NSW Education Standards Authority

2020 **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 21–32
- 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 In maintaining homeostasis, which of the following is a behavioural adaptation?

A. Sweating to cool down

B. Curling up in a ball to keep warm

C. Speeding up or slowing down cell metabolism

D. Skin going red as more blood flows to surface

2 Sexual reproduction in plants involves

A. pollination caused by dispersal of seeds.

B. cloning as it creates copies of the parent plant.

C. mitosis leading to the formation of pollen grains.

D. fertilisation as a result of fusion of male and female gametes.

3 The following four events occur during reproduction in a placental mammal.

1. Fertilisation
2. Implantation
3. Ovulation
4. Placental formation

In which order do these events occur?

A. 2, 1, 3, 4

B. 2, 4, 1, 3

C. 3, 1, 2, 4

D. 3, 2, 4, 1

4 Malaria is a disease in humans caused by a single-celled *Plasmodium* species. It is transmitted by female mosquitoes.

Which of the following is true for malaria?

A. Both *Plasmodium* and the mosquito are vectors

B. Both *Plasmodium* and the mosquito are pathogens

C. The mosquito is the vector and *Plasmodium* is the pathogen

D. The mosquito is the pathogen and *Plasmodium* is the vector

5 Which row of the table best describes DNA in both prokaryotic and eukaryotic cells?

	Prokaryotic	*Eukaryotic*
A.	Circular	Circular
B.	Circular	Linear
C.	Linear	Circular
D.	Linear	Linear

6 Citrus canker is a bacterial disease that originates in south-east Asia and affects citrus fruit.

What would be the most effective way to prevent the disease from spreading into or across Australia?

A. Monitor citrus trees and fruit continuously.

B. Certify orchards before fruit is transported.

C. Keep citrus trees and fruit entering Australia in quarantine stations until the incubation period has passed.

D. Inspect citrus trees and fruit entering Australia in quarantine stations before transportation across Australia.

7 Students designed and conducted an investigation to test for the presence of microbes in THREE different food samples.

They inoculated agar plates with the samples and placed them in an incubator set to 25°C.

Which row of the table represents a valid design for the investigation?

	Independent variable	*Dependent variable*	*Experimental control*
A.	Food sample	Number of microbes	An agar plate without a sample
B.	Number of microbes	Food sample	Temperature set to 25°C
C.	Food sample	Number of microbes	Temperature set to 25°C
D.	Number of microbes	Food sample	An agar plate without a sample

8 Quarantine is ineffective as a measure to control non-infectious diseases because they

A. cannot develop in isolation.

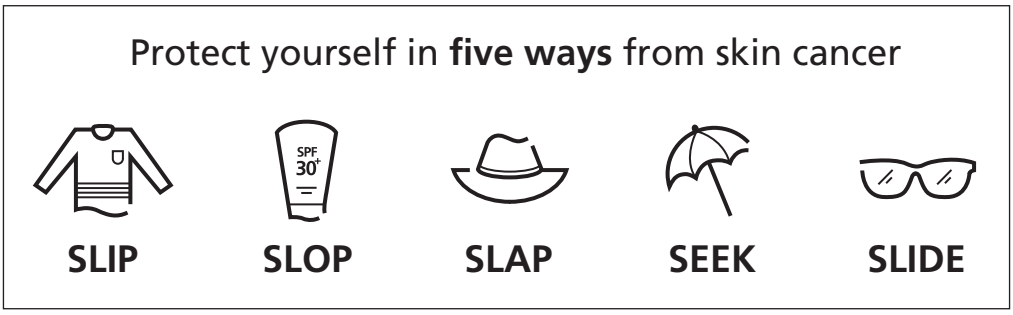
B. depend on long-term exposure to a pathogen.

C. may be inherited and affect the organism all their life.

D. may only be treated by genetic engineering altering cells.

9 A public education campaign was developed with the aim of lowering the incidence of skin cancer in the population.

The campaign was adopted Australia wide and is illustrated in the poster.



Which is the best method to measure the effectiveness of the campaign?

A. By measuring exposure to the sun and skin cancer incidence

B. By surveying beachgoers, asking if they remember the campaign

C. By comparing skin cancer incidence before and after the campaign

D. By counting the number of people on the beach wearing hats and sunglasses

10 A farmer intends to artificially inseminate cows with semen from a bull which has been chosen based on characteristics of colour and muscle mass.

The farmer does not know that the bull is heterozygous for a rare recessive allele not previously present in the farmer's cow population.

The introduction of this recessive allele to the population of cows is an example of

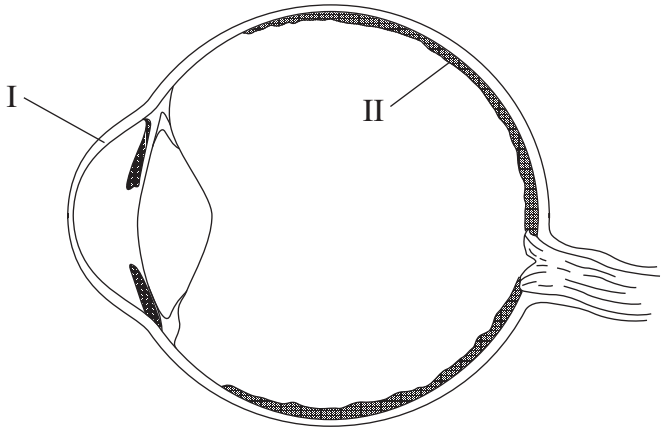
A. gene flow.

B. genetic drift.

C. natural selection.

D. selective breeding.

11 The diagram shows a model of the human eye.



Which of the following correctly identifies a labelled part and its function?

	Label	*Name*	*Function*
A.	I	Cornea	Refract light
B.	I	Retina	Transmit light
C.	II	Retina	Focus light
D.	II	Cornea	Absorb light

12 What is the purpose of cloning in agriculture?

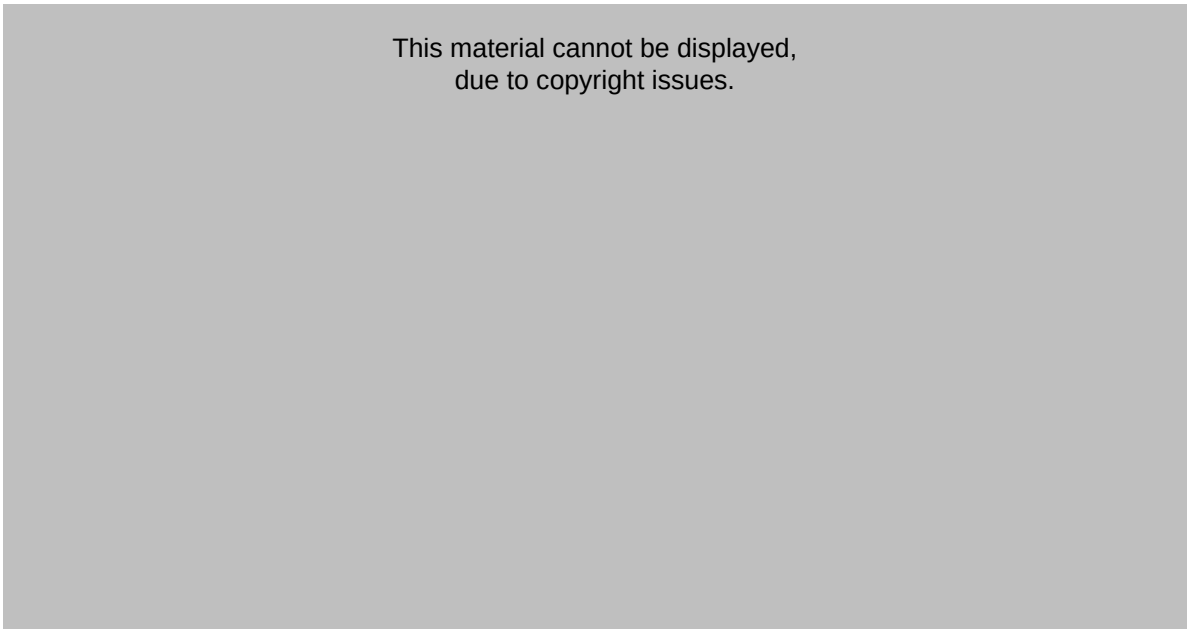
A. Increasing the frequency of recessive traits

B. Preserving favourable traits in the offspring

C. Preserving genetic variability in a population

D. Increasing combinations of alleles in a population

13 A type of genetic technology is shown in the diagram.



https://s3.amazonaws.com/s3.timetoast.com/public/uploads/photos/12791817/Gene_cloning.png

What type of cloning is modelled?

A. Gene cloning because bacteria are used.

B. Gene cloning because a human gene is being replicated.

C. Whole organism cloning because identical offspring are produced.

D. Whole organism cloning because the bacteria use asexual reproduction.

14 A normal allele results in liver cells with sufficient cholesterol receptors. A different allele results in liver cells without cholesterol receptors. Individuals who are heterozygous have liver cells with insufficient cholesterol receptors.

What type of inheritance is the most likely explanation for this?

A. Sex-linked

B. Autosomal dominant

C. Autosomal recessive

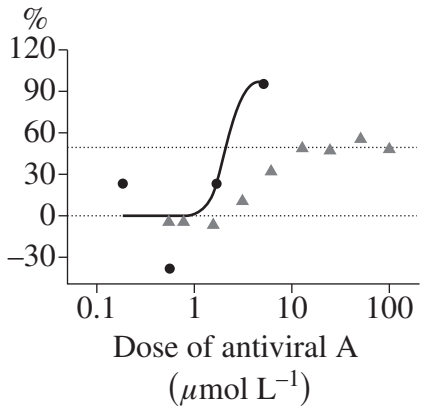
D. Incomplete dominance

15 Four antiviral drugs have been tested in a culture of human cells for their effectiveness in inhibiting infection from a new virus. The toxicity of the antivirals to human cells was also tested.

