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.

---

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.

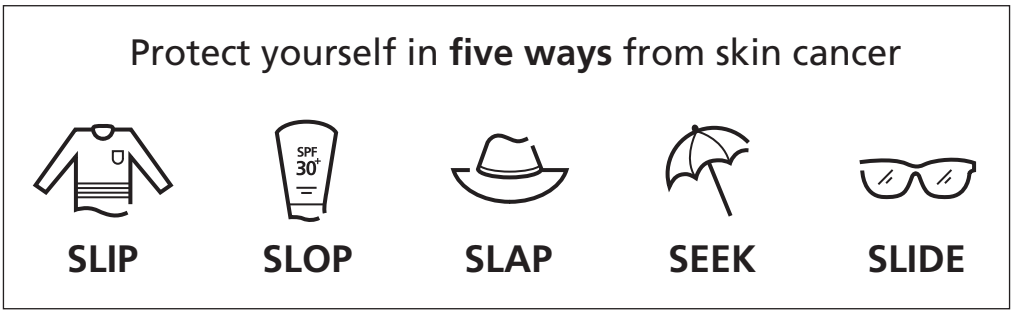
B. depend on long-term exposure to a pathogen.

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

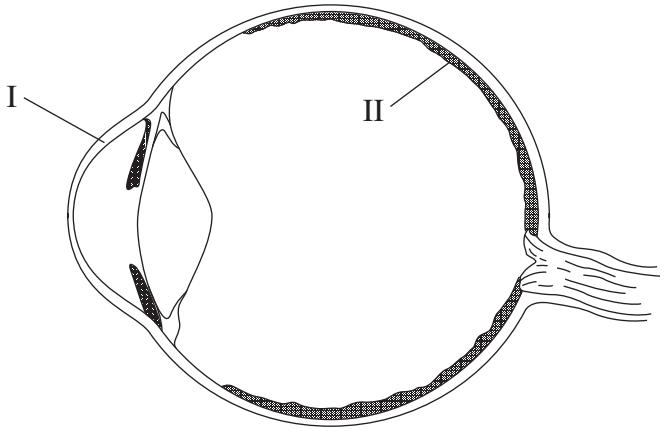
A. gene flow.

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?

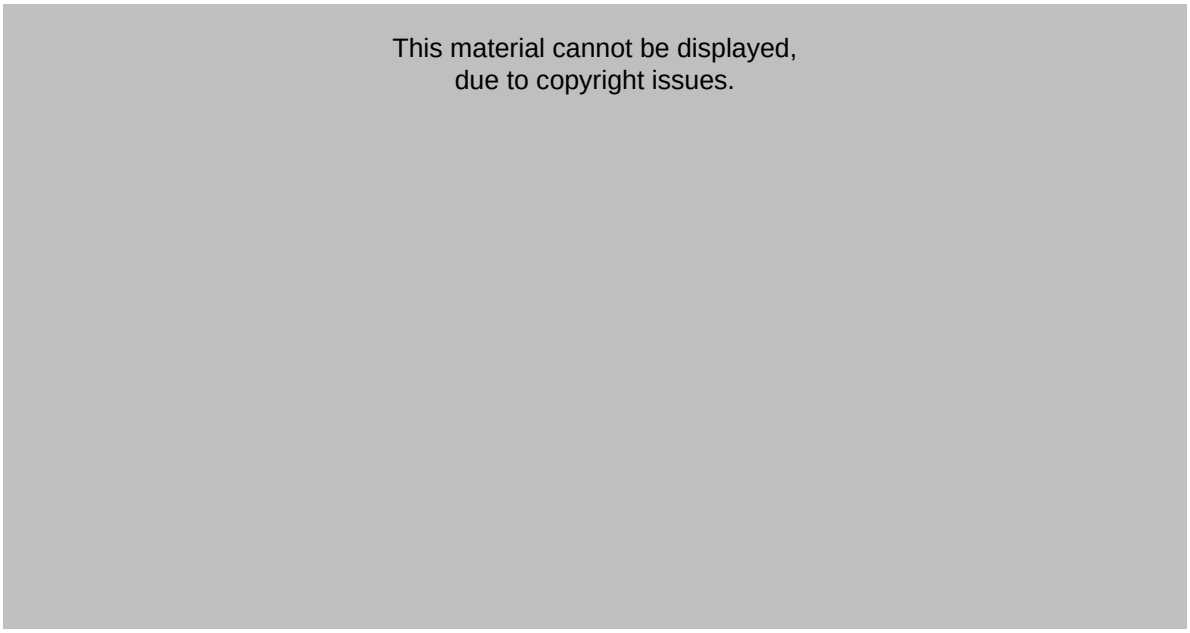
A. Increasing the frequency of recessive traits

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

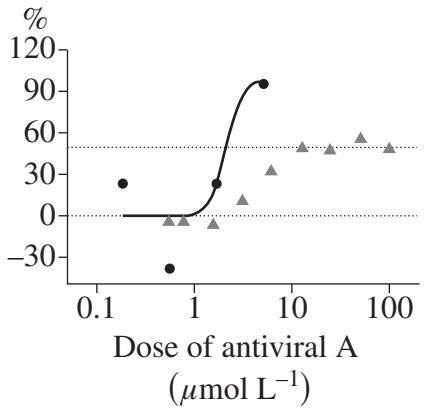
D. Incomplete dominance

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.

