



NSW Education Standards Authority

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Centre Number

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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.

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

What does the cochlear implant electrode array stimulate?

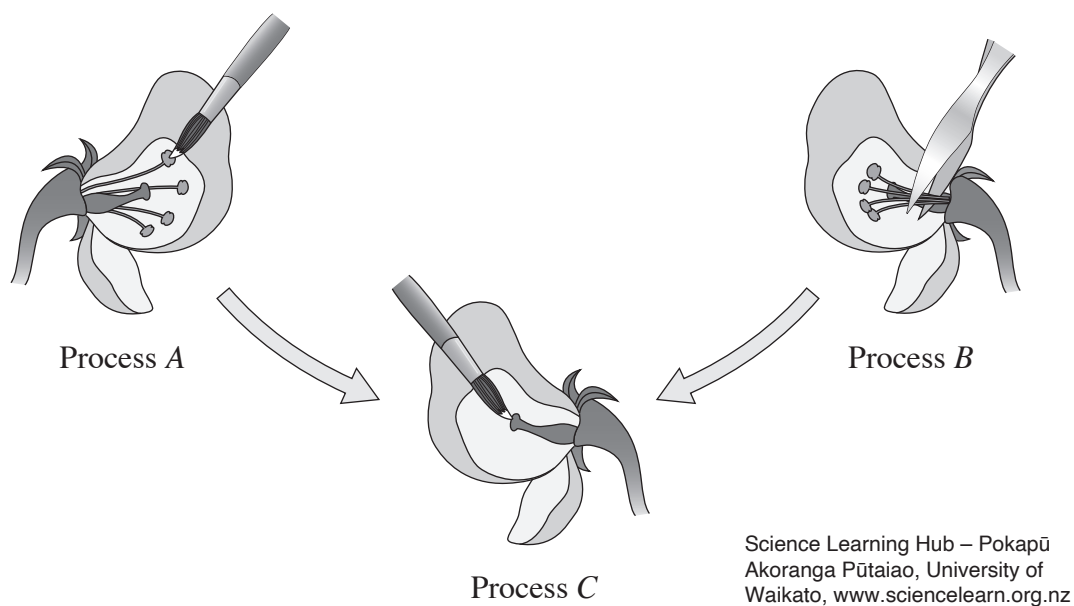
- A. Hairs
 - B. Ossicles
 - C. Oval window
 - D. Auditory nerve
- 2** Which of the following is an advantage of internal fertilisation?
- A. Decreases the risk of gamete dehydration
 - B. Increases the number of gametes released
 - C. Increases the number of zygotes at one time
 - D. Decreases the care 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.



The purpose of Process B is to

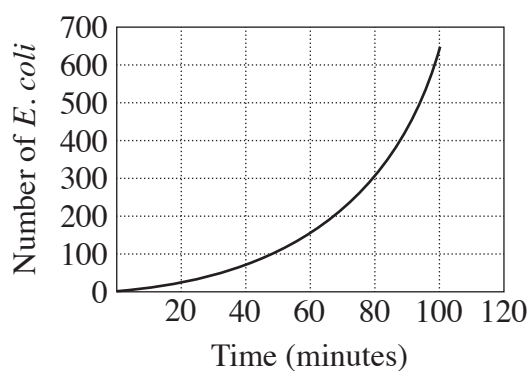
- A. produce seeds.
B. collect the pollen.
C. fertilise the flower.
D. prevent self-pollination.

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

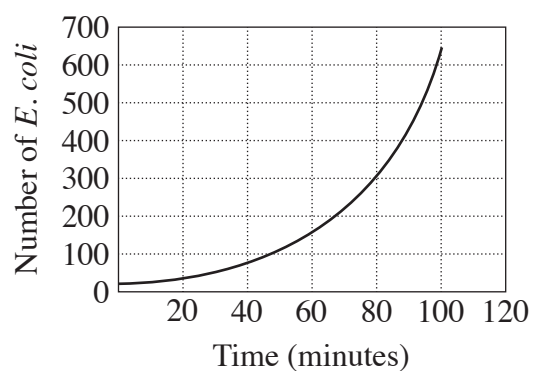
<i>Time (minutes)</i>	<i>Number of E. coli</i>
0	20
20	40
40	80
60	160
80	320
100	640

Which graph represents the data in the table?

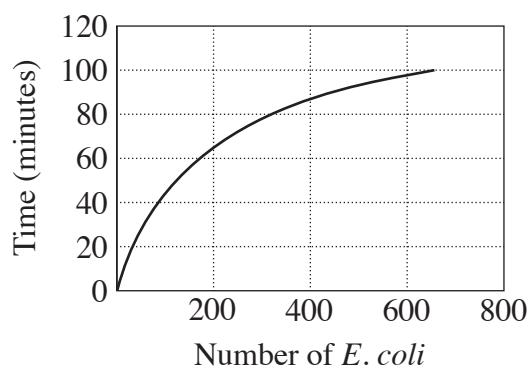
A.



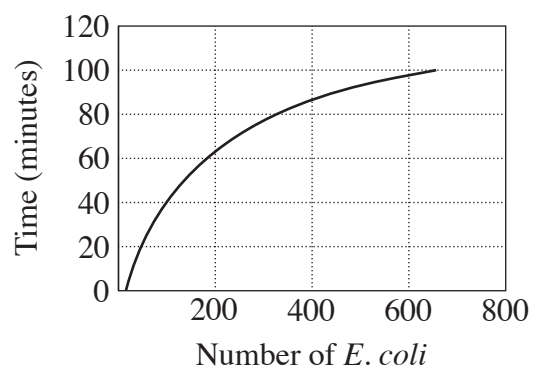
B.



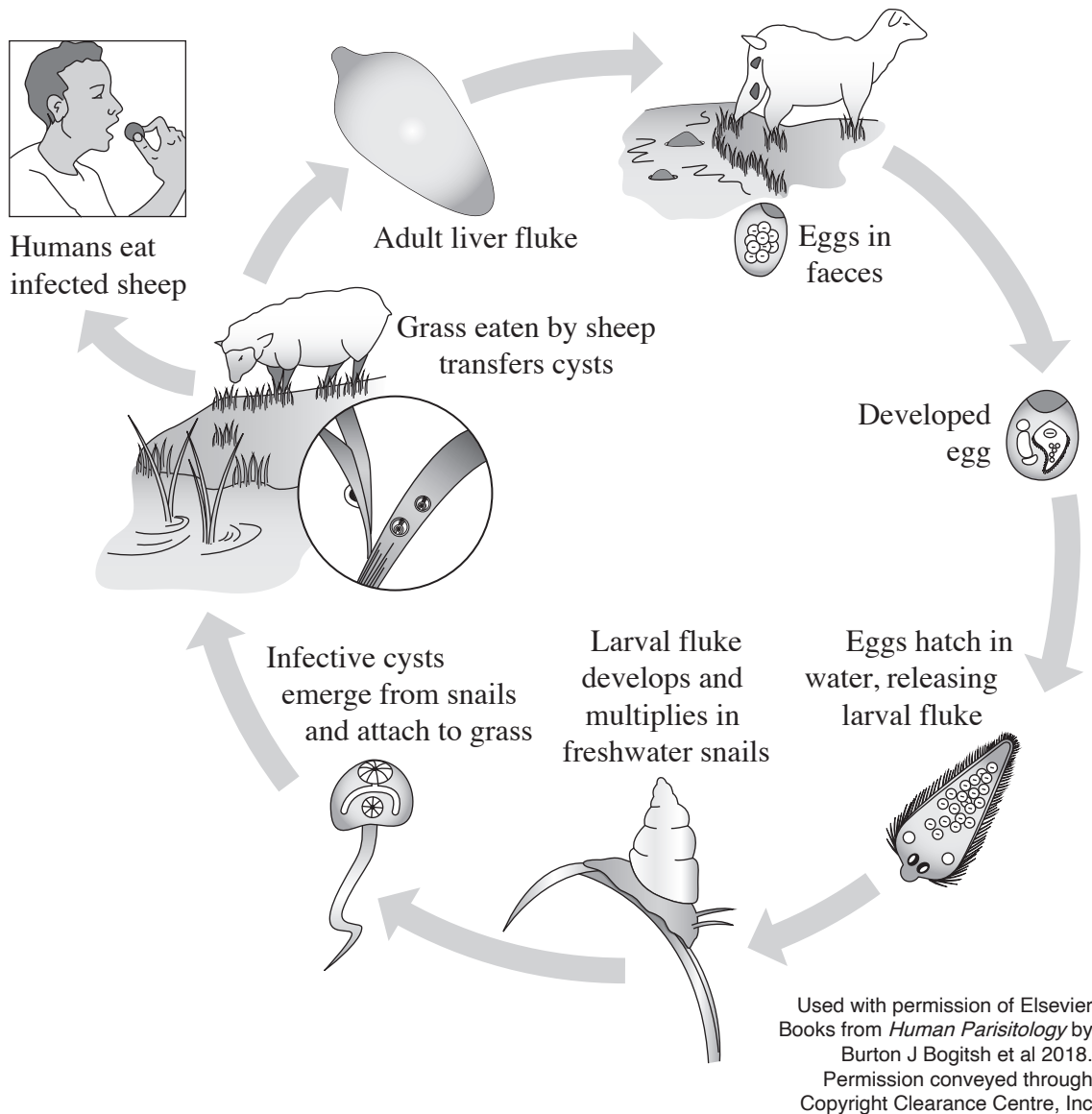
C.