The ability of the drugs to inhibit viral entry to the cells (% inhibition) and the proportion of the cells killed by the drugs (% toxicity) were recorded at different doses of each drug and shown in the graphs.

From the results shown, which antiviral drug is the safest and most effective at a dose of 1 μmol L^{-1}?

A.



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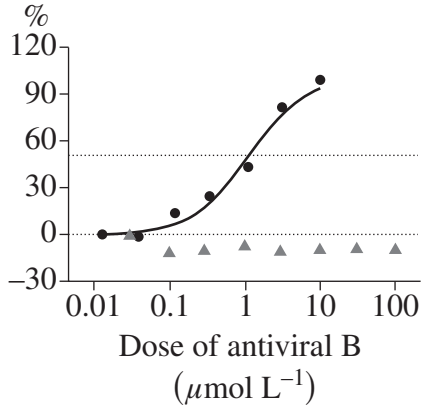
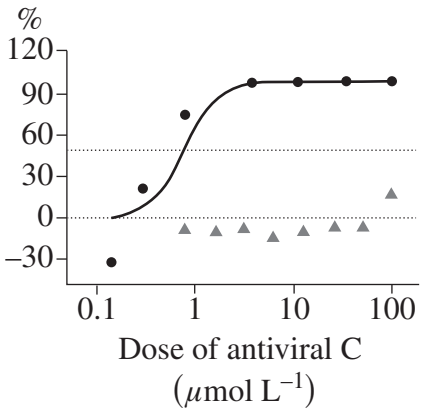
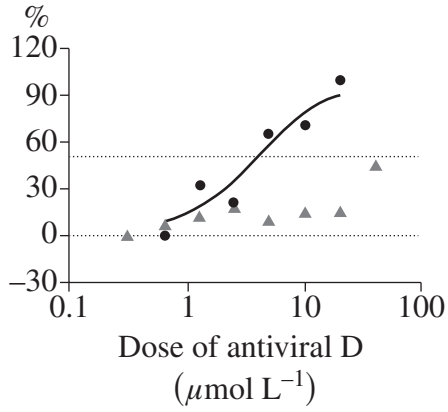


C.



D.



16 Analysis of DNA shows that adenine and guanine always make up 50% of the total amount of nitrogenous bases in DNA.

Which structural feature of DNA does this provide evidence for?

A. DNA is helical in structure.

B. DNA is always a double-stranded molecule.

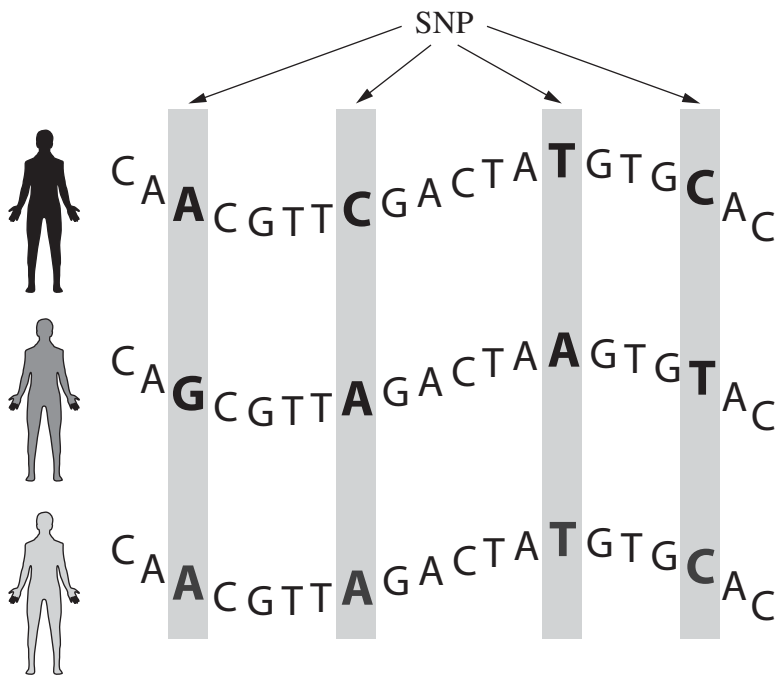
C. DNA always has adenine paired with guanine.

D. DNA is made up of equal amounts of nitrogenous bases.

17 There are about 10 million single nucleotide polymorphisms (SNPs) found in the human genome.

Four SNPs are modelled in the diagram.

Single nucleotide polymorphisms (SNPs)



The SNPs modelled do not affect the phenotype of the individuals shown.

Which is the best explanation for this?

A. Only one nucleotide is different at each SNP.

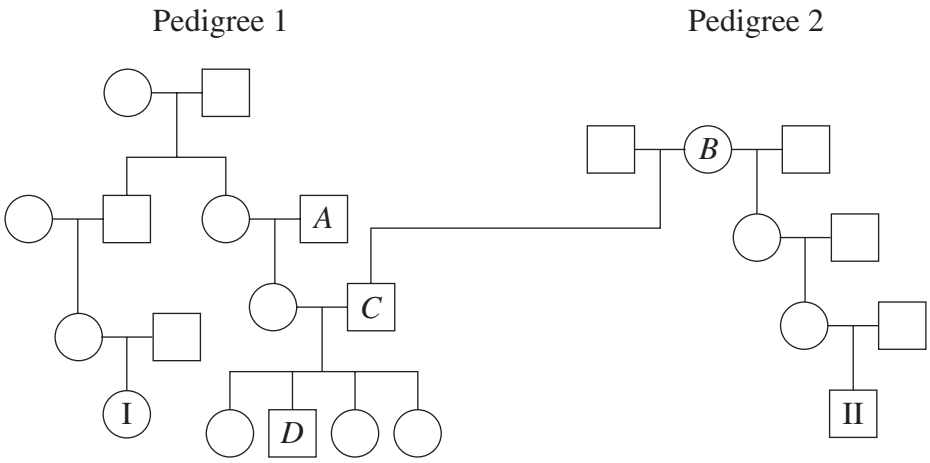
B. The SNPs are part of DNA that is not expressed.

C. AGA, CAA, TAT and CTC all code for the same amino acid.

D. The SNPs are present on one strand of the DNA molecule only.

18 SNP databases have been used in forensic investigations. One is outlined below.

1. DNA was collected at a crime scene 30 years ago.
2. Recently the crime scene DNA was analysed at 700 000 SNP locations.
3. An SNP profile was created and uploaded to a genealogy database.
4. The SNP profile from the crime scene indicated some shared SNPs with two individuals (who did not have SNPs in common).
5. The pedigrees were constructed for the two individuals.



KEY

I — Database female with some SNPs in common with crime scene DNA

II — Database male with some SNPs in common with crime scene DNA

Which person is most likely to be the suspect who should be investigated?

A. *A*

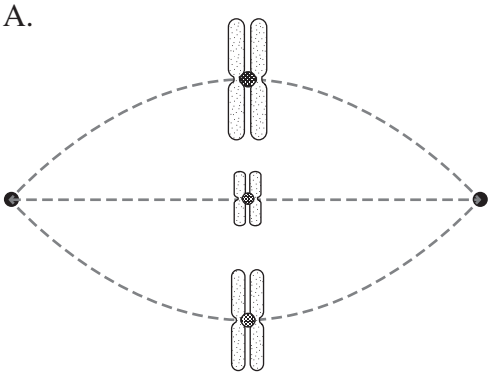
B. *B*

C. *C*

D. *D*

19 Which diagram correctly models one phase of meiosis in an organism that has six chromosomes in its somatic cells?

A.



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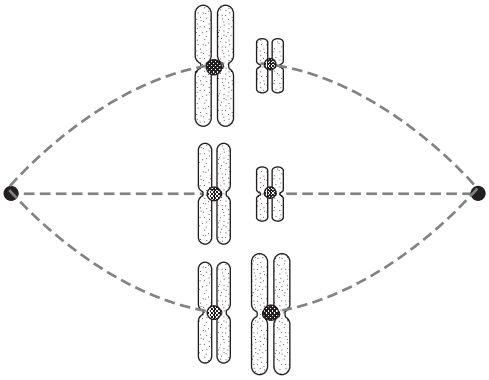

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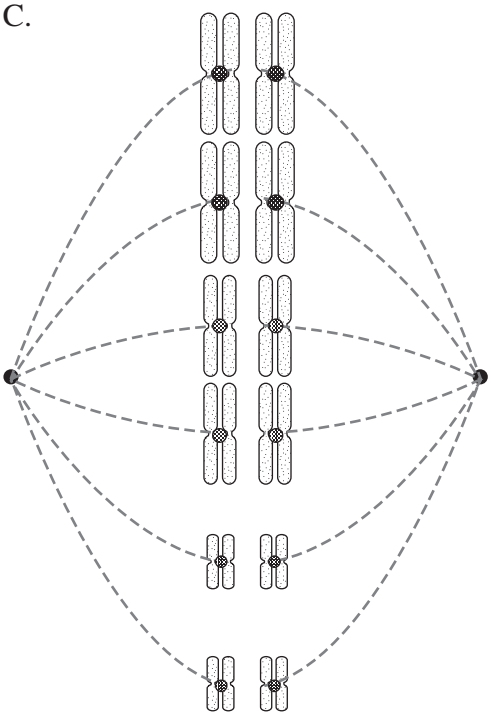

