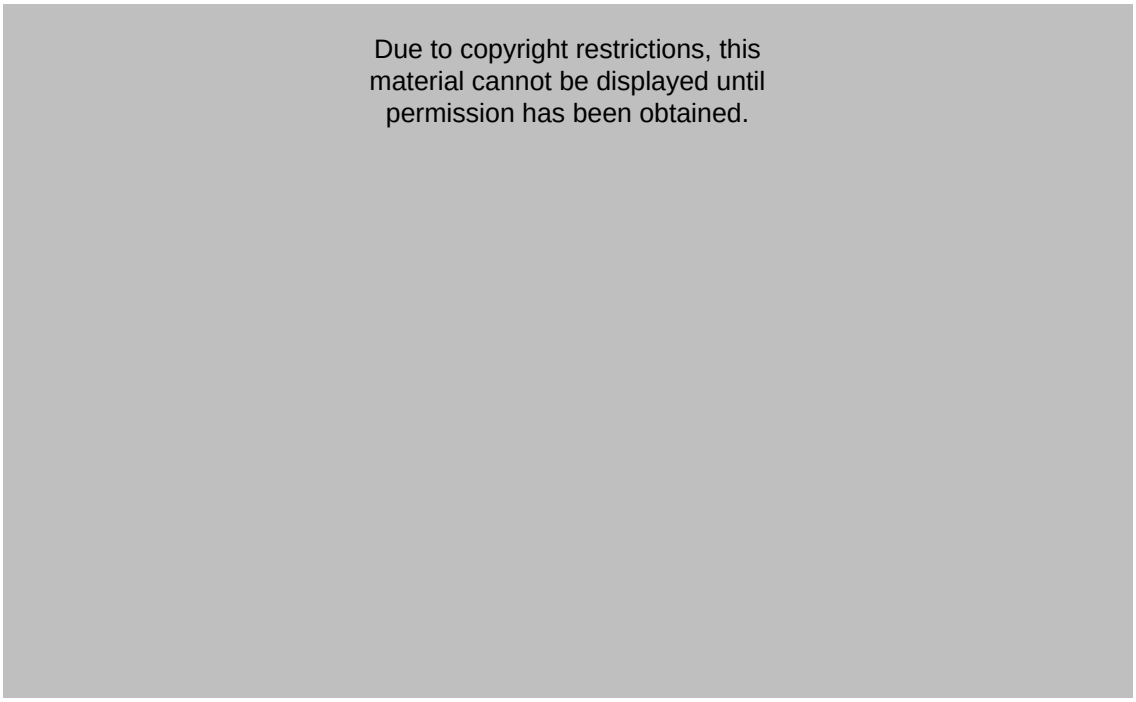
Question 23 (4 marks)

The following graph outlines some hormonal changes during pregnancy. **4**



Complete the table for TWO of the hormones graphed.

Hormone name	*Function in pregnancy*	*Trimester where peak occurs*

Question 24 (6 marks)

(a) Explain how problems with the structure and function of the eye can cause a named visual disorder. **3**

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(b) Describe ONE technology that is used to assist with the effects of a named visual disorder. **3**

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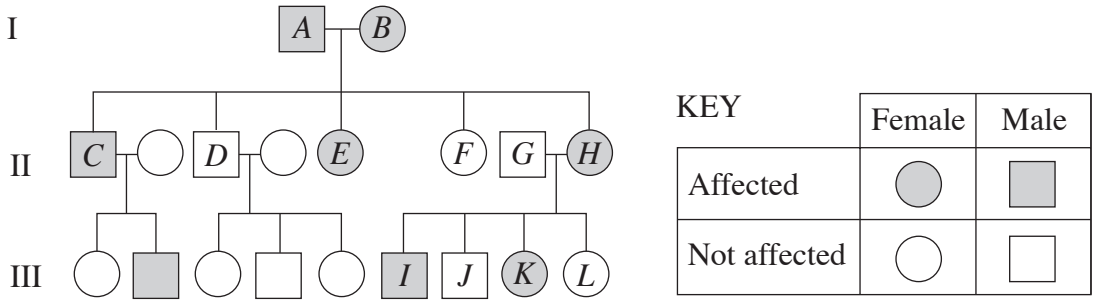
Question 25 (9 marks)

Huntington's disease is an autosomal dominant genetic disease.