D.



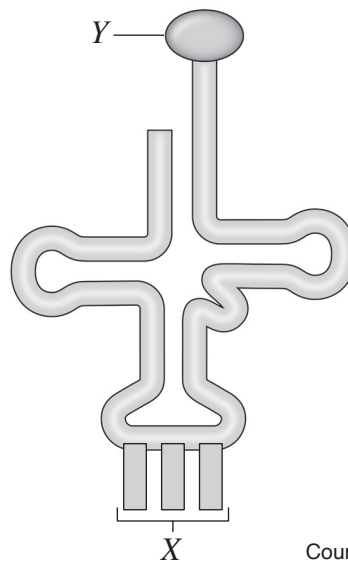
- 6 Liver fluke is a disease caused by parasites that infect grazing animals, including sheep. The life cycle of the liver fluke is shown.



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.

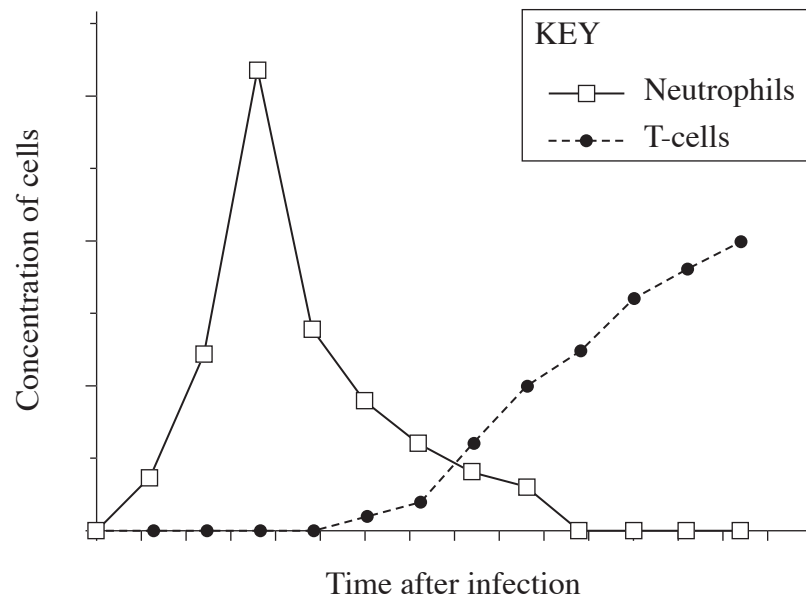


Courtesy of Medic Mind Ltd

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

	<i>X</i>	<i>Y</i>
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?

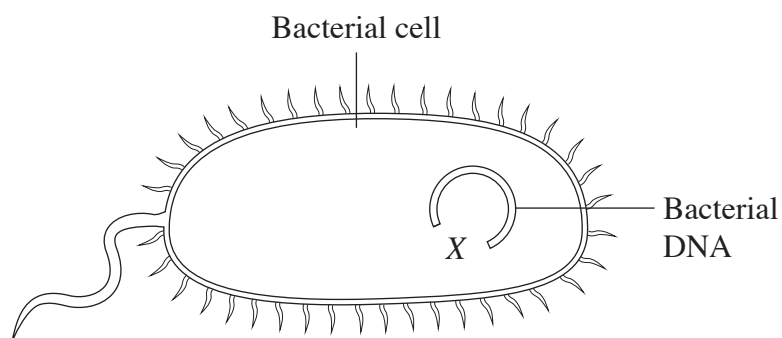
- A. Acquired
 - B. Adaptive
 - C. Innate
 - D. Primary
- 9 Sheep have 54 chromosomes, while goats have 60 chromosomes. The hybrid offspring of a sheep-goat pairing is called a geep.

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?

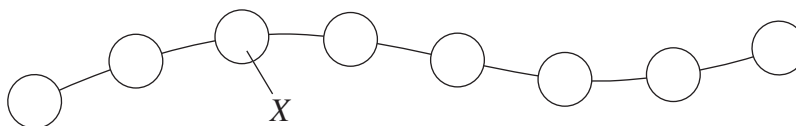
- A. $n = 29$ chromosomes
- B. $n = 52$ chromosomes
- C. $2n = 57$ chromosomes
- D. $2n = 114$ chromosomes

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



Which component would be inserted into gap X?

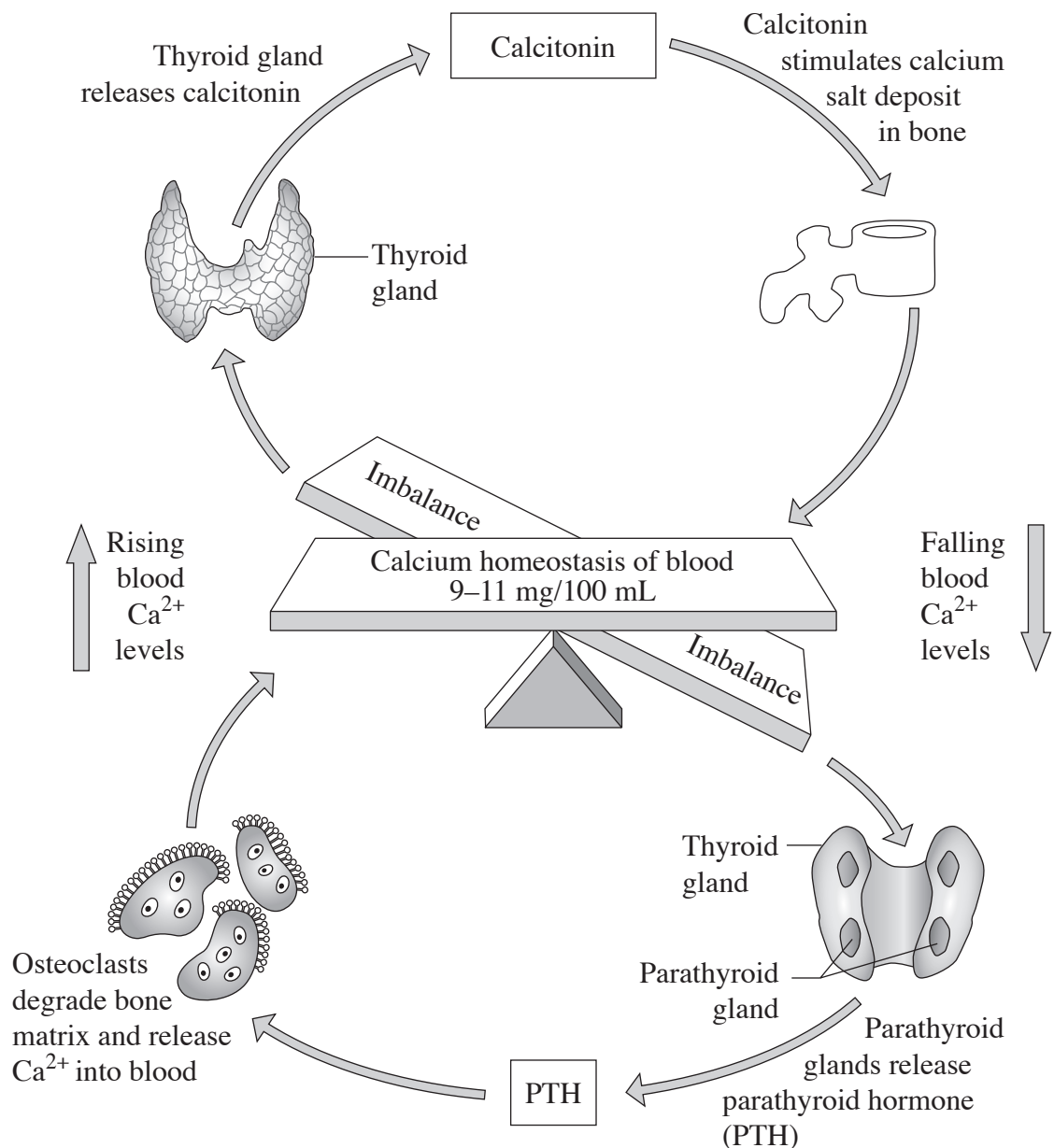
- A. A cell
 - B. A gene
 - C. An amino acid
 - D. A chromosome
- 11 The diagram shows part of a protein molecule.



Which row of the table is correct?

	<i>X</i>	<i>Level of protein structure</i>
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.



Marieb, Elaine N.; Keller, Suzanne M.; *Essentials of Human Anatomy & Physiology*; 13 edition; ©2022. Reprinted by permission of Pearson Education, Inc

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.