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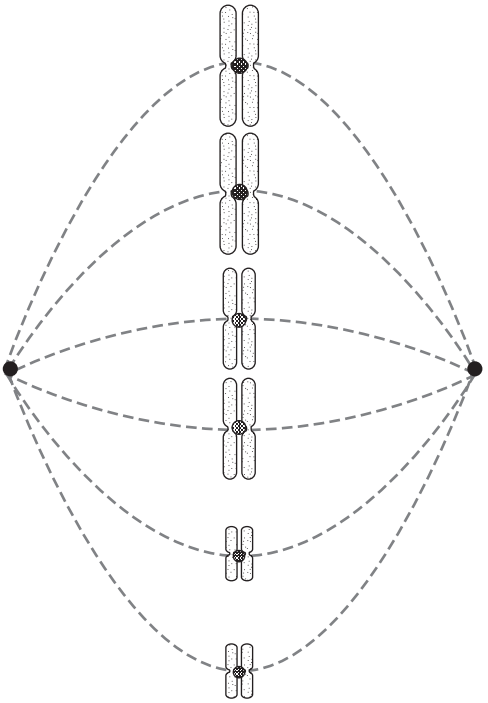
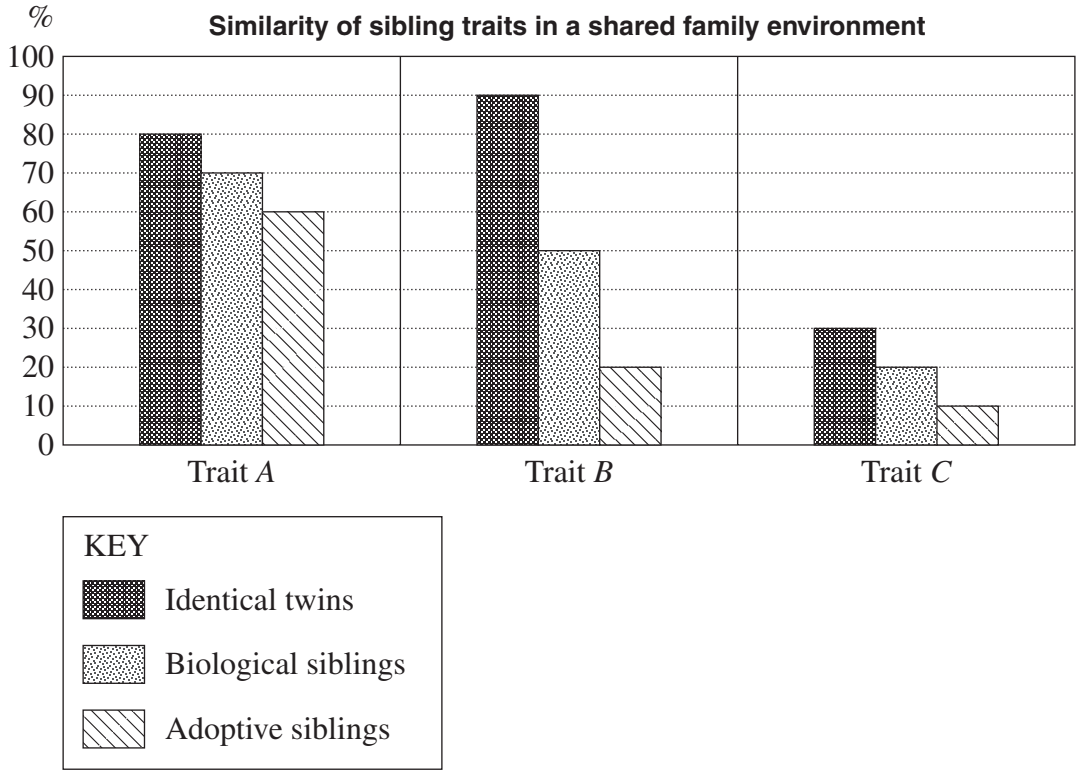


20 This chart illustrates three correlation patterns indicating the influence of genes and environment on different traits in individuals.



What does the data show about how genes and family environment affect the three traits?

	Trait A		*Trait B*		*Trait C*	
	Genes	*Family environment*	*Genes*	*Family environment*	*Genes*	*Family environment*
A.	Low	High	High	Low	Low	Low
B.	Low	High	High	Low	High	High
C.	High	Low	Low	High	Low	Low
D.	High	Low	Low	High	High	High

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2020 HIGHER SCHOOL CERTIFICATE EXAMINATION

Centre Number

Student Number

Biology

Section II Answer Booklet

80 marks
Attempt Questions 21–32
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)

Cholera is an acute diarrhoeal infection caused by the bacterium *Vibrio cholerae*. Humans are infected when they consume food or water that is contaminated with the bacterium. **3**

Outline THREE strategies that could prevent the spread of cholera.

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Question 22 (3 marks)

Outline a benefit and a limitation of using pharmaceuticals such as antibiotics to treat infectious disease. **3**

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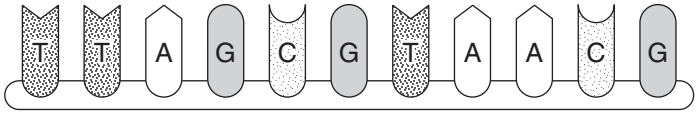
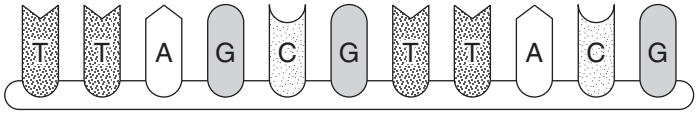
Question 23 (3 marks)

The following diagram shows a mutation.

Original DNA sequence



Mutated DNA sequence



(a) What type of mutation is shown in the diagram? **1**

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(b) Outline another type of mutation. **2**

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Question 24 (7 marks)

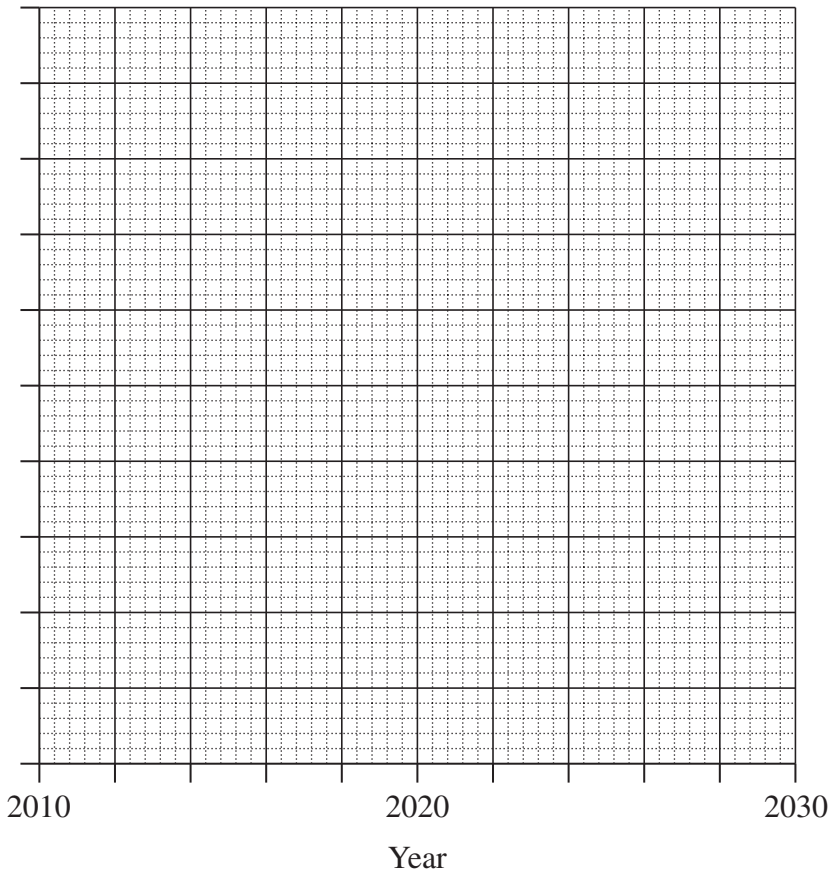
An indicator of kidney function is the volume of filtrate formed at the glomerulus in 1 minute (GFR).

GFR of healthy adult	> 100 mL min^{-1}
GFR needing dialysis	< 15 mL min^{-1}

A patient's kidney function was monitored and the following data recorded.

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019
GFR (mL min^{-1})	81	76	77	77	79	65	60	45	35

(a) Plot the data on the grid. **2**



(b) Use the graph to show the year that the patient is predicted to require dialysis. Show your working and answer on the graph. **2**

Question 24 continues on page 17

Question 24 (continued)

(c) Explain how dialysis compensates for the loss of a function of the kidneys. **3**

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End of Question 24

Please turn over

Question 25 (7 marks)

Students tested the hypothesis that the number of eggs/young produced was greater in animals using external fertilisation than those using internal fertilisation. They obtained the following data from secondary sources.

Mode of fertilisation	*Species*	*Average number of young born or eggs laid in one reproductive cycle*	Mean ± SD*
Internal fertilisation	Red kangaroo	1	43 ± 55
	Bush rat	6	
	White tipped reef shark	6	
	Loggerhead turtle	126	
	Red bellied black snake	18	
	Guppy (fish)	100	
External fertilisation	Pouched frog	13	40 ± 32
	Loveridge's frog	20	
	Corroboree frog	25	
	Turtle frog	50	
	Clownfish	100	
	Siamese fighting fish	30	
*SD is standard deviation which gives a measure of the amount of variation in the data.			