Source: WikiLectures https://www.wikilectures.eu/w/Huntington%27s_Disease

(a) Using the pedigree, justify the genotype of individual '*H*'. In your answer, refer to the letters on the pedigree to identify individuals. **3**

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Question 25 continues on page 23

Question 25 (continued)

(b) Huntington's disease is caused by a misfolded protein 'Huntingtin'. It is caused by excess repeats of the DNA sequence CAG on the coding strand of DNA. The mRNA that is produced has the same sequence as the DNA. **1**

Use the codon chart, starting in the centre, to identify the amino acid that is repeated.

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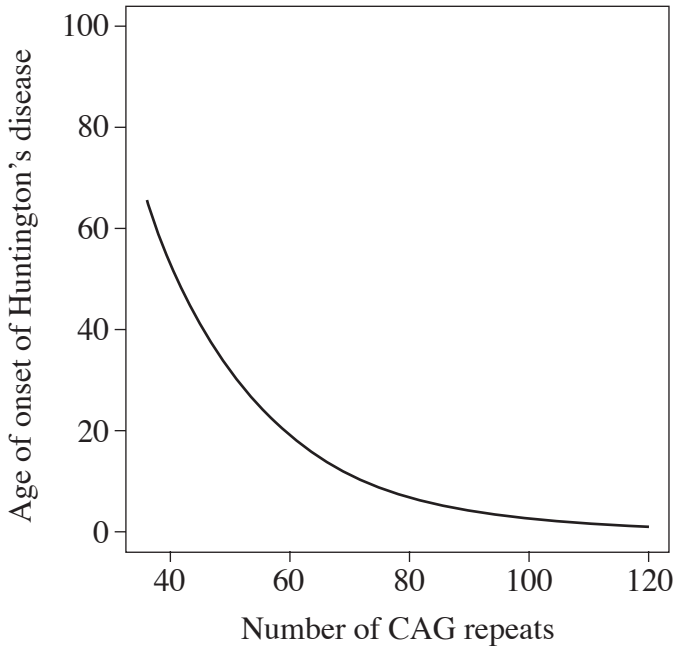
Question 25 continues on page 24

Question 25 (continued)

(c) The normal Huntingtin protein has 10–26 repeats of CAG. In Huntington's disease there are 37–80 repeats. This leads to an alteration in the structure of the protein. The graph shows the relationship between the age of onset of Huntington's disease and the number of CAG repeats. **2**



Adapted from Fig1. Relationship between age at neurologic onset and number of HD CAG repeat units. Gusella, J.F., Persichetti, F. & MacDonald, M.E. The Genetic Defect Causing Huntington's Disease: Repeated in Other Contexts?. Mol Med 3, 238–246 (1997). https://doi.org/10.1007/BF03401677

Explain the relationship between the number of CAG repeats and the age of onset of Huntington's disease.

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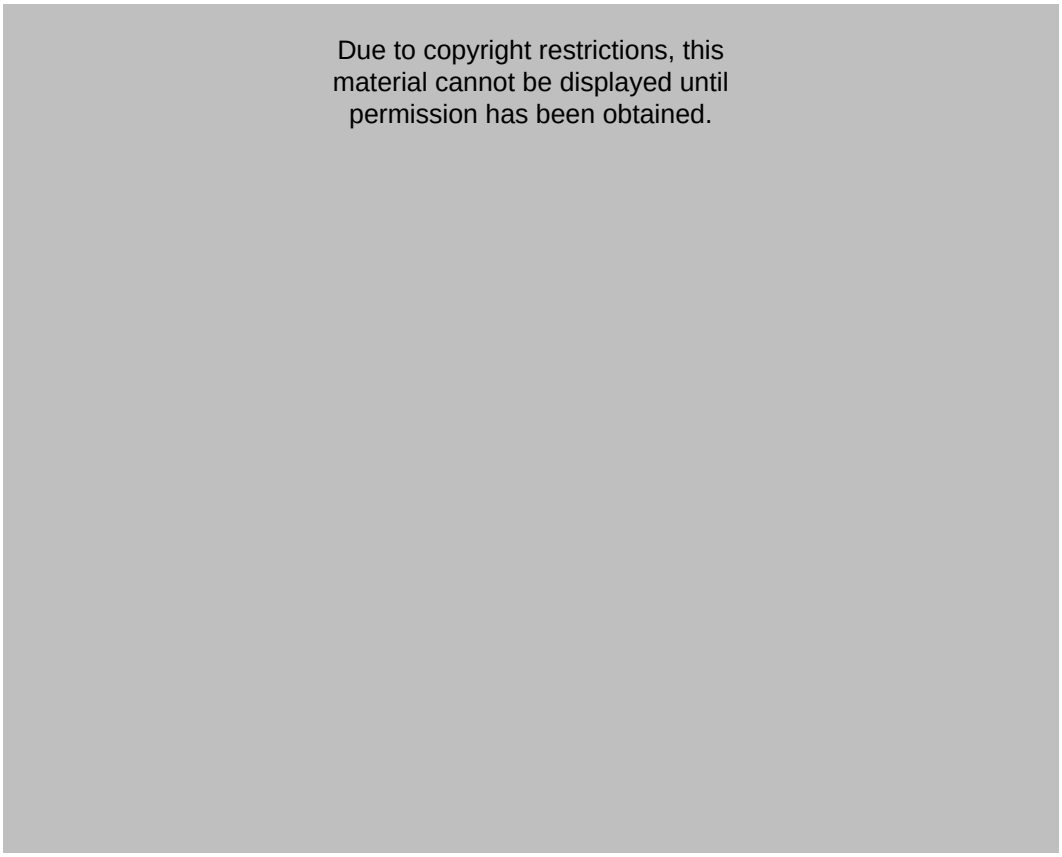
Question 25 continues on page 25