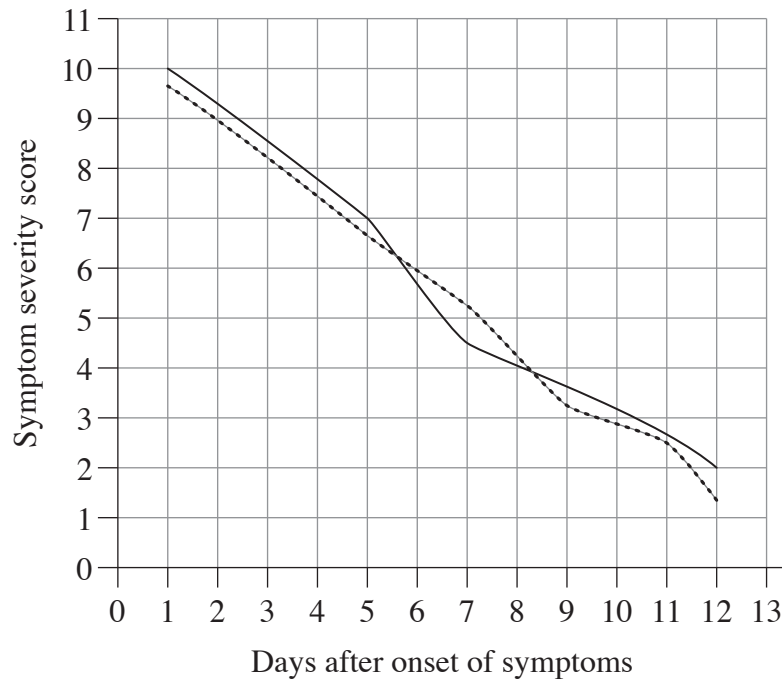
Pellagra is a disease which causes delusions or mental confusion, diarrhoea, weakness and loss of appetite caused by insufficient levels of iron and niacin.

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?

	<i>Minamata Disease</i>	<i>Pellagra</i>	<i>Wildervanck Syndrome</i>
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.



KEY

- Treated with pharmaceutical
..... Not treated with pharmaceutical

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.

	<i>New cases</i>	<i>Existing cases – five year survival</i>	<i>Deaths</i>
Males	499	801	590
Females	143	239	206
<i>Total</i>	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 .

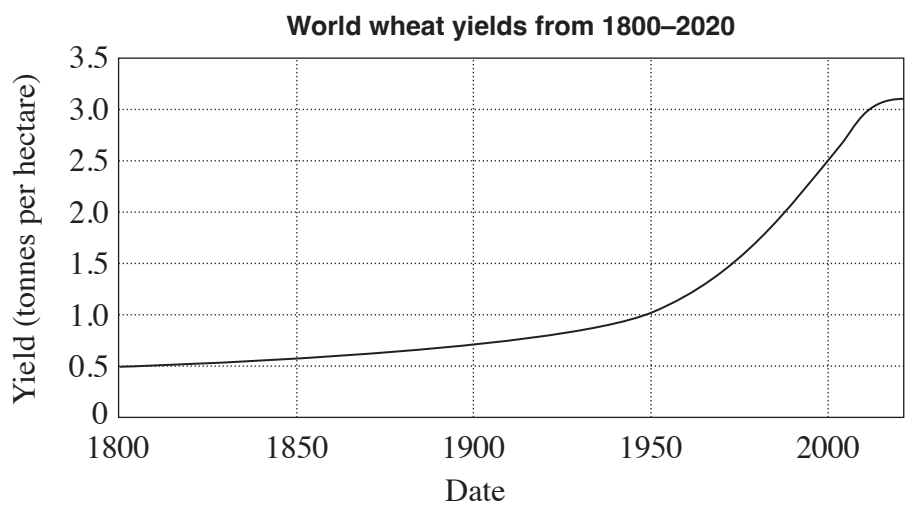
<i>Blood type</i>	<i>Genotype(s)</i>
A	$I^A I^A$ or $I^A i$
B	$I^B I^B$ or $I^B i$
AB	$I^A I^B$
O	$i i$

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?

	<i>Past</i> (until 1960)	<i>Present</i> (1960–2023)	<i>Future</i> (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

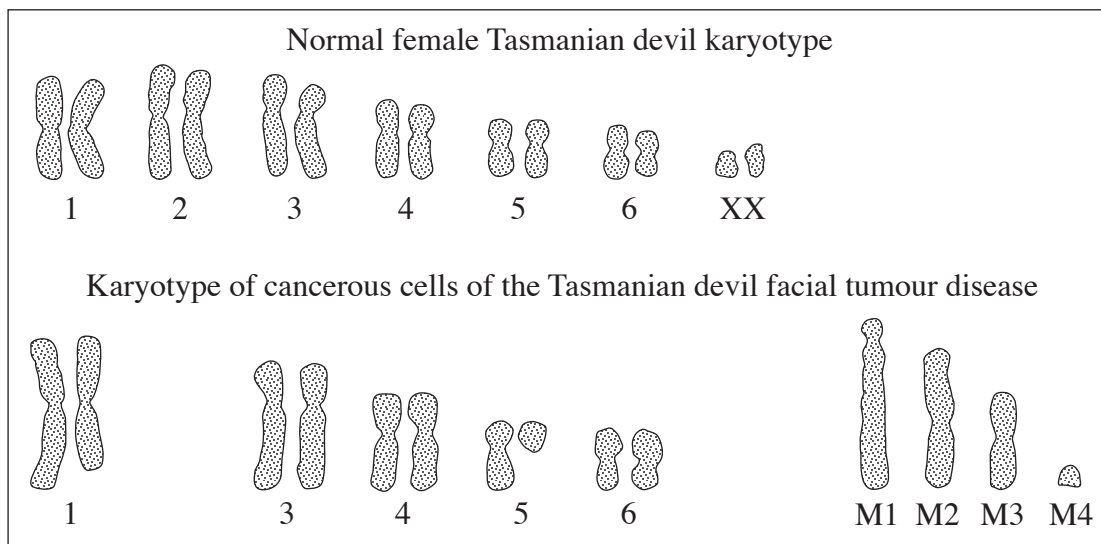
19 The following are the five steps in the process of gene cloning.

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.



Pearse.AM, Swift K, *Transmission of devil facial-tumour disease*. Nature 439, 549 (2006)

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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Centre Number

Biology

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Student Number

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)

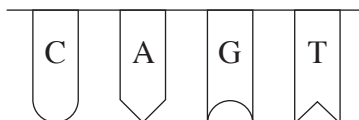
- (a) Identify the components of a nucleotide.

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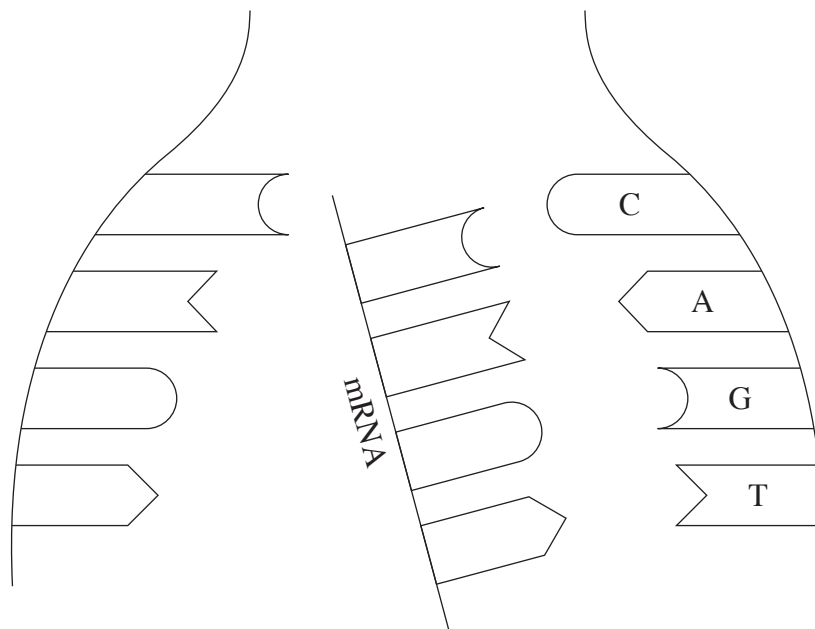
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- (b) A section of a leading strand of DNA has a sequence of CAGT.

2



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



Do NOT write in this area.

Question 22 (6 marks)

- (a) Describe how phagocytes help protect against pathogens.