(a) What conclusion can be drawn from the data? Justify your answer. **3**

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Question 25 continues on page 19

Question 25 (continued)

(b) Justify an improvement to the students' experimental design to test the same hypothesis. **2**

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(c) Explain ONE advantage for animals of using external fertilisation. **2**

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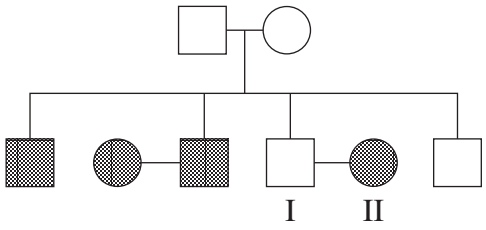
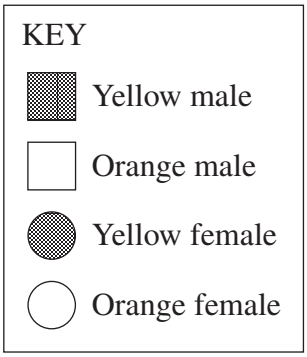
End of Question 25

Question 26 (6 marks)

One of the genes involved in determining the colour of a species of fish has two alleles: yellow and orange.

The diagram shows a pedigree chart for the inheritance of colour in the fish.





(a) Use the pedigree chart to explain why the yellow allele is recessive. **2**

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Question 26 continues on page 21

(b) Explain how a cross between individuals I and II could be used to determine whether the inheritance of colour in the fish is sex-linked or autosomal. **4**

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End of Question 26

Question 27 (6 marks)

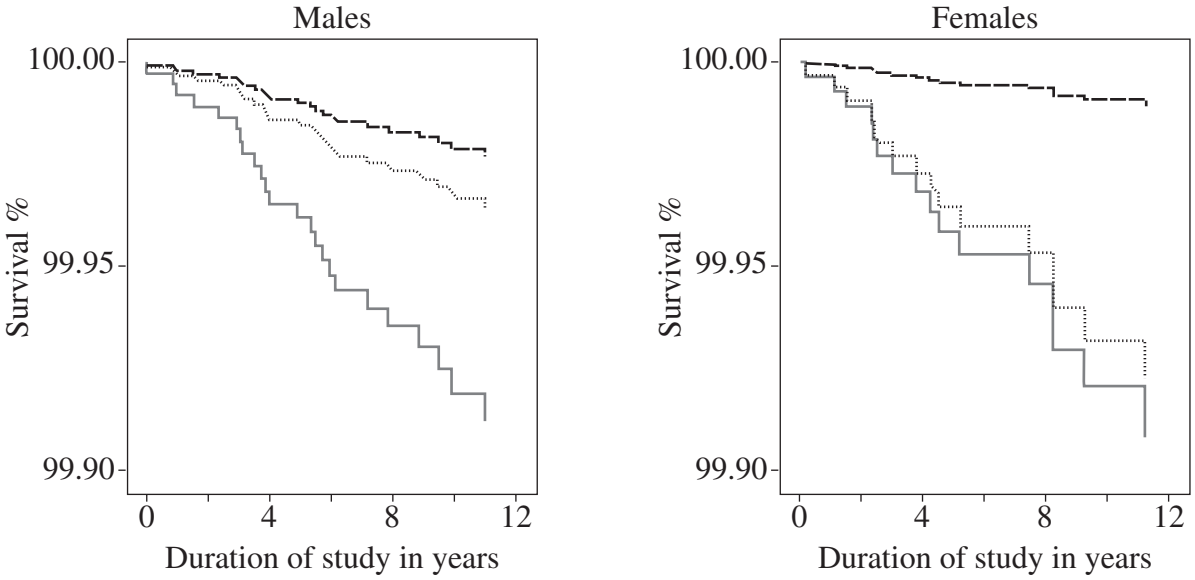
Exposure to arsenic in drinking water has been associated with the onset of many diseases. The World Health Organisation recommends arsenic levels in drinking water should be below 10 μg L^{-1}.

An epidemiological study involving 58 406 young adults was conducted over an 11-year period in one country to investigate young-adult mortality due to chronic exposure to arsenic in local drinking water. Each individual's average exposure and cumulative exposure to arsenic over the time of the study were calculated. Age, sex, education and socioeconomic status were taken into account during the analysis of the results.

The graphs show survival rates for males and females over the 11-year period associated with different average levels of exposure to arsenic in drinking water.

KEY

----- < 90 μg L^{-1} ..... 90–223 μg L^{-1} ——— > 223 μg L^{-1}



Question 27 continues on page 23

Question 27 (continued)

(a) Identify TWO features of the method used that contributed to the validity of this study. **2**

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(b) The hypothesis put forward was that exposure to arsenic in drinking water increases mortality in young adults. **4**

Discuss the data presented in the graphs in relation to this hypothesis.

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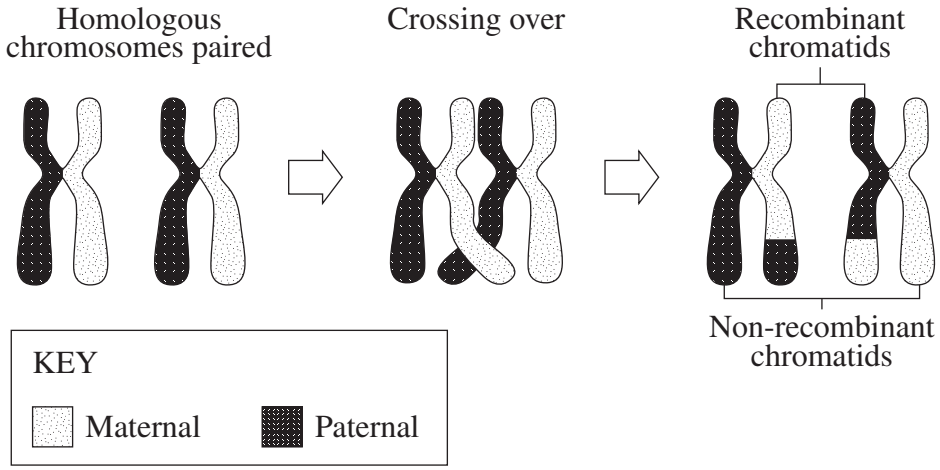
End of Question 27

Question 28 (6 marks)

(a) A student drew a diagram to model part of the process of meiosis. **3**



Explain the misunderstanding of meiosis shown in this model.

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(b) Explain the effect of meiosis on genetic variation. **3**

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Question 29 (5 marks)

Explain how TWO processes that affect the gene pool of populations can lead to evolution. **5**

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Question 30 (7 marks)

Explain the impact that genetic technologies have had on the management of both infectious and non-infectious diseases. **7**

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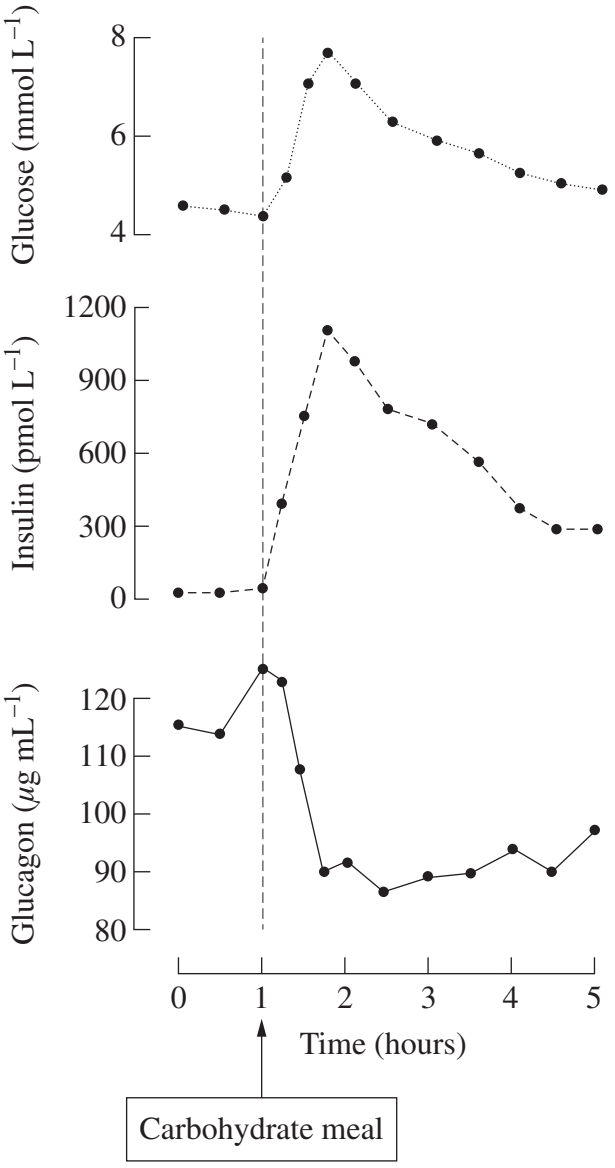
Question 31 (9 marks)

(a) The levels of glucose, insulin and glucagon were measured in the plasma of 24 healthy adults at intervals over a 5-hour period. After 1 hour at rest the patients ate a large carbohydrate meal. The results are shown. **6**

Figure 1

Figure 2

Figure 3



Reproduced by permission of Prof Norman Joels

Question 31 continues on page 29

Question 31 (continued)

Use the data provided to explain how blood glucose is controlled in the body.

