

## **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?

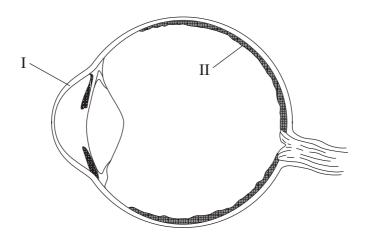
- A. By measuring exposure to the sun and skin cancer incidence
- B. By surveying beachgoers, asking if they remember the campaign
- C. By comparing skin cancer incidence before and after the campaign
- D. By counting the number of people on the beach wearing hats and sunglasses

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

- 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

A type of genetic technology is shown in the diagram.
This material cannot be displayed, due to copyright issues.
https://s3.amazonaws.com/s3.timetoast.com/public/uploads/photos/12791817/Gene_cloning.png

What type of cloning is modelled?

13

- 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

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.

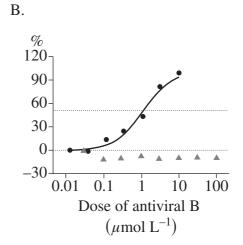
The ability of the drugs to inhibit viral entry to the cells (% inhibition) and the proportion of the cells killed by the drugs (% toxicity) were recorded at different doses of each drug and shown in the graphs.

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



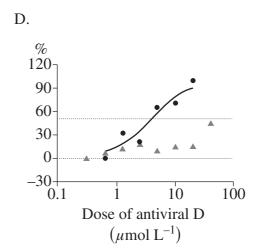
A.

90
120
90
60
30
0
-30
0
1 1 10 100
Dose of antiviral A
(\(\mu\text{mol L}^{-1}\)



C.

(%)
120
90
60
30
0
-30
0
11 1 10 100
Dose of antiviral C
(µmol L<sup>-1</sup>)



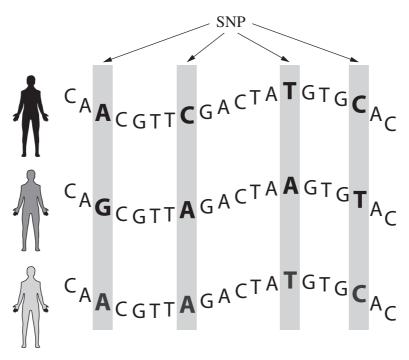
Analysis of DNA shows that adenine and guanine always make up 50% of the total amount of nitrogenous bases in DNA.

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.



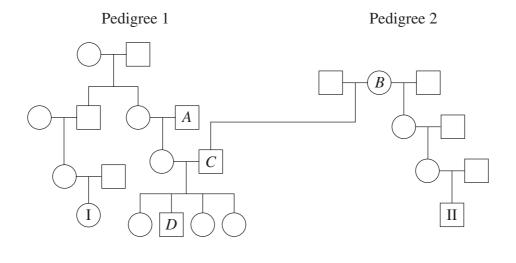


The SNPs modelled do not affect the phenotype of the individuals shown.

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**

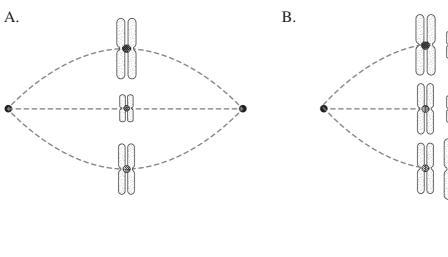
- I Database female with some SNPs in common with crime scene DNA
- II Database male with some SNPs in common with crime scene DNA

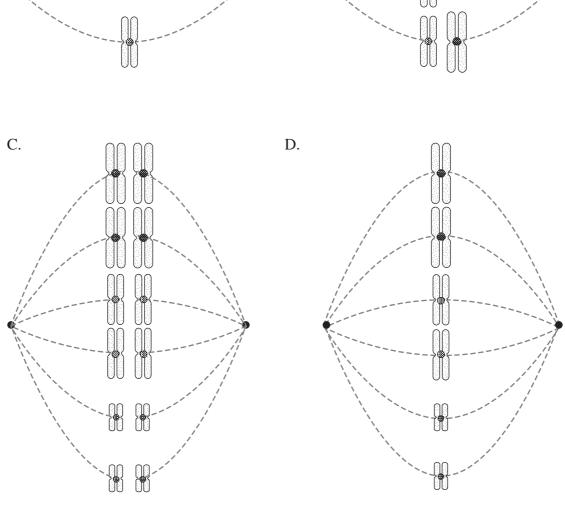
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Which person is most likely to be the suspect who should be investigated?