Question 25 (continued)

(d) Diagram 1 shows a pedigree of a family known to be affected by Huntington's disease. Diagram 2 shows the results of gel electrophoresis on fragments of DNA from chromosome four, known to be altered in Huntington's disease. **3**



Predict whether individuals *S* and *U* will be affected by Huntington's disease, and if so, at what age. Use data from the diagrams to justify your answer.

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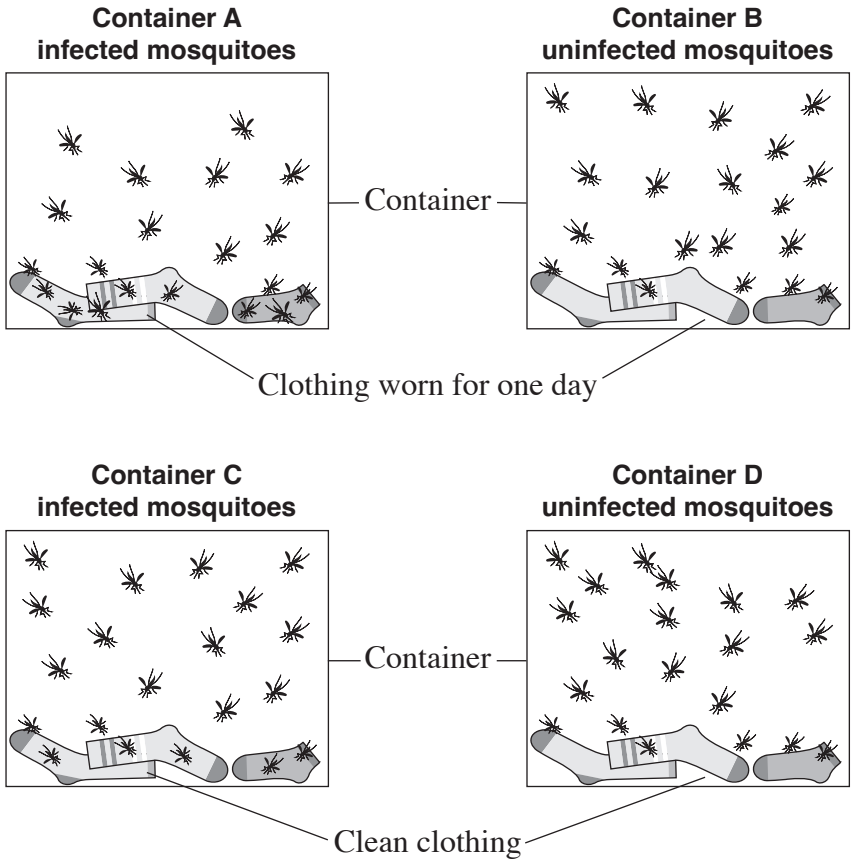
End of Question 25

Question 26 (5 marks)

Malaria is a potentially fatal infectious disease that is spread to humans by infected mosquitoes. Scientists investigated the behaviour of 20 mosquitoes for an hour in each of the four containers shown.

Aim: To determine if wearing clean clothing reduces the transmission of malaria.



Assume infected mosquitoes that land on clothing transmit malaria.

(a) Identify the dependent variable and a controlled variable in this investigation. **2**

Dependent variable .....

Controlled variable .....