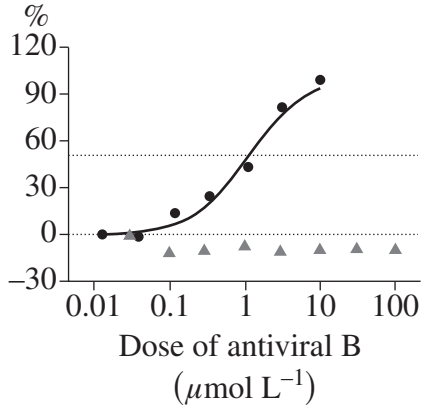
The ability of the drugs to inhibit viral entry to the cells (% inhibition) and the proportion of the cells killed by the drugs (% toxicity) were recorded at different doses of each drug and shown in the graphs.

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

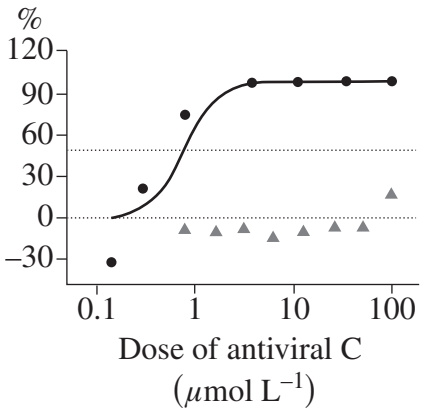
A.



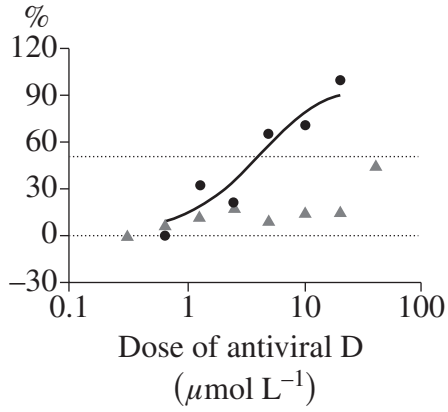
B.



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.

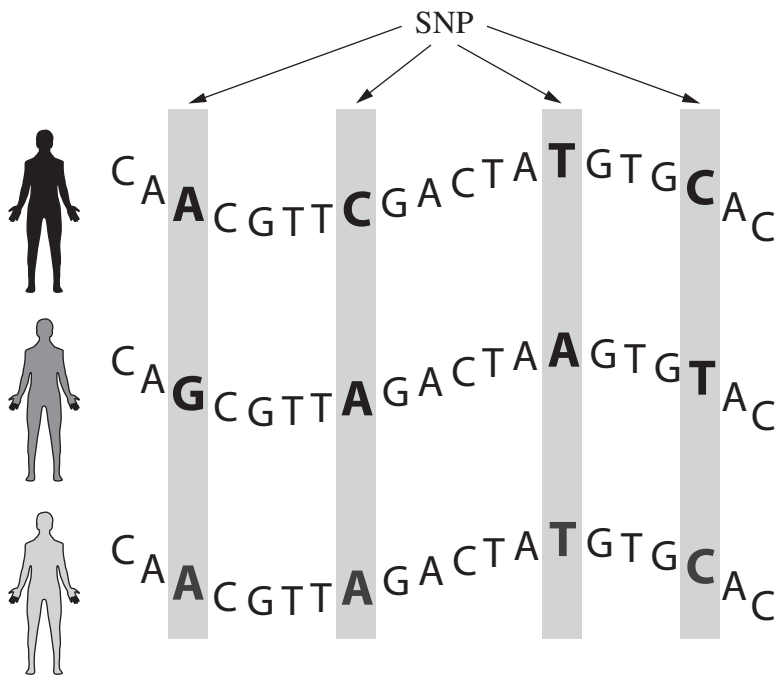
C. DNA always has adenine paired with guanine.

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.