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

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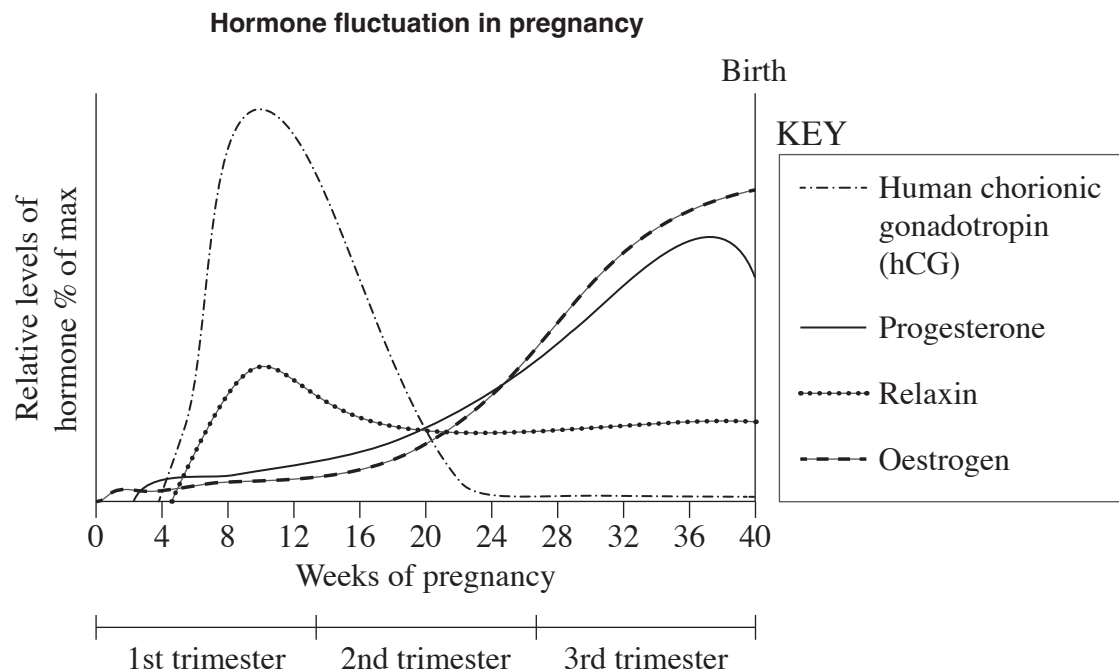
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Question 23 (4 marks)

The following graph outlines some hormonal changes during pregnancy.

4



© Learneo, Inc. <https://www.coursehero.com/sg/anatomy-and-physiology/pregnancy/>

Complete the table for TWO of the hormones graphed.

<i>Hormone name</i>	<i>Function in pregnancy</i>	<i>Trimester where peak occurs</i>

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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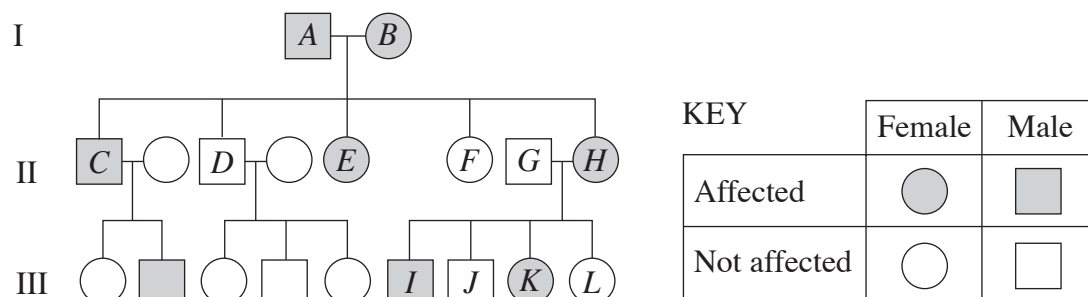
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Question 25 (9 marks)

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.

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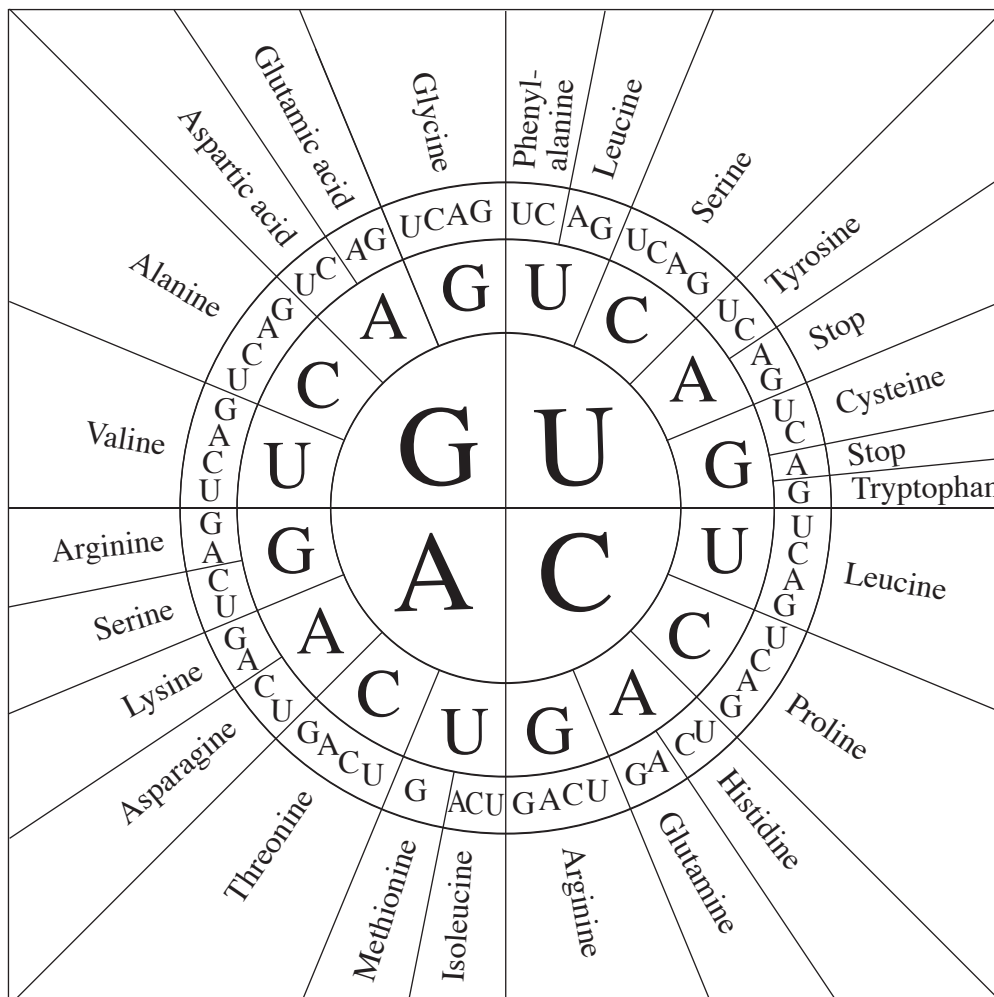
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Question 25 continues on page 23

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



Please use the following link:
<https://history-computer.com/simple-codon-chart-is-easy-to-use/>

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

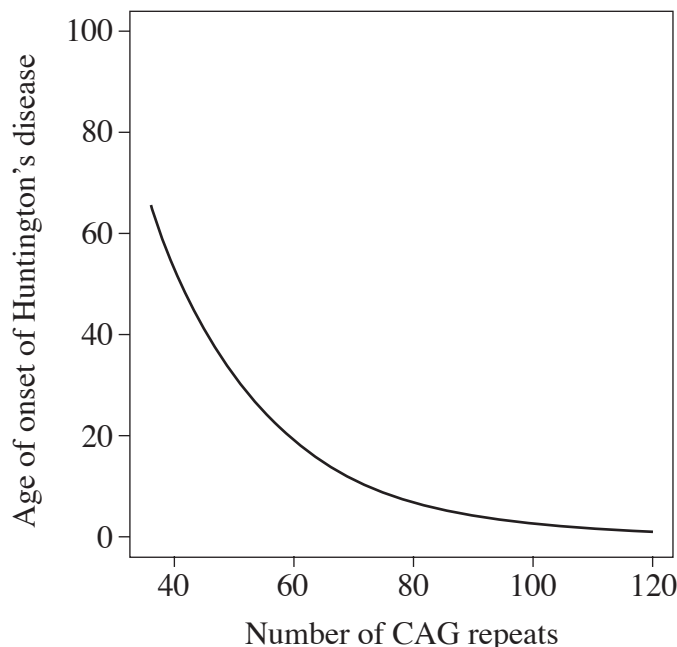
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Question 25 continues on page 24

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

Diagram 1

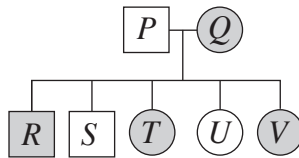
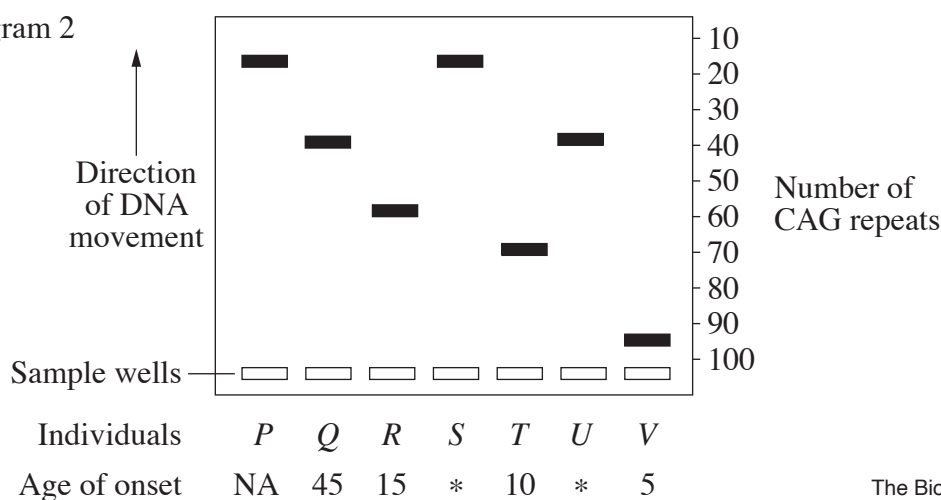