Question 26 continues on page 27

(b) The results of the investigation showing the number of times mosquitoes landed on the clothing in an hour are provided. **3**

Experiment	*Container A*	*Container B*	*Container C*	*Container D*
1	15	7	12	5
2	19	5	9	3
3	12	4	14	6
4	18	6	13	4
5	19	6	10	3

Justify a suitable conclusion for this investigation.

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End of Question 26

Question 27 (7 marks)

Air pollution has been linked to a variety of non-infectious neurological (brain) disorders. Some of the symptoms include memory loss, cognitive decline and impaired movement and coordination. **7**

500 people from each of three major cities were surveyed and were monitored and tested for a period of 12 months. Each group included males and females aged between 20 and 50 years of age.

The results after 12 months were as follows:

CITY	% OF SAMPLE WITH SYMPTOMS	
	Males	*Females*
1	7	3
2	9	9
3	11	4

Evaluate the method used in this epidemiological study in determining a link between air pollution and the symptoms.

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Question 27 continues on page 29

Question 27 (continued)

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End of Question 27

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Question 28 (4 marks)

(a) Describe a feature that distinguishes a viral from a bacterial pathogen. **2**

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(b) A waterborne disease outbreak occurred after a flood. **2**

Outline an experimental procedure that could be used to determine if the pathogen is viral or bacterial.

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Question 29 (6 marks)

Organisms use various mechanisms to maintain their internal environment within tolerance limits.

(a) Outline a physiological adaptation in endotherms which assists in maintaining their internal environment. **2**

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(b) Explain TWO adaptations in plants that help to maintain water balance. **4**

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Question 30 (5 marks)

Tetanus vaccines were introduced in 1953 resulting in reduced case numbers. The majority of recorded cases occurred in people aged 65 and over. **5**

The graph shows the vaccination schedule for tetanus.

Due to copyright restrictions, this material cannot be displayed until permission has been obtained.

Assess the use of vaccinations and the vaccination schedule. Use the data provided to support your answer.

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Question 31 (4 marks)

Describe a named genetic technology and its use in a medical application. **4**

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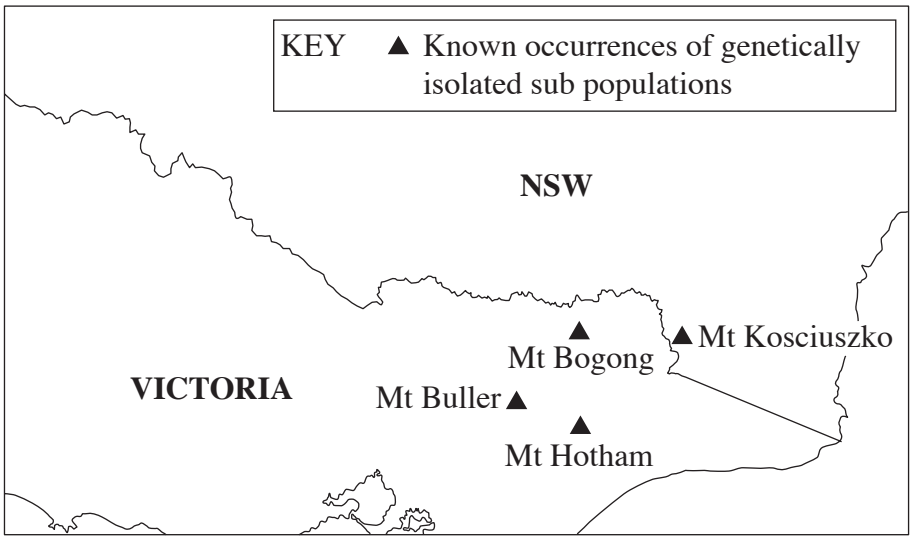
Question 32 (7 marks)

The mountain pygmy possum (*Burramys parvus*) is restricted to four regions in Australia's alpine zone. The species is listed as critically endangered with less than 2000 adults remaining. The range of the mountain pygmy possum has contracted due to a gradually warming climate. **7**

National distribution of the mountain pygmy possum



Department of Environment, Land, Water and Planning. 2016. National Recovery Plan for the Mountain Pygmy-possum Burramys parvus. Australian Government, Canberra © State of Victoria (Department of Energy, Environment and Climate Action)

Loss and degradation of these habitats have affected local populations. The graph shows changes in the Mt Buller population following recent bushfires and the introduction of male pygmy possums from Mt Bogong.

Due to copyright restrictions, this material cannot be displayed until permission has been obtained.