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Question 31 continues on page 30

Question 31 (continued)

(b) Outline how in humans, maintenance of temperature is different to the way that glucose is controlled. **3**

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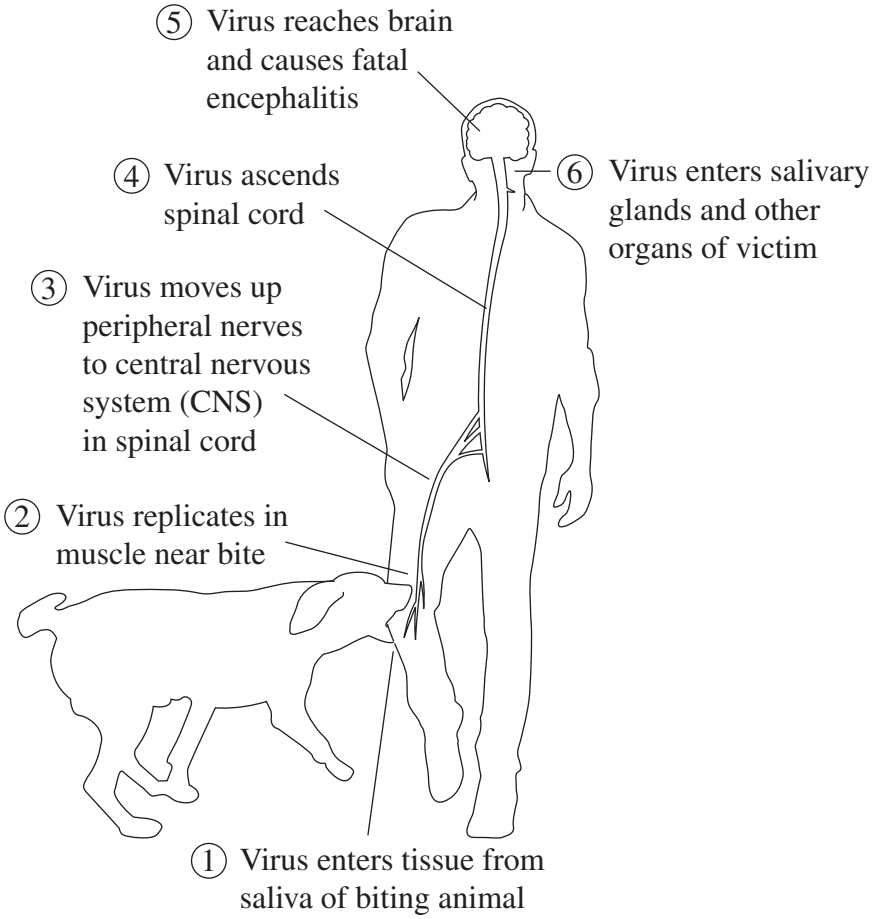
End of Question 31

Question 32 (18 marks)

(a) Rabies is a disease that can affect all mammals and is caused by the rabies virus. It is transmitted by the bite of an infected animal. Without treatment it almost always results in death. **2**



Use the information provided to identify TWO features of the rabies infection that facilitate transmission of the pathogen to a new host.

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Question 32 continues on page 32

Question 32 (continued)

(b) The rabies virus is a single-stranded RNA virus. It contains and codes for only five proteins. The diagrams show the structure and reproduction of the virus.

Diagram 1 – structure

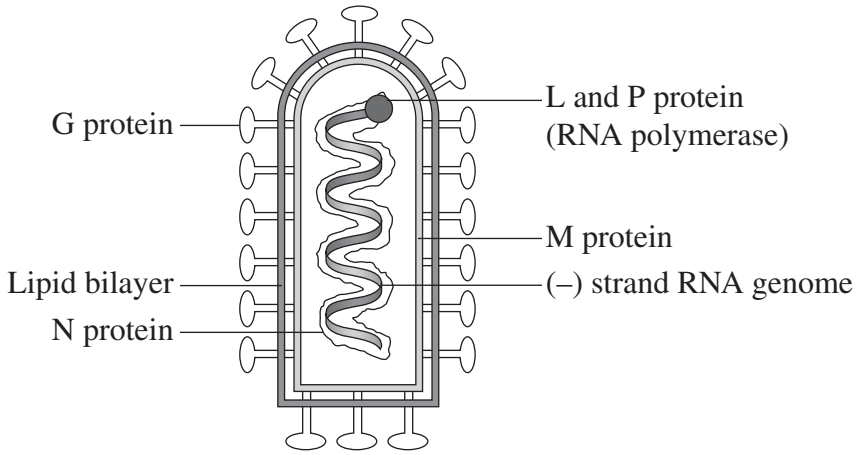
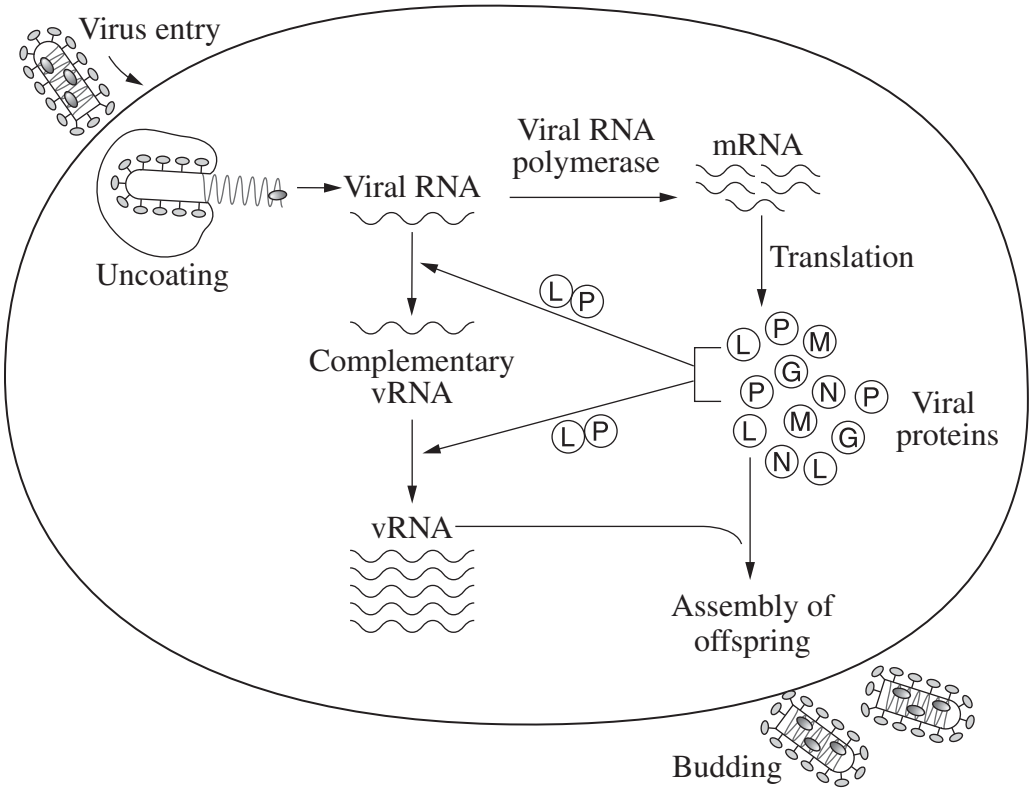


Diagram 2 – reproduction



Question 32 continues on page 33

Question 32 (continued)

(i) Use the information provided in Diagram 1 to explain why the rabies virus cannot be classified as a cellular pathogen. **3**

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(ii) After infection the virus reproduces in muscle cells near the bite site and in the central nervous system. This requires the single-stranded rabies RNA to be transcribed, translated and replicated in the cytoplasm of host cells. These processes are shown in Diagram 2. **5**

Use the information provided in Diagrams 1 and 2 to explain the role of viral RNA polymerase in the reproduction of the virus.

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Question 32 continues on page 34

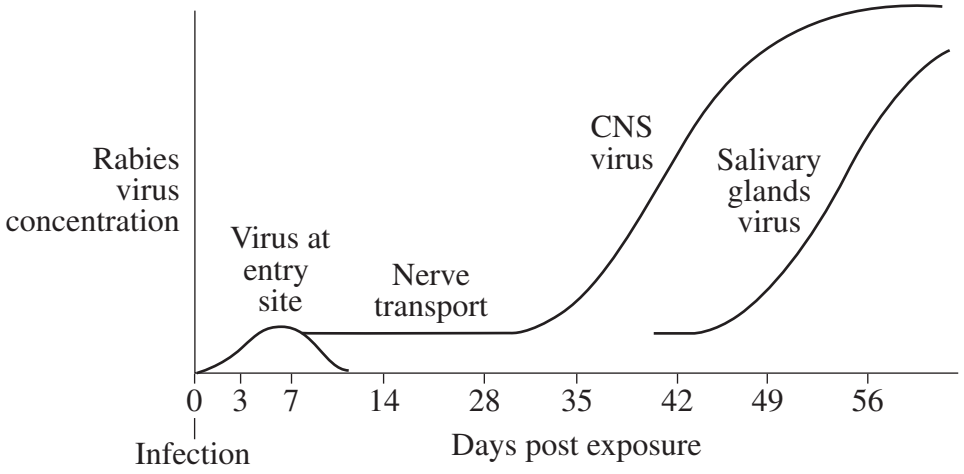
Question 32 (continued)

(c) Post exposure prophylaxis (PEP) is given to patients who have been bitten by a rabid animal. **8**