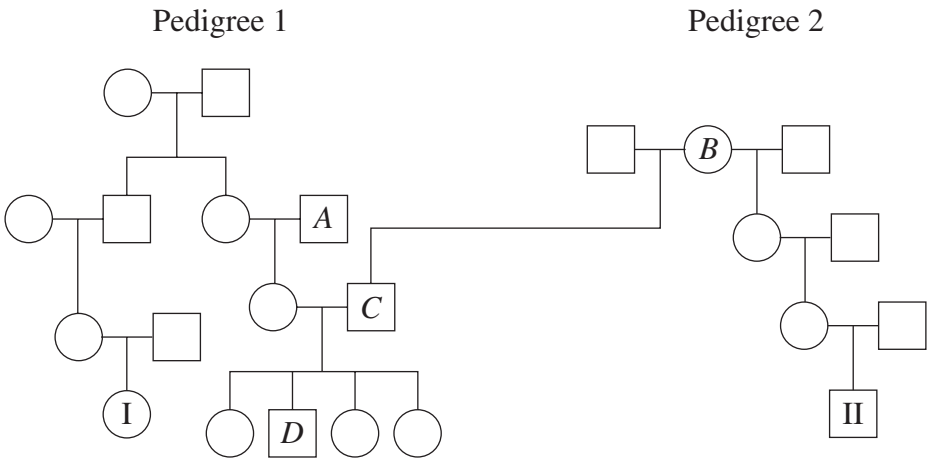
B. The SNPs are part of DNA that is not expressed.

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*

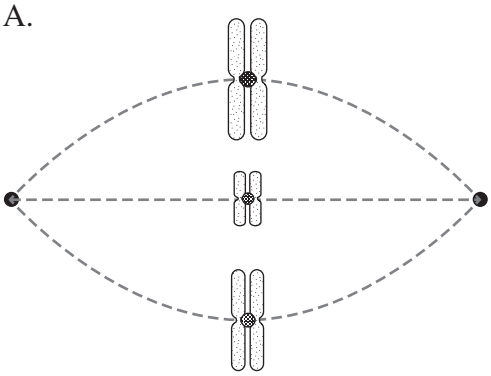
B. *B*

C. *C*

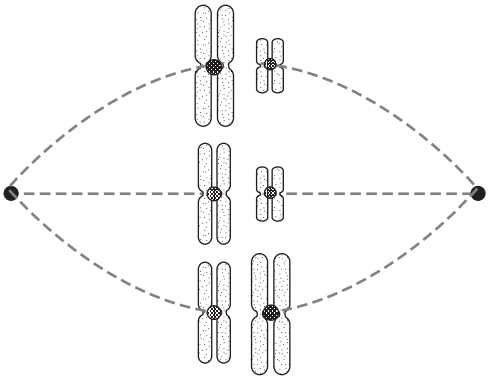
D. *D*

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

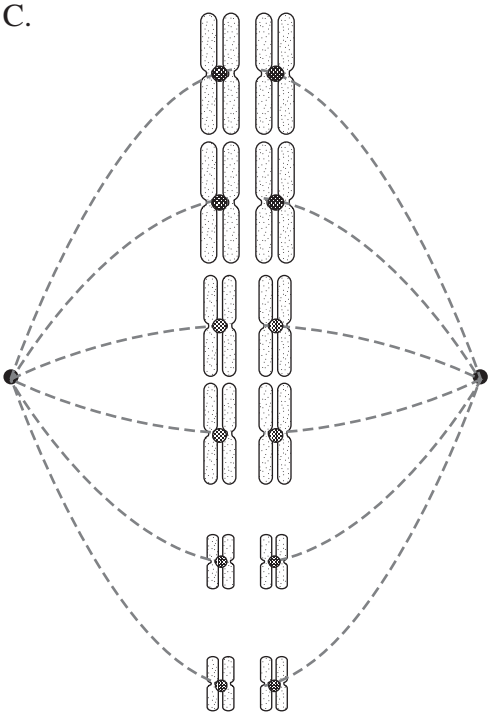
A.



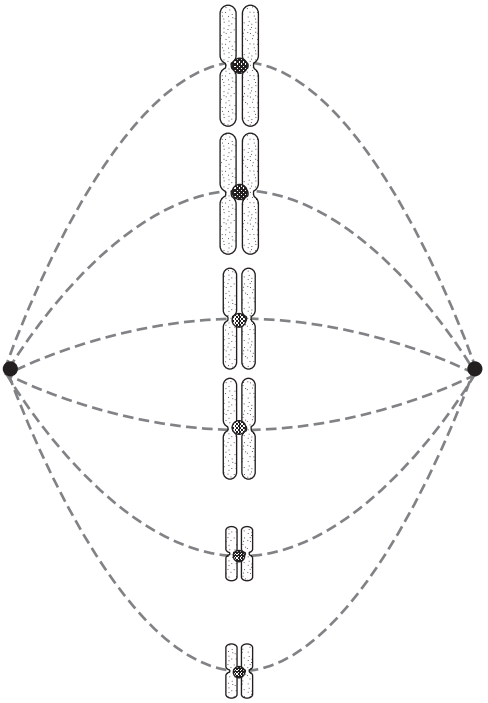
B.