Diagram 2



KEY * – currently unaffected NA – not affected

The Biology Project developed by the University of Arizona – link to: www.biology.arizona.edu/molecular_bio/problem_sets/recombinant_dna_technology/07t.html

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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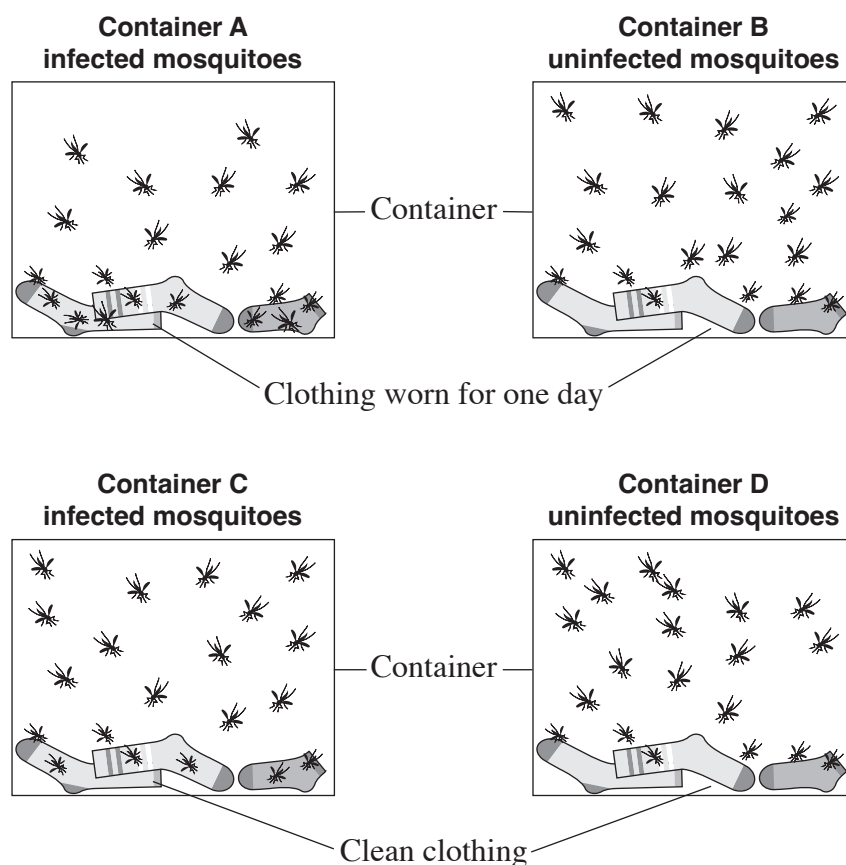
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End of Question 25

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

Question 26 (continued)

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

3

<i>Experiment</i>	<i>Container A</i>	<i>Container B</i>	<i>Container C</i>	<i>Container D</i>
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)

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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.

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	
	<i>Males</i>	<i>Females</i>
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.

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

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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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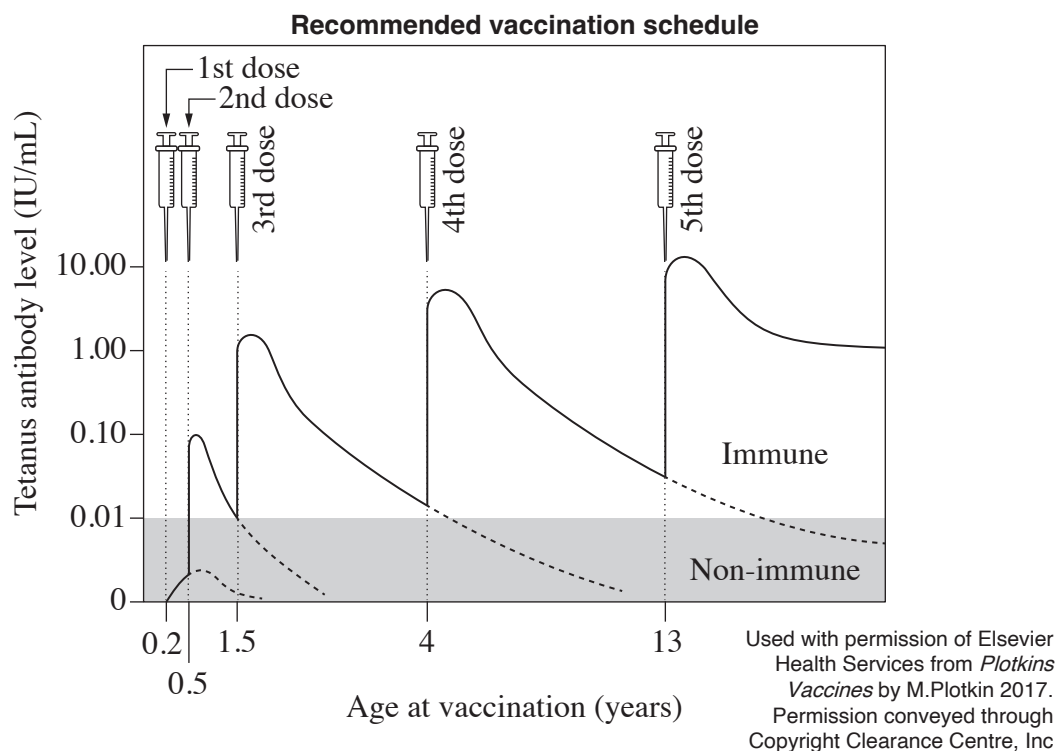
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The graph shows the vaccination schedule for tetanus.



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.

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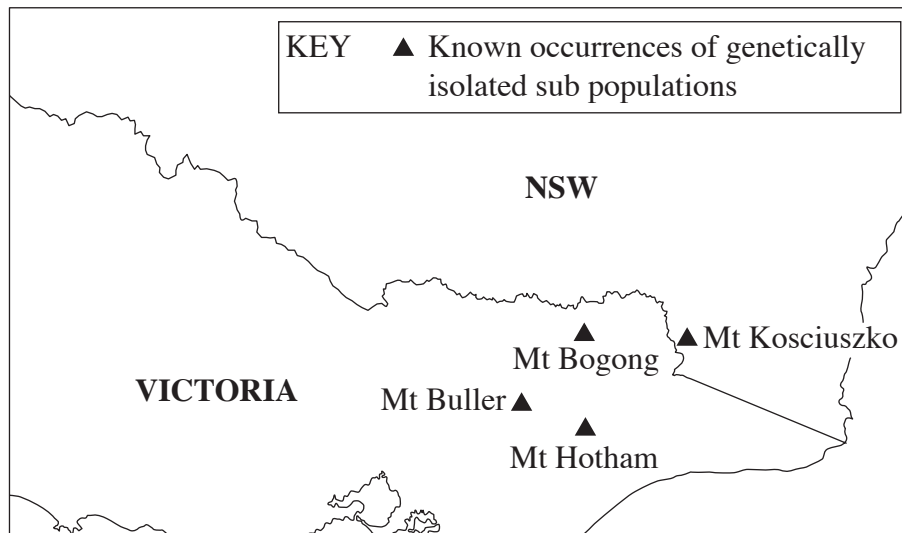
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Question 32 (7 marks)

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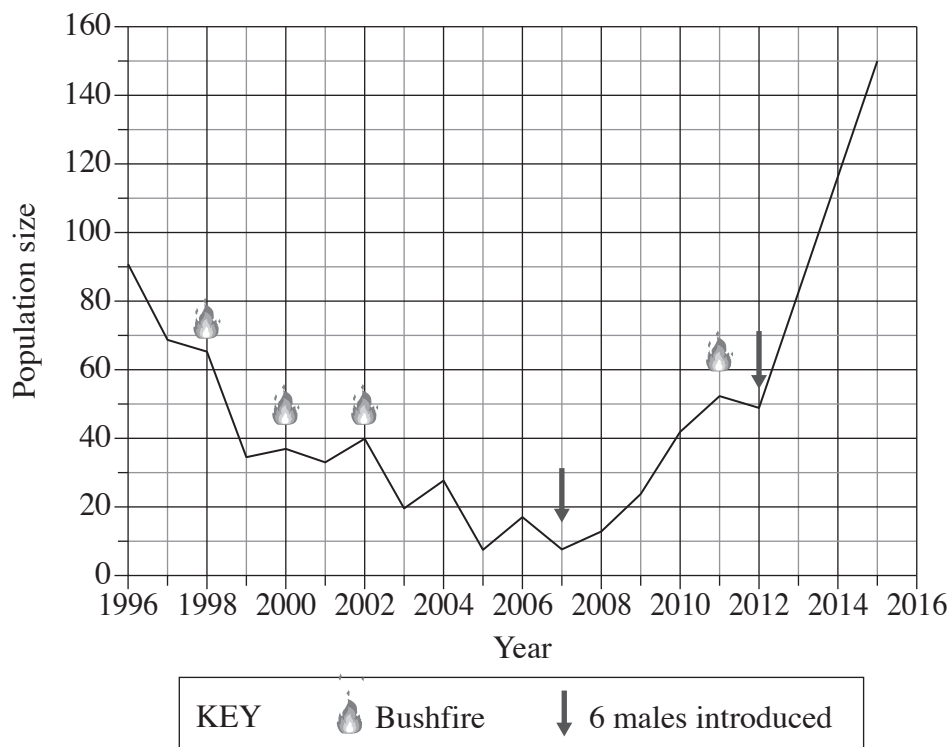
The mountain pygmy possum (*Burramys parvus*) is restricted to four regions in Australia's alpine zone. The species is listed as critically endangered with less than 2000 adults remaining. The range of the mountain pygmy possum has contracted due to a gradually warming climate.