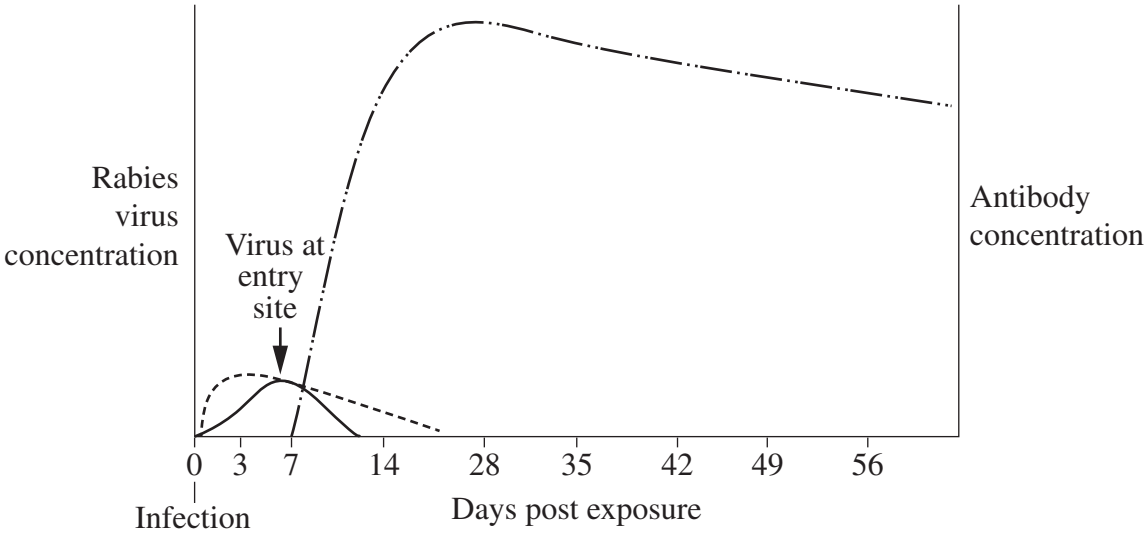
PEP includes an injection of human rabies antibodies (HRIG) as well as injections of a rabies vaccine at 0, 3, 7 and 14 days after exposure to the virus.

The following graphs show a generalised response to rabies infection without and with PEP.

Rabies infection without PEP



Rabies infection with PEP



KEY
- Virus concentration
- Passive immunity – HRIG antibodies
- Vaccine-induced antibodies

Question 32 continues on page 35

Question 32 (continued)

Explain how PEP prevents rabies developing after infection with the virus. Support your answer with reference to the information and data provided throughout Question 32.

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End of paper

Section II extra writing space

If you use this space, clearly indicate which question you are answering.

Office Use Only – Do NOT write anything, or make any marks below this line.

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2020 HSC Biology Marking Guidelines

Section I

Multiple-choice Answer Key

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

Section II

Question 21

Criteria	Marks
• Outlines THREE strategies that could help prevent the spread of cholera	3
• Identifies THREE strategies that could help prevent the spread of disease OR • Outlines TWO strategies that could help prevent the spread of cholera	2
• Provides some relevant information	1

Sample answer:

Washing hands after going to the toilet removes bacteria from the skin. The purification of drinking water will kill the bacteria present in the water. Proper disposal of sewage would stop the exposure of people to the bacteria.

Question 22

Criteria	Marks
• Outlines a benefit and a limitation of the use of pharmaceuticals to treat infectious disease	3
• Identifies a relevant benefit and limitation OR • Outlines a benefit or limitation of the use of pharmaceuticals to treat infectious disease	2
• Provides some relevant information	1

Sample answer:

Antibiotics can be used to treat bacterial infections as they can inhibit bacterial growth. Antibiotic resistance in bacteria is becoming increasingly common and is reducing the effectiveness of many antibiotics.

Question 23 (a)

Criteria	Marks
• Identifies the correct mutation	1

Sample answer:

Point mutation.

Question 23 (b)

Criteria	Marks
• Outlines a type of mutation other than point mutation	2
• Identifies another type of mutation	1

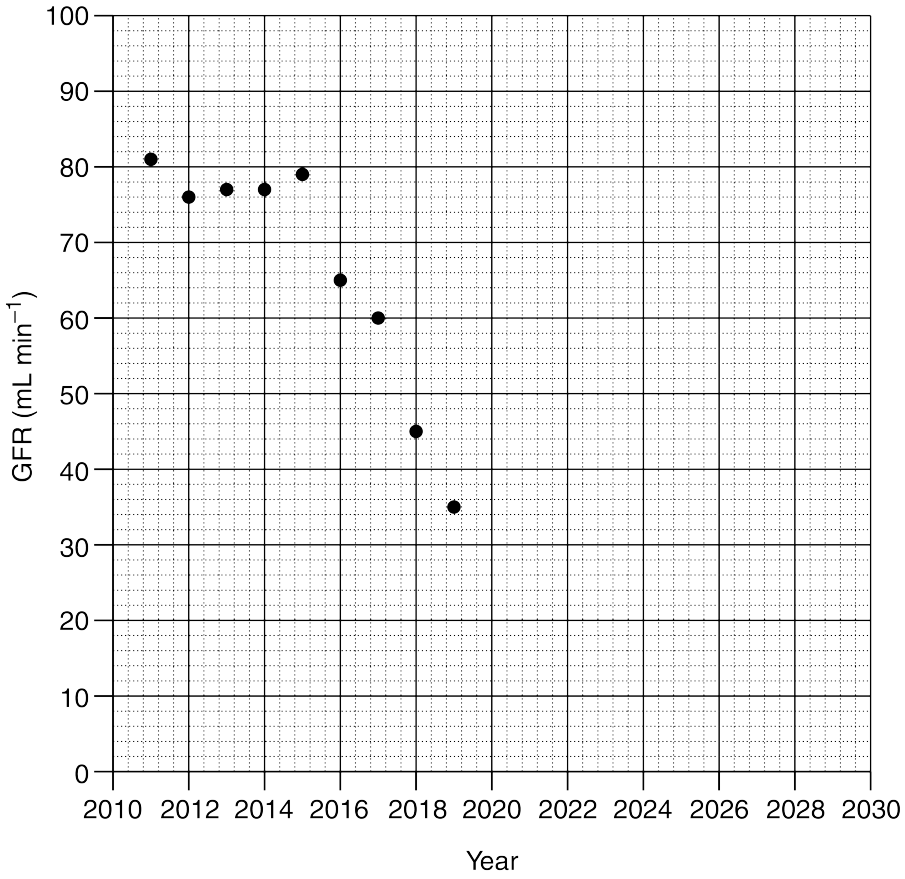
Sample answer:

Chromosomal mutations involve changes to the number of chromosomes in the genome.

Question 24 (a)

Criteria	Marks
• Completes appropriate graph of data	2
• Provides some relevant information	1

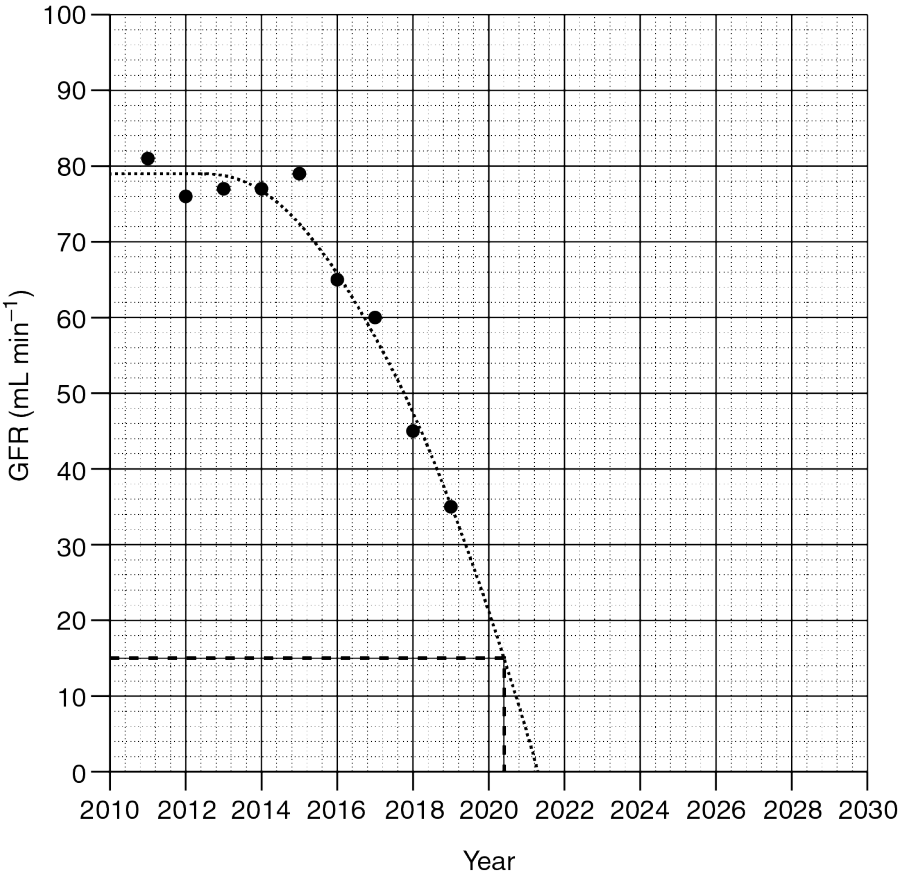
Sample answer:



Question 24 (b)

Criteria	Marks
• Uses a suitable line of best fit to show the year dialysis is likely to be required	2
• Attempts to use the graph to show the year dialysis is likely to be required	1

Sample answer:



Question 24 (c)

Criteria	Marks
• Describes a process occurring in dialysis • Relates how the identified process compensates for loss of a function of the kidneys	3
• Outlines process(es) in dialysis • Relates a process to loss of a function of the kidneys	2
• Provides some relevant information	1

Sample answer:

Loss of kidney function may result in a failure to remove urea from blood. In dialysis, blood from the patient passes through selectively permeable dialysis tubing. Because the urea diffuses from the high concentrations in the blood to the low concentrations in the dialysate, the urea is removed from the blood.