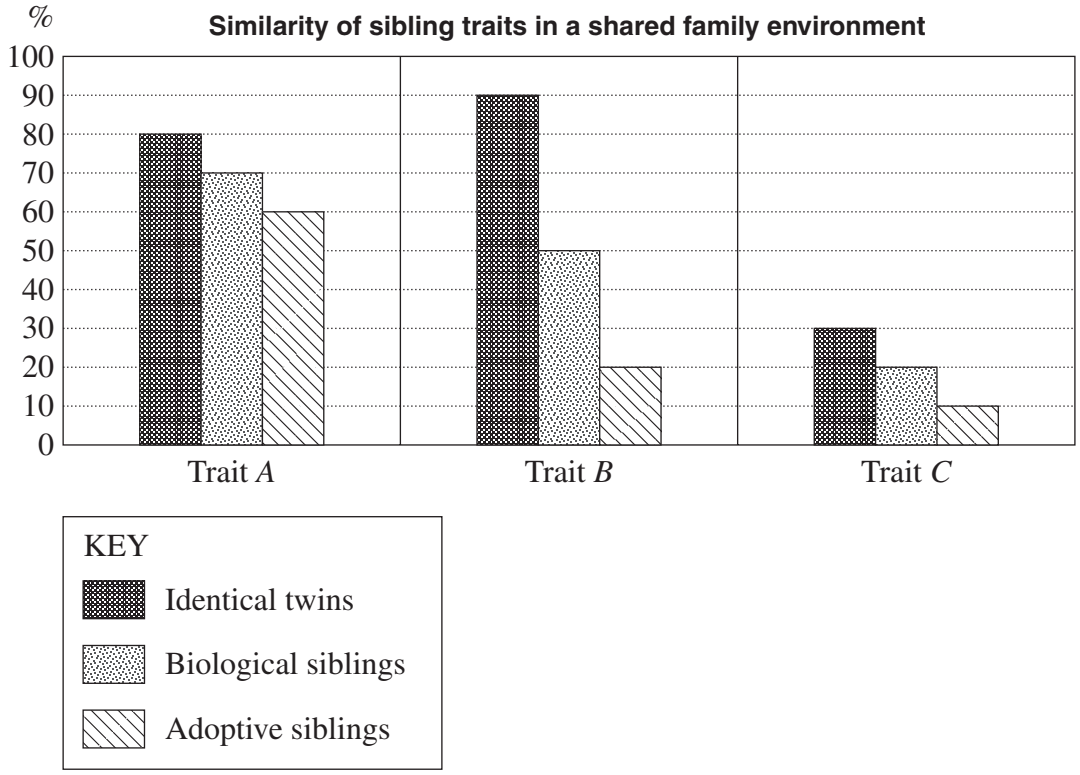
C.



D.



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

BLANK PAGE

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.

.....

.....

.....

.....

.....

Question 22 (3 marks)

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

.....

.....

.....

.....

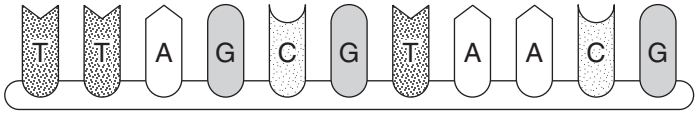
.....

.....

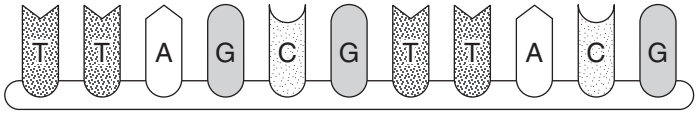
Question 23 (3 marks)

The following diagram shows a mutation.

Original DNA sequence



Mutated DNA sequence



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

.....

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

.....

.....

.....

Do NOT write in this area.

Question 24 (7 marks)

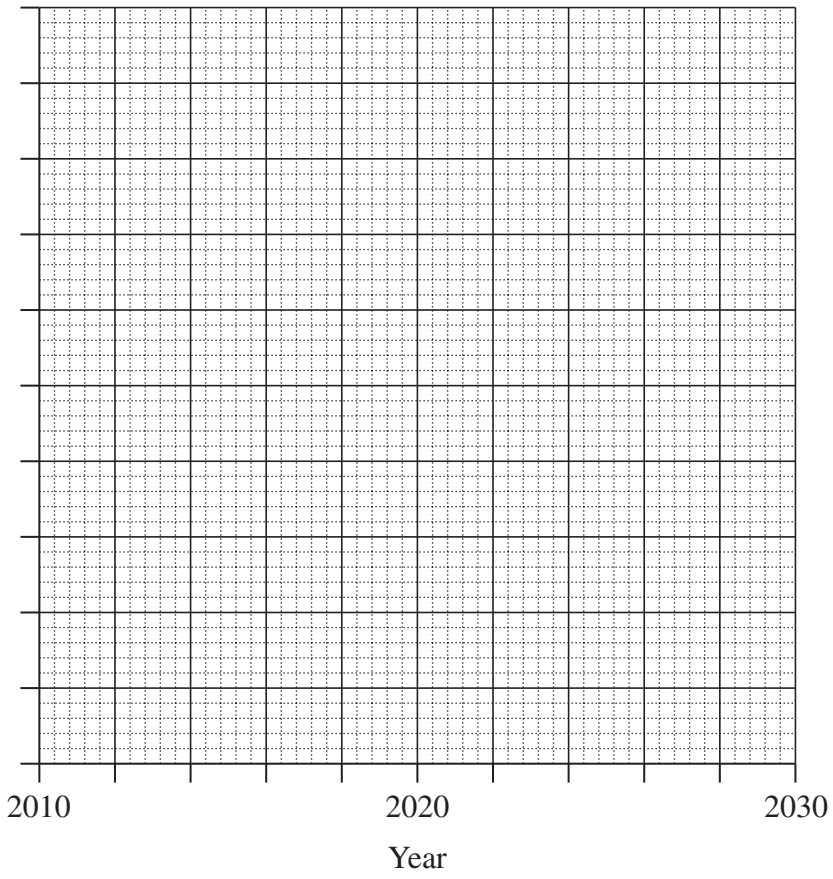
An indicator of kidney function is the volume of filtrate formed at the glomerulus in 1 minute (GFR).