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.



Weeks, A.R., Heinze, D., Perrin, L. et al. Genetic rescue increases fitness and aids rapid recovery of an endangered marsupial population. *Nature Communication* 8, 1071 (2017). <https://www.nature.com/articles/s41467-017-01182-3/figures/1>

Question 32 continues on page 35

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– 35 –

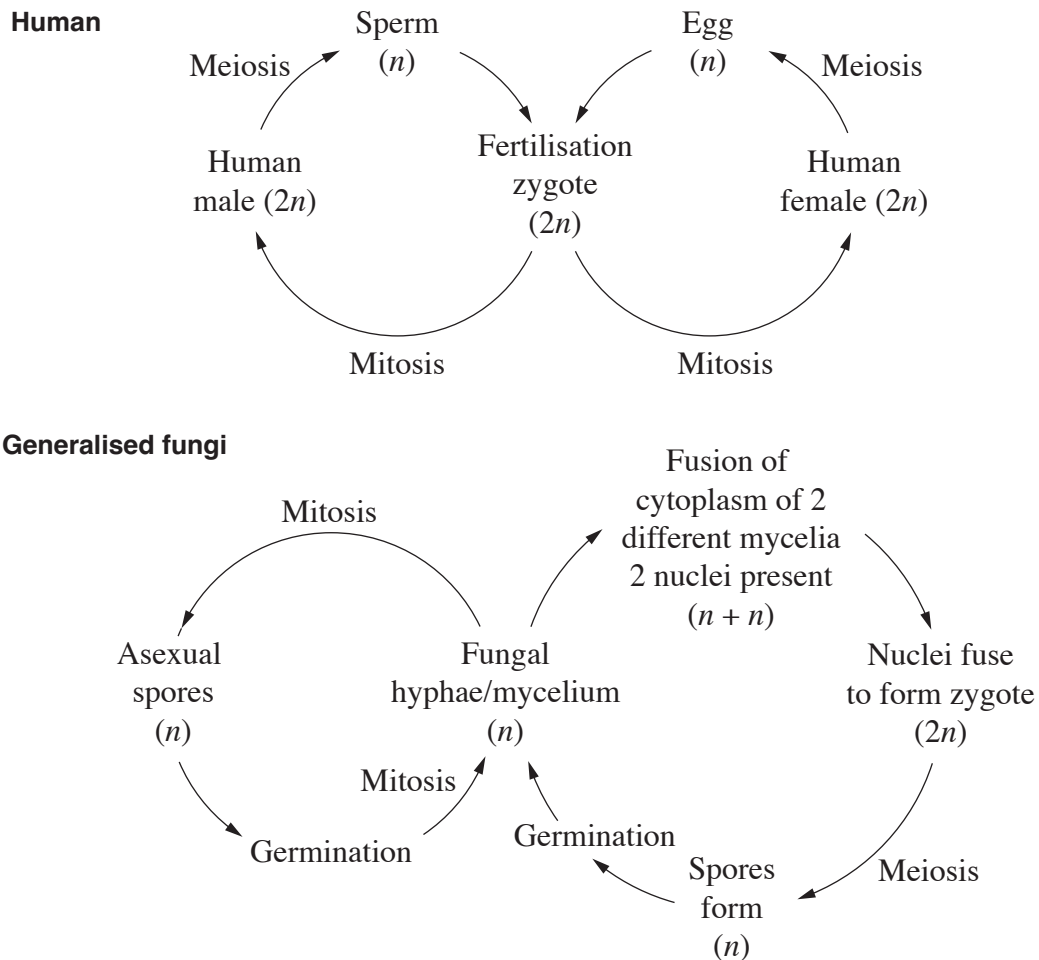
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Question 33 (4 marks)

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

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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.

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The table shows examples of the application of these biotechnologies.

<i>Biotechnology</i>	<i>Example</i>
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, <i>Bos taurus</i> and <i>Bos indicus</i> . 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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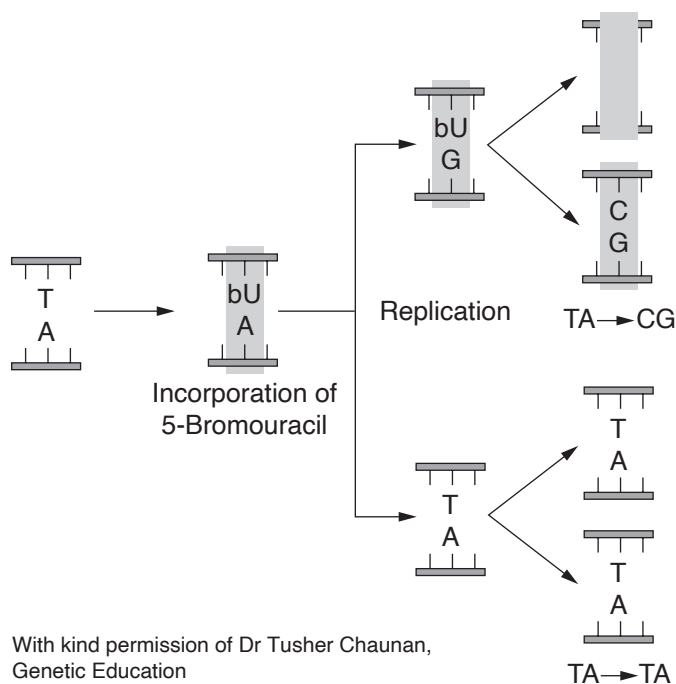
End of Question 34

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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.



© Genetic Education <https://geneticeducation.co.in/mutagen-definition-types-and-effect/>

- (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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2023 HSC Biology Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21 (a)

Criteria	Marks
Identifies sugar, phosphate and a base	1

Sample answer:

Sugar, phosphate and base

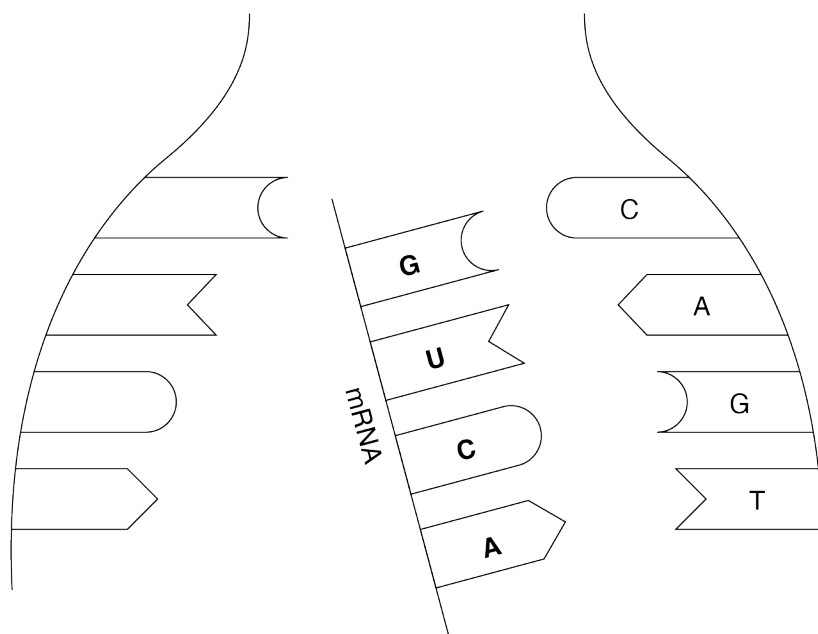
Answers could include:

Adenine, thymine, cytosine or guanine.

Question 21 (b)

Criteria	Marks
Completes the diagram with the correct mRNA sequence	2
- Identifies uracil as a replacement for thymine for the mRNA sequence OR - Completes the diagram with the complimentary DNA sequence	1

Sample answer:



Question 22 (a)

Criteria	Marks
• Provides a clear description of how phagocytes help protect against pathogens	2
• Provides some relevant information	1

Sample answer:

They engulf or enclose a pathogen/antigen as it can identify non-self-substances. Once the pathogen is engulfed, the phagocyte breaks down the pathogen or antigen.