Question 32 continues on page 35

Question 32 (continued)

Evaluate how bushfires and the introduction of males from other locations have affected the population size and gene pool of the Mt Buller pygmy possum population.

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End of Question 32

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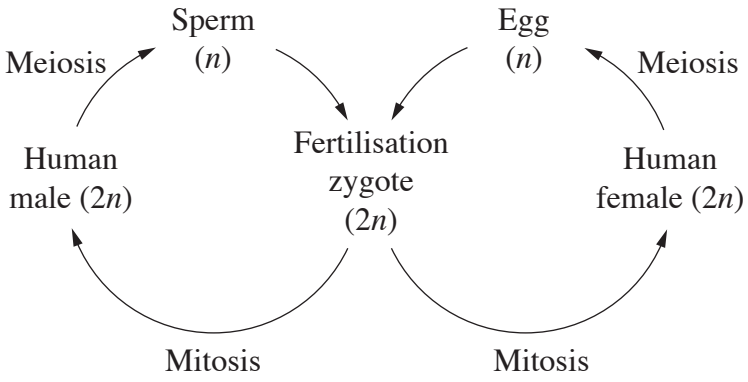
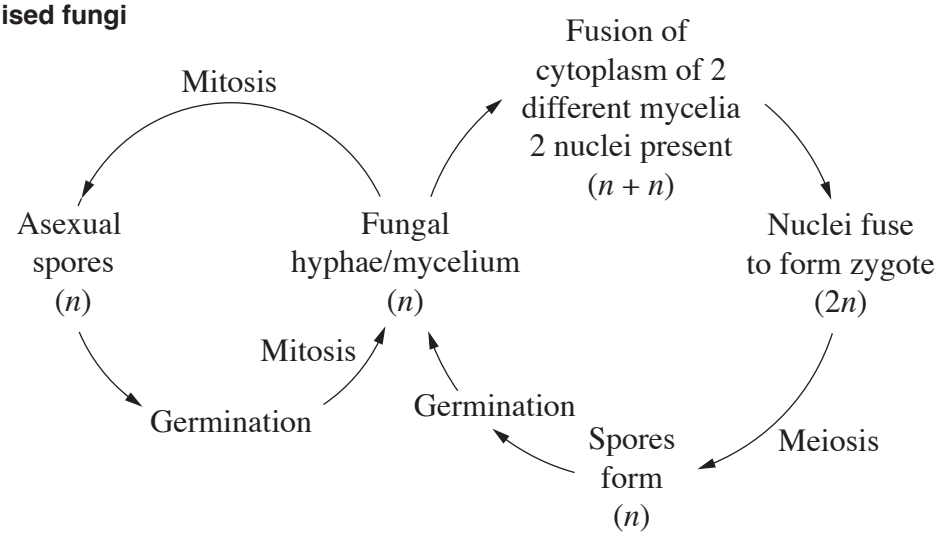
Question 33 (4 marks)

Mechanisms of reproduction for both humans and generalised fungi are shown in the diagrams. **4**

Human



Generalised fungi



Describe the similarities and differences of reproduction in humans and generalised fungi.

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Question 34 (5 marks)

Cattle have been domesticated by humans for approximately 10 000 years. Many biotechnologies have been employed in the farming of cattle. **5**

The table shows examples of the application of these biotechnologies.

Biotechnology	*Example*
Selective breeding	The offspring of highest milk producing female cows were retained and over time cows that produced more milk were bred, leading to dairy breeds.
Artificial insemination	An American bull holds the current record for artificial insemination. He produced 2.4 million units of semen and has sired cattle in 50 countries.
Whole organism cloning	The success rate of cloning cattle is low. There are currently 30–40 cloned cattle in Australia. They are not used commercially.
Hybridisation	There are two species of domestic cattle, *Bos taurus* and *Bos indicus*. They can be hybridised to breed cattle with characteristics of both species.
Transgenic organisms	The first transgenic cow produced human serum albumin in its milk. The use of transgenic cattle is not widespread.

With reference to the table, evaluate the effect of biotechnologies on the biodiversity of cattle.

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Question 34 continues on page 39

Question 34 (continued)

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End of Question 34

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Question 35 (5 marks)

5-Bromouracil (bU) is a synthetic chemical mutagen. It bonds with adenine in place of thymine in DNA. During replication, it then binds with guanine.

This will then make a guanine–cytosine pair on one strand of DNA instead of an adenine–thymine pair.

(a) Identify the type of mutation that is caused by bU. **1**

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(b) Describe the possible effects on a protein if this mutation occurred within a gene. **4**

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