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

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

.....

.....

.....

.....

.....

.....

.....

.....

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**

.....

.....

.....

.....

.....

.....

.....

Question 25 continues on page 19

Question 25 (continued)

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

.....

.....

.....

.....

.....

.....

.....

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

.....

.....

.....

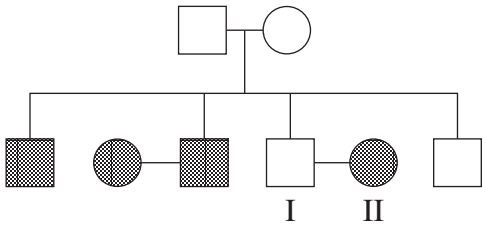
.....

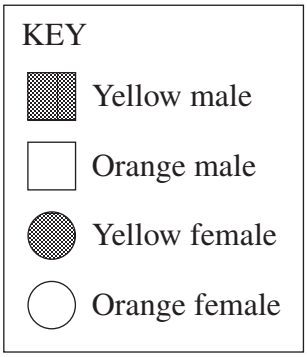
End of Question 25

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**

.....

.....

.....

.....

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**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

End of Question 26

Question 27 (6 marks)

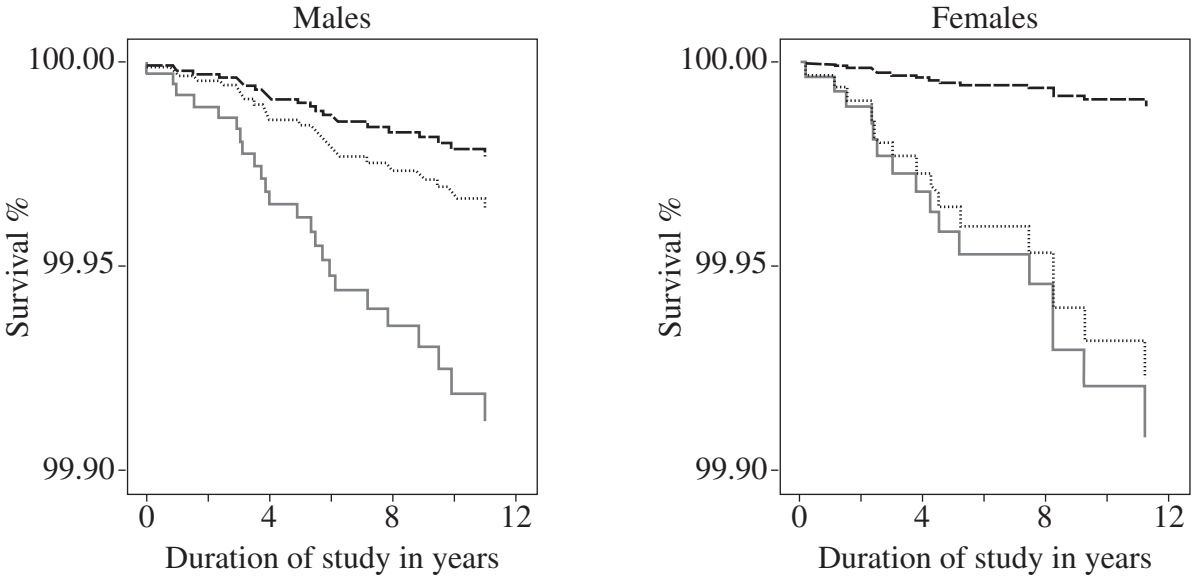
Exposure to arsenic in drinking water has been associated with the onset of many diseases. The World Health Organisation recommends arsenic levels in drinking water should be below 10 μg L^{-1}.

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**

.....

.....