Question 22 (b)

Criteria	Marks
• Demonstrates a thorough understanding of the immune response to the entry of a pathogen	4
• Demonstrates a sound understanding of the immune response to the entry of a pathogen	3
• Demonstrates some understanding of the immune response to the entry of a pathogen	2
• Provides some relevant information	1

Sample answer:

Pathogens carry protein markers (antigens), so that when it enters a body, it is recognised as non-self. The immune response is then activated to destroy the pathogen.

The antigen of the pathogen binds to the receptor of a B cell and activates it. This specific B cell replicates to form plasma cells. Plasma cells produce an antibody that is specific to the antigen.

Question 23

Criteria	Marks
Demonstrates a sound understanding of the function of TWO hormones in pregnancy and identifies the trimester in which each hormone secretion peaks	4
Demonstrates a sound understanding of the function of at least ONE hormone in pregnancy and identifies the trimester in which each hormone secretions peaks	3
- Demonstrates some understanding of the function of a hormone OR - Identifies the trimester in which each hormone secretion peaks	2
Provides some relevant information	1

Sample answer:

<i>Hormone name</i>	<i>Function in pregnancy</i>	<i>Trimester where peak occurs</i>
hCG	It thickens the lining of the placenta and stops menstruation	First trimester/10 weeks
Progesterone	Maintains uterus lining, helps the uterus grow and triggers hormones responsible for developing the babies' organs	Third trimester/38 weeks

Any of the hormones shown on the graph can be used to complete the table.

Question 24 (a)

Criteria	Marks
- Names a visual disorder - Relates problems with eye structure and function to the visual disorder	3
- Names a visual disorder - Sketches in general terms the cause of a visual disorder in relation to structure and/or function	2
Provides some relevant information	1

Sample answer:

The lens of the eye refracts light from the environment on the retina. Cataracts are a visual disorder caused by the clouding of the lens which is normally clear. Clouding stops light passing through the lens leading to blurry vision.

Question 24 (b)

Criteria	Marks
Provides characteristics and features of a technology that is used to assist with the effects of a visual disorder	3
Outlines a technology that assists with the effects of a visual disorder	2
Provides some relevant information	1

Sample answer:

A technology that assists with the effects of a visual disorder is laser surgery. One type of laser surgery is LASIK. It is used to correct myopia, hyperopia and astigmatism which are caused by refraction errors in the eye which can be caused by problems with the shape of the cornea. In LASIK surgery a thin flap is opened on the surface of the cornea a laser then reshapes the cornea to provide the correct refraction and the flap is laid back into place.

Question 25 (a)

Criteria	Marks
• Justifies the correct genotype of individual <i>H</i> with reference to <i>H</i> 's offspring	3
• Identifies possible genotypes of autosomal dominant inheritance	2
• Provides some relevant information	1

Sample answer:

Individual '*H*' must be heterozygous for the Huntington's disease gene (genotype *Hh*). This is because she has children that do not have Huntington's disease (*J* and *L*) and children that do have Huntington's disease (*I* and *K*). Therefore she must carry both the allele for Huntington's disease (*H*) and the normal allele (*h*) because she has both normal and affected children.

Answers could include:

Punnet squares

Question 25 (b)

Criteria	Marks
• Identifies the correct amino acid	1

Sample answer:

Glutamine

Question 25 (c)

Criteria	Marks
- Explains the relationship between the age of onset of Huntington's disease and CAG repeats - Makes relevant reference to data on graph OR the effect of increased repeats on the protein structure	2
- Makes evident the relationship between the age of onset of Huntington's disease and CAG repeats OR - Makes some relevant reference to data on the graph	1

Sample answer:

As the number of repeats increases, the age of onset of Huntington's disease decreases eg when there are 60 CAG repeats the age of onset of Huntington's disease is 20 years of age. CAG repeats lead to the alteration of the protein responsible for the disease at an earlier age.

Answer could include:

CAG repeats lead to the change in the structure of the protein responsible for the disease at an earlier stage.

Question 25 (d)

Criteria	Marks
- Predicts the outcome for both individuals <i>S</i> and <i>U</i>, including age of onset - Provides suitable justification using data from the diagrams	3
- Predicts the outcome for one of the individuals, including age of onset OR - Makes some interpretation of data from the diagrams and how it relates to Huntington's disease	2
Provides some relevant information	1

Sample answer:

Individual *S* is not predicted to be affected by Huntington's disease. The gel electrophoresis shows a band at approximately 15 repeats this is the same as his father (*P*) who does not have the disease. Individual *U* will most likely get Huntington's disease at around age 45. Individual *U* has the same number of repeats as her mother (*Q*) around 38 repeats.

Question 26 (a)

Criteria	Marks
• Identifies the dependent variable AND a controlled variable	2
• Identifies a controlled variable OR • Identifies the dependent variable	1

Sample answer:

Dependent variable: the number of mosquitoes that land on the clothing

Controlled variable: any reasonable controlled variable eg size of container, number of mosquitoes in each container.

Question 26 (b)

Criteria	Marks
• Justifies an appropriate conclusion for the investigation	3
• Provides a relevant conclusion with limited justification	2
• Provides some relevant information	1

Sample answer:

Wearing clean clothing would reduce the transmission of malaria as mosquitoes land on clean clothing on average fewer times than on worn clothing. Infected mosquitoes landed on clothing three times as often as uninfected mosquitoes. Infected mosquitoes can only pass on infection if they land on a host and bite them.

Question 27

Criteria	Marks
• Demonstrates a thorough understanding of the characteristics and features of a valid epidemiological study • Provides a comprehensive analysis of the air pollution study • Makes an informed judgement	7
• Demonstrates a sound understanding of the characteristics and features of a valid epidemiological study • Provides an analysis of the air pollution study • Makes a suitable judgement	5–6
• Demonstrates some understanding of the characteristics and features of a valid epidemiological study • Supports answer with reference to the study	3–4
• Identifies features of an epidemiological study	2
• Provides some relevant information	1

Answers could include:

- The epidemiological study conducted was not a valid study and a statistically significant relationship between cause and effect is not shown
- The risk factors that might contribute to the occurrence of the disease include age, sex, ethnic group, occupation
- Different ethnic groups are not indicated in the sample
- The time period of 12 months may not be long enough for symptoms to develop
- The occupation of individuals is not taken into account, this may impact health giving similar symptoms
- There is no indication of the locality within each city and whether those surveyed are near industry or not
- No indication of the degree of symptoms
- The study must be done on a very large population, with large range in terms of socioeconomic status and geography, for trends to be reliable
- Some subjects may be affected by other factors
- Subjects should also have varying levels of exposure to air pollution. Greater exposure to the air pollution should correspond to greater incidence of the symptoms.

Question 28 (a)

Criteria	Marks
• Provides a feature that can be used to distinguish a bacterium from a virus	2
• Provides some relevant information	1

Sample answer:

The size of a bacterium is 1–10µm, a virus is 0.05–0.1µm so a bacterium is much larger than a virus.

Answers could include:

- Bacteria is a prokaryotic cellular organism; Viruses are comprised of nucleic acids and a protein coat and are not cellular
- Bacteria are living organisms; Viruses are usually considered non-living
- Bacteria can reproduce by binary fission; Viruses use host cells to replicate.

Question 28 (b)

Criteria	Marks
• Sketches in general terms a method that can be used to distinguish between bacterial and viral pathogens	2
• Provides some relevant information	1

Sample answer:

The presence of a bacterial pathogen could be identified by using an agar culture. A viral pathogen cannot be cultured on agar. A bacterial pathogen can be observed using a high-powered light microscope, but a viral pathogen would not be able to be observed as it is too small.

Answers could include:

Subjecting the pathogen to antibiotics will cause bacteria to die, but not affect the virus.

Question 29 (a)

Criteria	Marks
• Sketches in general terms a physiological adaptation in endotherms	2
• Provides some relevant information	1

Sample answer:

Endotherms can undergo vasoconstriction to decrease blood flow and volume. This reduces heat loss through the skin.

Answers could include:

- Vasodilation will expand blood vessels to increase blood flow to skin to promote cooling
- Water balance is maintained by the kidneys extracting water from urine.

Question 29 (b)

Criteria	Marks
• Explains TWO adaptations in plants that help maintain water balance	4
• Relates ONE adaptation to the maintenance of water balance in plants and identifies a second adaptation OR • Outlines TWO adaptations in plants that help maintain water balance	3
• Relates ONE adaptation to the maintenance of water balance in plants OR • Identifies adaptations in plants to maintain water balance	2
• Provides some relevant information	1

Sample answer:

Sunken stomates	Stomata may be sunken in pits in the epidermis. Moist air is trapped over the top of the stomate. The saturated air above the stomates reduces the evaporation rate.
Thick waxy cuticle	A thick waxy cuticle makes the leaf watertight, it acts as a barrier to evaporation and also the shiny surface reflects heat and so lowers the leaf temperature.