Question 25 (a)

Criteria	Marks
• Draws an appropriate conclusion from the data • Uses the data to provide justification for the validity of the conclusion	3
• Draws a relevant conclusion • Uses the data to provide a reason for the conclusion	2
• Provides some relevant information about the data	1

Sample answer:

Since there is little difference between the mean numbers of young/eggs produced in animals using the two modes of reproduction, and the variability of the data is large as shown by the standard deviations, the students could conclude that there is no difference between the number of young produced and the mode of fertilisation.

Question 25 (b)

Criteria	Marks
• Justifies a suitable improvement	2
• Provides a suitable improvement	1

Sample answer:

The students have selected only a very few species for their study and either by chance or by specific selection of these species the number of eggs/young born are similar. A much larger number of species should be included if the current hypothesis is to be reinvestigated.

Question 25 (c)

Criteria	Marks
• Explains an advantage of external fertilisation	2
• Provides a relevant advantage of external fertilisation	1

Sample answer:

Animals using external fertilisation will expend less energy on gestation, as this will occur outside the body.

Question 26 (a)

Criteria	Marks
• Uses the pedigree chart to explain that the yellow allele is recessive	2
• Provides some relevant information	1

Sample answer:

The inheritance of yellow colour is recessive since both parents are orange but have yellow offspring. The yellow allele must be present in both parents but it is not expressed.

Question 26 (b)

Criteria	Marks
• Explains the possible outcomes of a cross between I and II • Relates differences in the outcomes of the cross to justify the type of inheritance • Communicates information succinctly using appropriate scientific terms and formats	4
• Explains some outcomes of the cross between I and II including sex-linked inheritance • Communicates information logically using appropriate scientific terms and formats	3
• Describes an outcome of the cross between I and II through either sex-linked inheritance OR Mendelian genetics	2
• Provides any information relevant to the inheritance of colour in the fish	1

Sample answer:

If the inheritance is sex linked, then I and II would be X^AY and X^aX^a respectively. A cross between I and II would result in all male offspring being yellow and all female offspring being orange.

If the inheritance is not sex linked then II would have the genotype aa, whereas I would either have the genotype, AA or Aa. If I was AA then all of the offspring would be orange. But if I was Aa, then 50% of the offspring would be yellow while the other 50% would be orange and the colours would be equally distributed between male and female offspring.

Therefore, the absence of an orange, male fish as a result of the cross between I and II would confirm that the inheritance of colour in the fish is sex linked.

Answers could include:

Punnet squares.

Question 27 (a)

Criteria	Marks
• Identifies TWO features that contribute to the validity of the study	2
• Identifies ONE feature that contributes to the validity of this study	1

Sample answer:

Factors which contribute to the validity of the study could include:

- Age
- Sex
- Arsenic exposure
- Large sample size
- Socioeconomic status

Question 27 (b)

Criteria	Marks
• Provides points for and/or against the hypothesis • Relates points made to the data	4
• Provides a point for or against the hypothesis • Relates point to the data	3
• Describes trends	2
• Provides some relevant information	1

Sample answer:

Survival is highest in those exposed to less than 90 μg L^{-1} arsenic in both males and females. This group serves as a control showing that most young people in the study survived over the 11-year period. The level of arsenic to which they were exposed is higher than recommended by WHO but survival was high nevertheless.

In both males and females, increasing doses of arsenic led to decreased survival, which suggests that arsenic is causing the decline in survival. The increasing response to increasing doses was best seen in the males. In females, all doses over 90 μg L^{-1} led to a similar survival decrease which suggests there may be other factors that interact with the dose of arsenic to produce this result. Other factors could include nutritional state or genes.

Survival declined progressively over the 11 years, which supports the idea that as arsenic exposure increases over the years, survival declines. However, although the numbers in the study were large, survival only dropped by 0.1% or less.

Question 28 (a)

Criteria	Marks
• Explains the misunderstanding of meiosis shown in the model	3
• Describes in general terms the misunderstanding shown in the model	2
• Provides some relevant information	1

Sample answer:

The paired homologous chromosomes are incorrectly drawn. In a pair of chromosomes, one is paternal and the other is maternal. Prior to crossing over, each chromosome duplicates itself forming two chromatids and they should be identical, that is both chromatids should be either maternal or paternal and not different as shown in the model.

Question 28 (b)

Criteria	Marks
• Explains processes in meiosis that lead to genetic variation	3
• Explains a process in meiosis that leads to genetic variation OR • Identifies processes in meiosis that lead to genetic variation	2
• Provides some relevant information	1

Sample answer:

In meiosis, homologous chromosomes are lined up in Metaphase I in random order and orientation (independently assorted). They separate in Meiosis I, resulting in different combinations of parental chromosomes in the gametes. Crossing over is the exchange of genetic material between the chromatids of homologous chromosomes during Meiosis I. This leads to a new combination of alleles on each chromatid.

Question 29

Criteria	Marks
• Demonstrates a thorough understanding of TWO mechanisms by which gene pools change • Relates changes in the gene pool to evolution	5
• Links changes in the gene pool to evolution AND • Demonstrates a thorough understanding of ONE mechanism by which gene pools change OR • Demonstrates some understanding of TWO mechanisms by which gene pools change	3–4
• Outlines ways in which gene pools can change OR • Links changes in gene pools to evolution	2
• Provides some relevant information	1

Sample answer:

A gene pool is the total genetic diversity of a population – it results in variation of phenotypes and provides the basis for natural selection. When the gene pool of a population changes evolution has occurred.

Gene pools may change as a result of mutation, gene flow and genetic drift. Gene flow is the movement of alleles into or out of a population. For example a migrant animal may add new alleles when it reproduces with individuals in the population. Genetic drift is a change in allele frequency as a result of random selection of alleles. This is especially marked in a small, remnant population. The few remaining individuals that survive carry a small sample of the alleles in the original population.

Question 30

Criteria	Marks
• Outlines two relevant genetic technologies • Demonstrates a thorough understanding of infectious and non-infectious diseases • Relates the impact of specific genetic technologies to the management of both types of diseases	7
• Outlines/identifies two relevant genetic technologies • Demonstrates a sound understanding of infectious and non-infectious diseases • Relates the impact of genetic technologies to the management of diseases	5–6
• Outlines a relevant genetic technology • Demonstrates a sound knowledge of infectious and/or non-infectious diseases • Provides impact(s) of using genetic technologies	3–4
• Identifies a relevant technology AND • Demonstrates a basic knowledge of infectious or non-infectious diseases OR • Provides an impact of the technology	2
• Provides any relevant information	1

Sample answer:

Non-infectious diseases such as diabetes and cystic fibrosis are not caused by pathogens. In type 1 diabetes the pancreas no longer produces insulin. Recombinant DNA technology has produced bacteria that have a human insulin gene inserted and then produce insulin. The insulin can then be used to treat diabetic patients and keep them alive.

Replacing faulty genes in inherited diseases such as cystic fibrosis would be able to cure such conditions. It is possible to deliver a replacement gene to the lung cells via recombinant viruses. However, when lung cells are replaced the new cells (formed from stem cells) do not have the healthy version of the gene.

Infectious diseases are caused by pathogens. Crops such as corn are affected by the European corn borer. Recombinant Bt corn is produced by taking a gene from *Bacillus thuringiensis.* The gene codes for a protein that is toxic to the European corn borer, thus reducing disease in corn crops.

Question 31 (a)

Criteria	Marks
• Explains all the graphs with respect to the negative feedback control of blood glucose in healthy humans • Makes clear references to features of the graphs • Shows detailed understanding of control of blood glucose	6
• Explains the graphs with respect to the negative feedback control of blood glucose in healthy humans • Makes references to features of the graphs • Shows understanding of control of blood glucose	5
• Describes the graphs • Links the graphs to features of the negative feedback control of blood glucose	4
• Refers to feature(s) of the graphs • Links the feature(s) to the negative feedback control of blood glucose	3
• Refers to features of the graphs OR • Refers to a feature of a graph • Provides a feature of negative feedback control of blood glucose	2
• Provides some relevant information	1

Sample answer:

The plasma levels measured in the first 60 minutes represent resting levels. After the meal, plasma glucose rises as a direct result of absorption of glucose from the gut into the bloodstream.

Rising blood glucose stimulates *β* cells in the pancreas to release the hormone insulin, which stimulates body cells to take up glucose to be used in their metabolism and the liver to take up glucose to be stored as glycogen. Therefore, the rise in insulin in Figure 2 is a direct result of the rise in plasma glucose. As the cells and liver take up glucose, they remove the glucose from the blood leading to the subsequent fall in plasma glucose levels. The falling glucose removes the stimulation of *β* cells and by this negative feedback mechanism, insulin levels also fall.