(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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

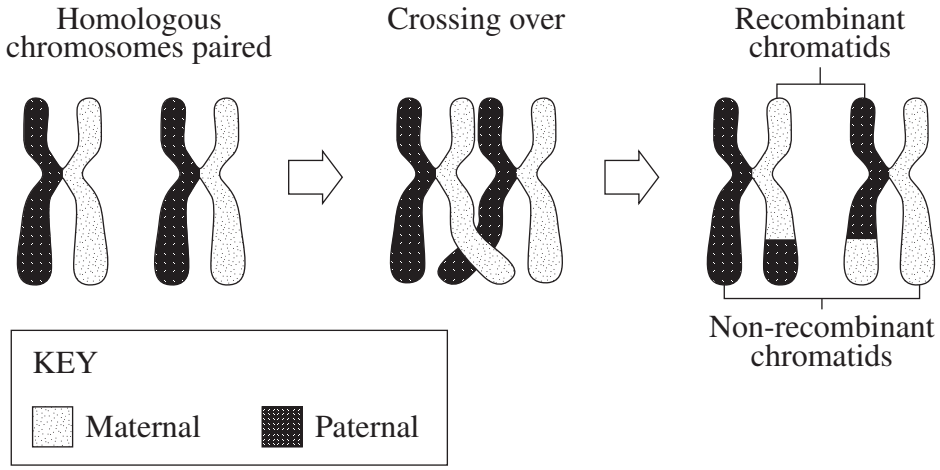
.....

.....

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.

.....

.....

.....

.....

.....

.....

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 29 (5 marks)

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

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Do NOT write in this area.

Question 30 (7 marks)

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

BLANK PAGE

Please turn over

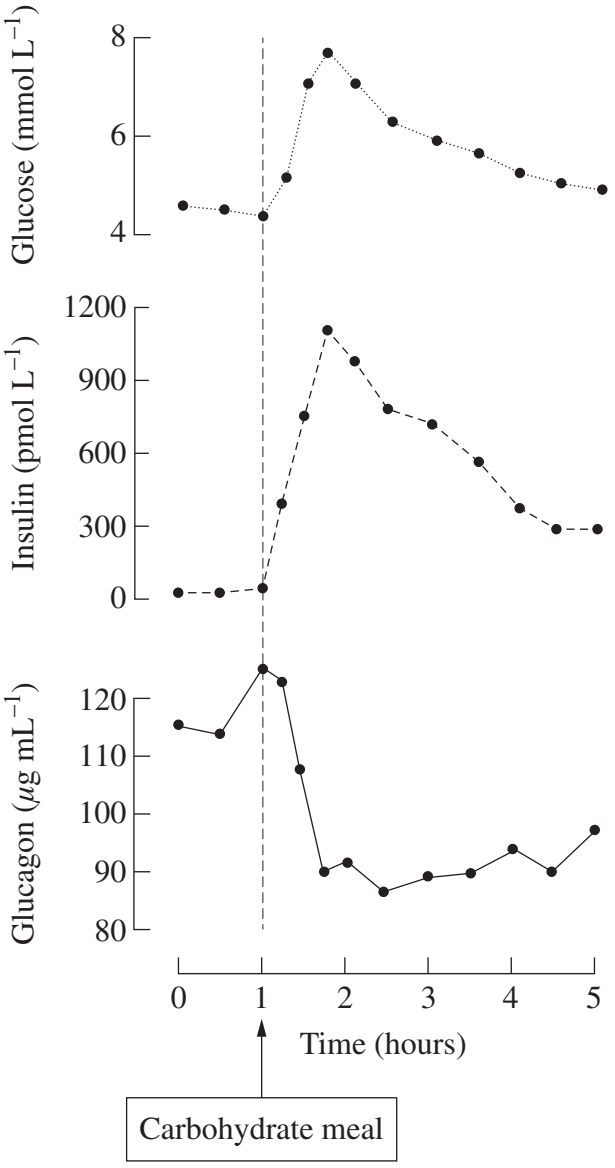
Question 31 (9 marks)

(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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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**

.....

.....

.....

.....

.....

.....