Question 30

Criteria	Marks
• Demonstrates a comprehensive understanding of the use of vaccines and the vaccination schedule, with reference to the graph and provided information • Makes a judgement about the value of the vaccination schedule	5
• Demonstrates a sound understanding of the use of vaccines and the vaccination schedule, with some reference to the graph or provided information • Makes a relevant judgement	4
• Demonstrates some understanding of the use of vaccines and the vaccination schedule	3
• Demonstrates understanding of vaccination and/or vaccination schedules	2
• Provides some relevant information	1

Sample answer:

Vaccinations are used to initiate an immune response using a form of the pathogen/antigen that will not result in infection. From the graph, the more booster shots, the longer the period of time the person is considered immune. Cases occurring in people aged over 65 would be the result of not having a booster for a long time. The reduction in numbers of tetanus cases would suggest that vaccinations are effective while the recurring schedule ensures a person maintains immunity.

Question 31

Criteria	Marks
• Provides a comprehensive description of a named genetic technology and its use in a medical application	4
• Provides a sound description of a genetic technology and its use in a medical application	3
• Identifies and outlines a genetic technology and its use in a medical application	2
• Provides some relevant information	1

Sample answer:

Human insulin is produced by recombinant DNA technology to help diabetics.

Restriction enzymes are used to cut the insulin gene from a human cell. The same restriction enzyme is used to cut a section from a plasmid of *E.coli* to ensure the sticky ends are complimentary. The plasmid is then resealed with the insulin gene inserted. The recombined plasmid is then inserted into a host to produce human insulin.

The insulin is then used by patients to manage diabetes.

Question 32

Criteria	Marks
• Demonstrates an extensive understanding of the relationships between bushfires and introducing males on the population size and gene pool of the Mt Buller pygmy possum population • Makes an informed judgement about factors affecting the Mt Buller pygmy possum population	7
• Demonstrates a sound understanding of the relationships between bushfires and introducing males on the population size and gene pool of the Mt Buller pygmy possum population • Makes a suitable judgement about factors affecting the Mt Buller pygmy possum population	5–6
• Demonstrates an understanding of the relationships between bushfires or introducing males on the population size and/or gene pool of the Mt Buller pygmy possum population	3–4
• Identifies the relationship between bushfires or introducing males on the population size or gene pool of the Mt Buller pygmy possum population	2
• Provides some relevant information	1

Answers could include:

- Bushfires and the introduction of mating males have had an impact on the gene pool and population size of the Mt Buller pygmy possum population
- Bushfires in general reduce the population size as individuals die. The introduction of mating males from a distant population will bring new genes and increase the gene pool
- The size of the population of pygmy possums at Mt Buller was low in 1996, at about 90 individuals. This means that the diversity of alleles in the gene pool was low
- Fires in 1998, 2000 and 2002 further reduced the population size and further restricted the alleles present in the gene pool
- The remaining population following three different fires made up the new gene pool where the frequency of certain alleles may disappear or become more frequent depending on the population that remained
- This may have led to genetic drift (bottleneck effect) in this population where the low diversity of alleles in the population led to a further reduction in the population between 2002–2007
- In 2007 and 2012, 6 males from Mt Bogong were introduced. Their genes may have been different as their populations are a long way apart and isolated from one another
- This could have produced gene flow from the Mt Bogong pygmy possum population to the Mt Buller population increasing genetic diversity, the number of suitable adaptations and leading to an increase in population from about eight individuals in 2007 to 150 in 2016
- The improved diversity of this population and conserving the population with greater variation amongst the population has enabled the Mt Buller sub-population to improve its capacity to adapt to changing conditions as a direct result of this gene pool mixing.

May also discuss:

- Genetic diversity and the cause of bottlenecks, gene flow, genetic drift and long-term health of the local gene pool.

Question 33

Criteria	Marks
Interprets the stimulus to provide similarities and differences between the reproduction of fungi and humans	4
Interprets the stimulus to provide a similarity and a difference between the reproduction of fungi and humans	3
Provides a similarity and/or a difference in the reproduction of fungi and humans	2
Provides some relevant information	1

Sample answer:

The reproduction of fungi and humans has some similarities. Both use meiosis in their reproduction to produce gametes in humans and spores in fungi. Both involve the fusion of genetic material to produce a zygote. However, there are also differences in their reproduction. In humans all reproduction is sexual. Fungi have both sexual and asexual reproduction. In humans, fertilisation produces a diploid zygote. In fungi, after the mycelium fuse there is a stage where there are two nuclei present in the cytoplasm.

Answer could include:

Other correct information from the stimulus.

Question 34

Criteria	Marks
• Demonstrates an extensive understanding of the biotechnologies applied to cattle with relevant references to the table • Makes an informed judgement of the effect of biotechnologies on the biodiversity of cattle	5
• Demonstrates a sound understanding of the biotechnologies applied to cattle with some references to the table • Makes a suitable judgement of the effect of biotechnologies on the biodiversity of cattle	4
• Demonstrates an understanding of the effect of biotechnologies on biodiversity of cattle	3
• Identifies an effect of a biotechnology	2
• Provides some relevant information	1

Sample answer:

Biotechnologies can increase, maintain and decrease biodiversity in cattle. Artificial insemination generally reduces biodiversity as one male can be used to sire many offspring. This reduces the number bulls that pass on their genetics reducing the biodiversity in the species. Selective breeding reduces biodiversity as only individuals with desired characteristics are allowed to breed and pass on their genes. Producing transgenic organisms may increase the genetic diversity in cattle by introducing genes not originally present, but as it is not widely used it is not currently having a large impact on biodiversity. Whole organism cloning will also reduce biodiversity as cloned organisms are genetically identical to the parent organism. However, this is not used commercially in cattle so will not have a large effect on biodiversity. These biotechnologies used in the farming of cattle have the overall effect of decreasing the biodiversity in cattle.

Answer could include:

Hybridisation will increase the biodiversity within cattle as new gene combinations will be produced. It may also reduce biodiversity if the hybridised cattle are bred in preference to the original breeds.

Question 35 (a)

Criteria	Marks
Identifies the type of mutation caused by bU	1

Sample answer:

Point or substitution mutation

Question 35 (b)

Criteria	Marks
- Demonstrates a comprehensive understanding of the possible ways the mutation could alter the DNA sequence that determines the amino acid sequence - Relates how a changed amino acid sequence could change the structure of the protein and implications for protein function	4
- Demonstrates a sound understanding of a possible way the mutation could alter the DNA sequence that determines the amino acid sequence - Relates how a changed amino acid sequence could change the structure of the protein or implications for protein function	3
Identifies a possible way the mutation could alter the DNA sequence or the amino acid sequence and resulting protein	2
Provides some relevant information	1

Sample answer:

Polypeptide synthesis is the process of creating an mRNA strand based on the DNA strand. The sequence of bases along the mRNA strand that codes for specific amino acids found in organisms.

One strand will have the original adenine and replicate the same sequence. The mutated strand will contain guanine and continue to reproduce the mutated gene.

If a new mutated codon is for the same amino acid as the non-mutated codon, there will be no change to the protein.

If the new codon codes for a different amino acid, a different polypeptide chain will form. This could result in different folding which could result in a non-functioning protein being produced. If a stop codon is formed as a result of the mutation, the chain will not form after that point and if it occurs on the AUG START, then it will not start.

2023 HSC Biology Mapping Grid

Section I

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

Section II

Question	Marks	Content	Syllabus outcomes
21 (a)	1	Mod 5 Cell Replication	12-12
21 (b)	2	Mod 5 DNA and Polypeptide Synthesis	12-6, 12-12
22 (a)	2	Mod 7 Responses to Pathogens	12-14
22 (b)	4	Mod 7 Responses to Pathogens	12-14
23	4	Mod 5 Reproduction	12-4, 12-12
24 (a)	3	Mod 8 Technologies and Disorders	12-15
24 (b)	3	Mod 8 Technologies and Disorders	12-15
25 (a)	3	Mod 5 Genetic Variation	12-5, 12-12
25 (b)	1	Mod 5 DNA and Polypeptide Synthesis	12-12
25 (c)	2	Mod 8 Causes and Effects	12-6, 12-15
25 (d)	3	Mod 5 Genetic Variation	12-6, 12-12
26 (a)	2	Mod 7 Prevention, Treatment and Control	12-2, 12-5, 12-14

Question	Marks	Content	Syllabus outcomes
26 (b)	3	Mod 7 Prevention, Treatment and Control	12-2, 12-5, 12-6, 12-7, 12-14
27	7	Mod 8 Epidemiology	12-5, 12-15
28 (a)	2	Mod 7 Cause of Infectious Disease	12-14
28 (b)	2	Mod 7 Cause of Infectious Disease	12-14
29 (a)	2	Mod 8 Homeostasis	12-15
29 (b)	4	Mod 8 Homeostasis	12-15
30	5	Mod 7 Prevention, Treatment and Control	12-5, 12-14
31	4	Mod 6 Genetic Technologies	12-13
32	7	Mod 6 Mutation	12-13
33	4	Mod 5 Reproduction	12-12
34	5	Mod 6 Biotechnology	12-13
35 (a)	1	Mod 6 Mutation	12-4, 12-13
35 (b)	4	Mod 6 Mutation	12-4, 12-13