Glucagon is a hormone that is an important part of the negative feedback loop that controls glucose levels in the blood. If plasma glucose falls to low levels, glucagon is released from alpha cells in the pancreas and causes glucose to be released into the blood from glycogen stores in the liver and muscles to restore normal glucose levels. In Figure 1, as glucose rises the alpha cells will produce less glucagon and falling glucagon levels can be seen in Figure 3. This will result in less glucose being released from the liver, reducing glucose levels.

Question 31 (b)

Criteria	Marks
• Outlines differences between control of blood glucose and body temperature	3
• Outlines a difference between control of blood glucose and body temperature OR • Identifies two differences	2
• Provides some relevant information	1

Sample answer:

Temperature changes are detected by the hypothalamus in the brain but changes in glucose are detected by the pancreas. The response to changes in temperature is via the nervous system but glucose is regulated via hormones.

Question 32 (a)

Criteria	Marks
• Identifies features that facilitate the transmission of rabies between hosts	2
• Provides some relevant information	1

Sample answer:

The virus is able to travel via the nervous system to the salivary glands. This can result in direct contact transmission when the infected host bites another animal.

Question 32 (b) (i)

Criteria	Marks
• Explains a feature that distinguishes the rabies virus from cellular pathogens	3
• Outlines feature(s) that distinguish between viral and cellular pathogens	2
• Provides some relevant information	1

Sample answer:

The rabies virus has a small genome composed of single-stranded RNA but the genome of cellular pathogens such as bacteria is much larger and is in the form of DNA which enables complex cellular processes without a host.

Question 32 (b) (ii)

Criteria	Marks
• Explains the role of RNA polymerase in reproduction of the rabies virus, including reference to transcription, production of proteins and viral RNA replication • Relates newly produced proteins to RNA polymerase and viral RNA replication	5
• Describes the role of RNA polymerase in reproduction of the rabies virus, including reference to transcription, production of proteins and viral RNA replication • Relates newly produced proteins to RNA polymerase	4
• Outlines the role of RNA polymerase in reproduction of the rabies virus including reference to the processes of transcription and RNA replication	3
• Provides some features of the role of RNA polymerase in reproduction of the rabies virus	2
• Provides some relevant information	1

Sample answer:

The viral RNA polymerase, which is made up of the L and P proteins, is responsible for the production of viral proteins and viral RNA, which are the components of new rabies viral particles.

RNA polymerase is responsible for transcription of the viral RNA into complementary mRNA strands, which are then translated into rabies viral proteins, G, M, N, P and L, by host cell ribosomes.

The replication of rabies viral RNA is facilitated by the newly produced L and P proteins (RNA polymerase). In this process, a complementary strand of viral RNA is produced from the original viral RNA strand. This complementary strand is then used as a template for the RNA polymerase to catalyse the production of more viral RNA. The new strands produced are therefore the same as the original viral RNA.

RNA polymerase is responsible for both the viral RNA and proteins needed in reproducing the virus.

Question 32 (c)

Criteria	Marks
• Accurately interprets and uses the relevant data and information to explain how PEP prevents rabies developing after exposure to the virus • Demonstrates an extensive knowledge of vaccination, passive and active immunity • Explains the role of antibodies • Communicates scientific information succinctly and logically using precise scientific terminology	8
• Interprets and uses the data to explain how PEP prevents rabies developing after exposure to the virus • Demonstrates a thorough knowledge of vaccination, passive and active immunity • Describes the role of antibodies • Communicates scientific information logically using correct terminology	7
• Interprets and uses data provided to explain how PEP prevents rabies • Demonstrates a sound knowledge of vaccination and immunity • Outlines the role of antibodies • Communicates using scientific terms	5–6
• Makes reference to information provided • Provides some information about the role of antibodies and/or vaccines in preventing rabies	3–4
• Provides relevant information about immunity and/or rabies	1–2

Sample answer:

Once the rabies virus has entered the wound it will use the patient's cells to replicate and the viral concentration increases (as seen in the first five days). Without PEP the virus will continue to replicate, migrate to the CNS (in the first graph this occurs by day 7), and eventually cause rabies and death.

Initially the patient does not have memory cells for the virus and does not produce antibodies to it. The injection of HRIG provides the patient with human antibodies that are specific to the virus, providing passive immunity. The antibodies will combine with viral molecules and inactivate them and also facilitate their destruction by white cells such as phagocytes. The PEP graph shows these antibodies will only last for up to 21 days but have an important initial role in controlling viral numbers (the data shows a reduction in viral concentration by days 6–8). The antibodies help to prevent the virus progressing to the CNS.

The rabies vaccine contains an inactivated, harmless version of the rabies virus and will result in the development of acquired, active immunity. This occurs when macrophages present the viral antigen to specific helper T cells that have surface receptors complementary to it. These helper T cells then stimulate specific B cells that have also been exposed to the antigen to undergo mitosis and cell differentiation. The daughter cells will either be plasma cells that produce antibodies or will be kept as memory B cells in case of future infection.

The PEP graph shows that by day 7 the production of antibodies begins and increases sharply over the next few days. This coincides with the rapid decrease in viral concentration. The viral particles are being inactivated by the presence of antibodies in increasing concentration.

By day 11 there are no viral particles left at the infection site and progression to the CNS and the disease has been avoided. Antibody concentration continues to increase as more rabies specific plasma cells are produced, with a maximum concentration being reached at 21 days after initial exposure and vaccination.

2020 HSC Biology
Mapping Grid

Section I

Question	Marks	Content	Syllabus outcomes
1	1	Mod 8 Homeostasis	Bio12–15
2	1	Mod 5 Reproduction	Bio12–12
3	1	Mod 5 Reproduction	Bio12–12
4	1	Mod 7 Causes of Infectious Disease	Bio12–14
5	1	Mod 5 DNA and Polypeptide Synthesis	Bio12–12
6	1	Mod 7 Prevention, Treatment and Control	Bio12–6, Bio12–14
7	1	Mod 7 Causes of Infectious Disease	Bio12–2, Bio12–14
8	1	Mod 8 Epidemiology	Bio 12–15
9	1	Mod 8 Epidemiology	Bio12–15
10	1	Mod 6 Mutation Mod 6 Genetic Technologies	Bio12–7, Bio12–13
11	1	Mod 8 Technologies and Disorders	Bio12–15
12	1	Mod 6 Genetic Technologies	Bio12–13
13	1	Mod 6 Genetic Technologies	Bio12–4, Bio12–13
14	1	Mod 5 Genetic Variation	Bio12–6, Bio12–12
15	1	Mod 7 Prevention, Treatment and Control	Bio12–5, Bio12–14
16	1	Mod 5 Cell Replication	Bio12–6, Bio12–12
17	1	Mod 6 Mutation	Bio12–13
18	1	Mod 6 Mutation	Bio12–6, Bio12–13
19	1	Mod 5 Genetic Variation	Bio12–6, Bio12–12
20	1	Mod 5 DNA and Polypeptide Synthesis	Bio12–6, Bio12–12

Section II

Question	Marks	Content	Syllabus outcomes
21	3	Mod 7 Prevention, Treatment and Control	Bio12–14
22	3	Mod 7 Prevention, Treatment and Control	Bio12–14
23 (a)	1	Mod 6 Mutation	Bio12–13
23 (b)	2	Mod 6 Mutation	Bio12–13
24 (a)	2	Mod 8 Technologies and Disorders	Bio12–4, Bio12–15
24 (b)	2	Mod 8 Technologies and Disorders	Bio12–4, Bio12–15
24 (c)	3	Mod 8 Technologies and Disorders	Bio12–6, Bio12–15
25 (a)	3	Mod 5 Reproduction	Bio12–2, Bio12–6, Bio12–12
25 (b)	2	Mod 5 Reproduction	Bio12–2, Bio12–6, Bio12–12
25 (c)	2	Mod 5 Reproduction	Bio12–6, Bio12–12
26 (a)	2	Mod 5 Genetic Variation	Bio12–5, Bio12–6, Bio12–12
26 (b)	4	Mod 5 Genetic Variation	Bio12–5, Bio12–6, Bio12–7, Bio 12-12

Question	Marks	Content	Syllabus outcomes
27 (a)	2	Mod 8 Epidemiology	Bio12–2, Bio12–15
27 (b)	4	Mod 8 Causes and Responses	Bio12–5, Bio12–6, Bio12-15
28 (a)	3	Mod 5 Cell Replication Mod 5 Genetic Variation	Bio12–6, Bio12–12, Bio12–13
28 (b)	3	Mod 6 Mutation	Bio12–6, Bio12–12, Bio12–13
29	5	Mod 6 Mutation	Bio12–6, Bio12–12, Bio12–13
30	7	Mod 6 Biotechnology Mod 6 Genetic Technologies Mod 7 Prevention, Treatment and Control Mod 8 Prevention	Bio12–6, Bio12–7, Bio12–13, Bio12–14, Bio12–15
31 (a)	6	Mod 8 Homeostasis	Bio12–5, Bio12–6, Bio12–7, Bio12–15
31 (b)	3	Mod 8 Homeostasis	Bio12–6, Bio12–7, Bio12–15
32 (a)	2	Mod 7 Causes of Infectious Disease	Bio12–14
32 (b) (i)	3	Mod 7 Causes of Infectious Disease	Bio12–6, Bio12–14
32 (b) (ii)	5	Mod 5 DNA and Polypeptide Synthesis Mod 7 Causes of Infectious Disease	Bio12–5, Bio12–6, Bio12–12, Bio12–14
32 (c)	8	Mod 7 Response to Pathogens Mod 7 Immunity Mod 7 Prevention, Treatment and Control	Bio12–5, Bio12–6, Bio12–7, Bio12–14