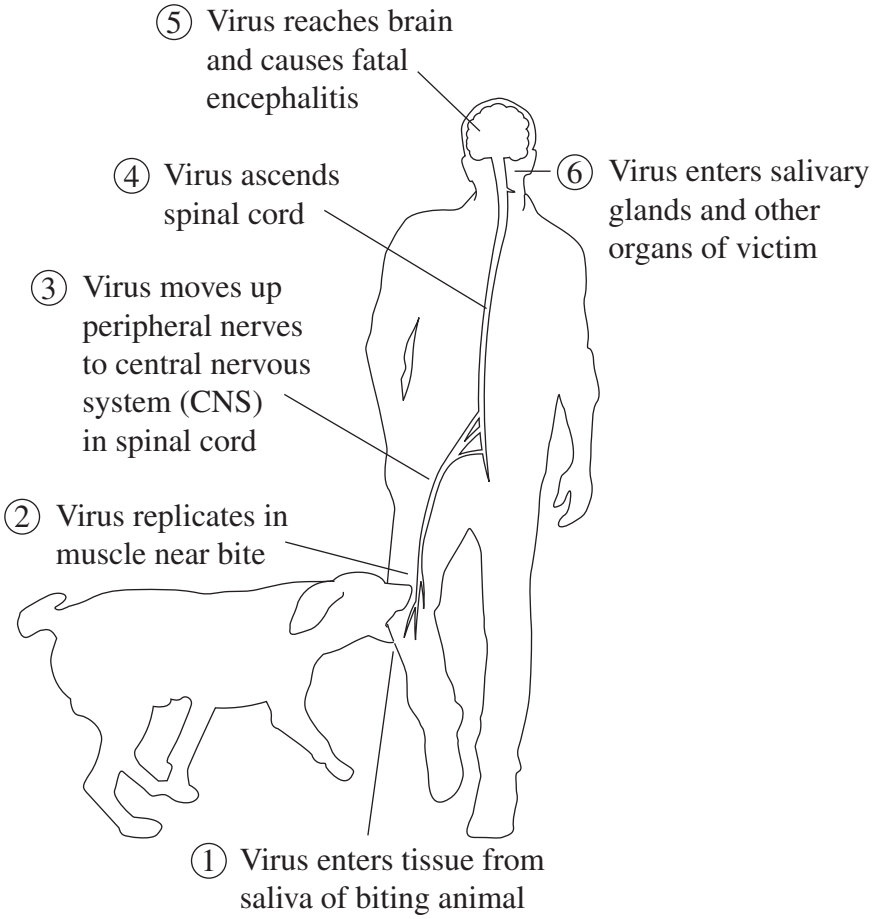
.....

.....

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.

.....

.....

.....

.....

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

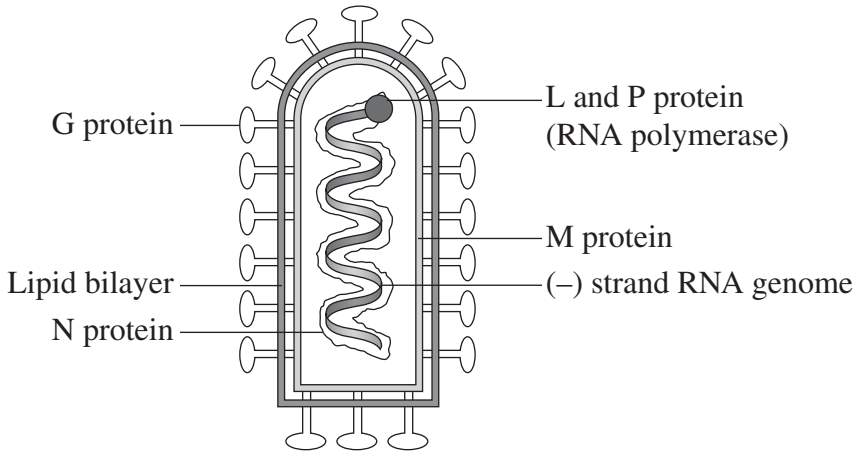
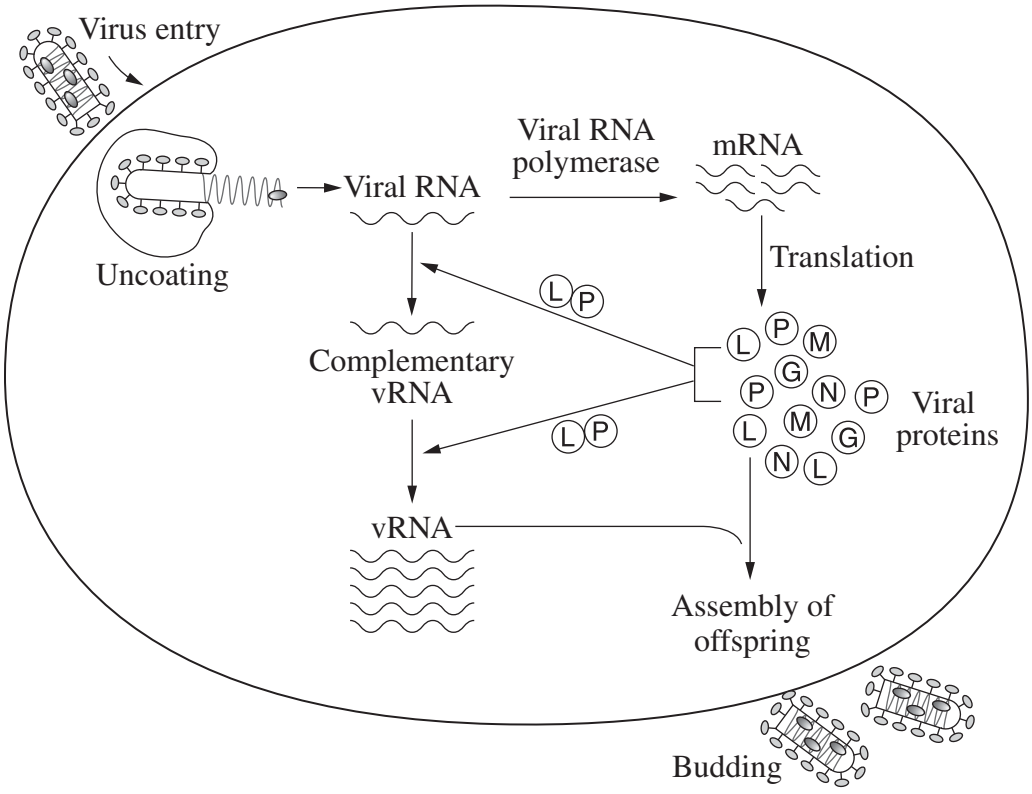


Diagram 2 – reproduction



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**

.....

.....

.....

.....

.....

.....

(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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Question 32 continues on page 34

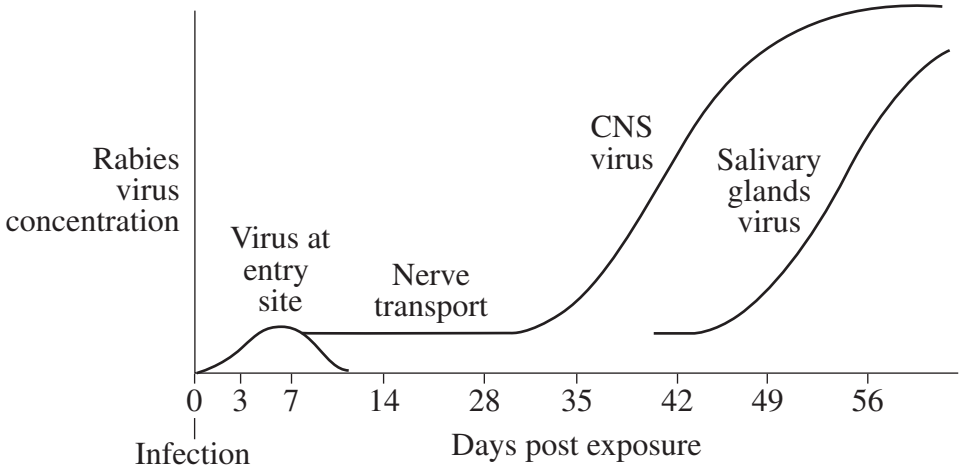
Question 32 (continued)

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

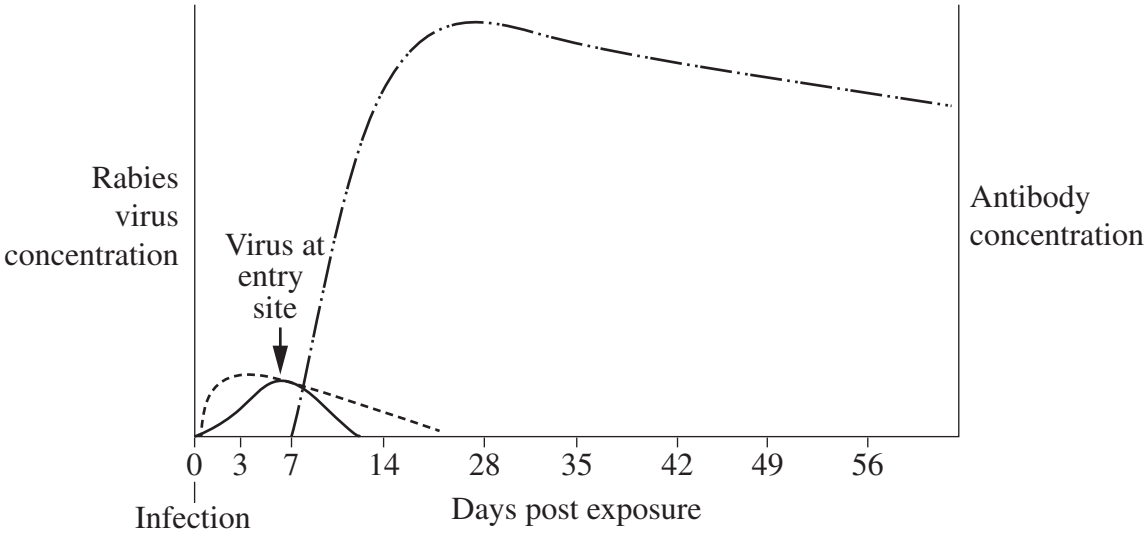
PEP includes an injection of human rabies antibodies (HRIG) as well as injections of a rabies vaccine at 0, 3, 7 and 14 days after exposure to the virus.

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.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

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.

0968310377

Do NOT write in this area.