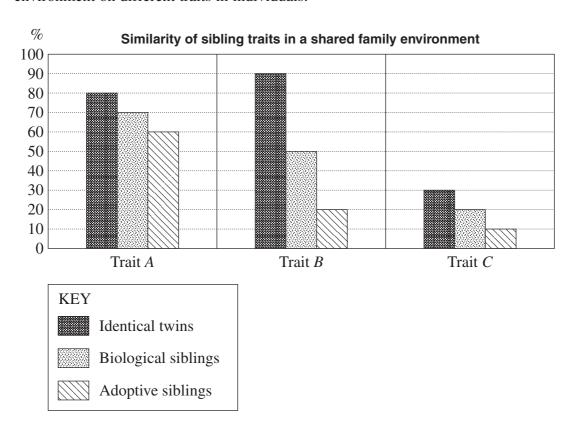
- A. *A*
- B. *B*
- C. *C*
- D. D

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





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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Biology						
Section II Answer Booklet			Stuc	lent	Nun	nber

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

Cholera is an acute diarrhoeal infection caused by the bacterium <i>Vibrio cholerae</i> . 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 21 (3 marks)

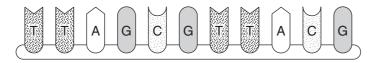
# Question 23 (3 marks)

The following diagram shows a mutation.

Original DNA sequence



Mutated DNA sequence



- (a) What type of mutation is shown in the diagram?
- (b) Outline another type of mutation.

1

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

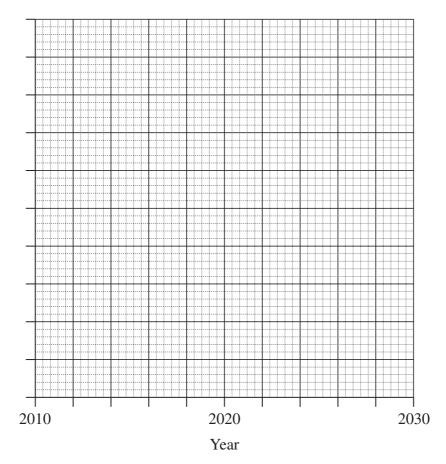
GFR of healthy adult	> 100 mL min <sup>-1</sup>
GFR needing dialysis	< 15 mL min <sup>-1</sup>

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 <sup>-1</sup> )	81	76	77	77	79	65	60	45	35

(a) Plot the data on the grid.





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

# Question 24 (continued)

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

**End of Question 24** 

Please turn over

3

## 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*	
	Red kangaroo	1		
	Bush rat	6		
Internal	White tipped reef shark	6	42   55	
fertilisation	Loggerhead turtle	126	$43 \pm 55$	
	Red bellied black snake	18		
	Guppy (fish)	100		
	Pouched frog	13		
	Loveridge's frog	20		
External	Corroboree frog	25	40 ± 22	
fertilisation	Turtle frog	50	$40 \pm 32$	
	Clownfish	100		
	Siamese fighting fish	30		

<sup>\*</sup>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.

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

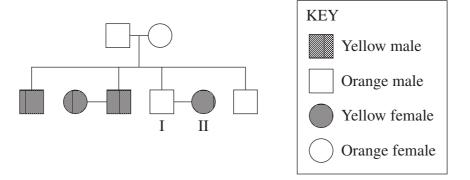
**End of Question 25** 

2

## 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.

Question 26 continues on page 21

# Question 26 (continued)

(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.

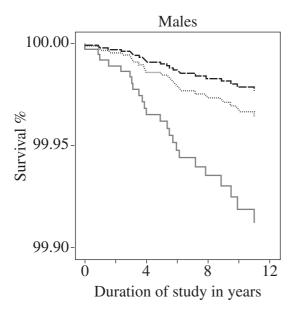
**End of Question 26** 

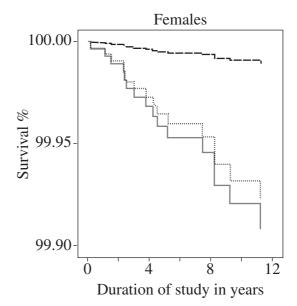
#### **Question 27** (6 marks)

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  $10 \mu g L^{-1}$ .

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.





Question 27 continues on page 23

Question	27	(continue	4)
Question	21	(Commue)	П

stud	ntify TWO features of the method used that contributed to the validity of this y.
•••••	
•••••	
	hypothesis put forward was that exposure to arsenic in drinking water eases mortality in young adults.
Disc	cuss the data presented in the graphs in relation to this hypothesis.
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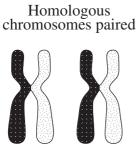
**End of Question 27** 

3

## Question 28 (6 marks)

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

3



(b)

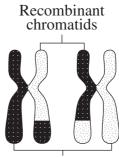






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Non-recombinant chromatids

KEY	
Maternal	Paternal

-	nisunderstanding		l. 

Explain the effect of meiosis on genetic variation.

# Question 29 (5 marks)

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

7

# Question 30 (7 marks)

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

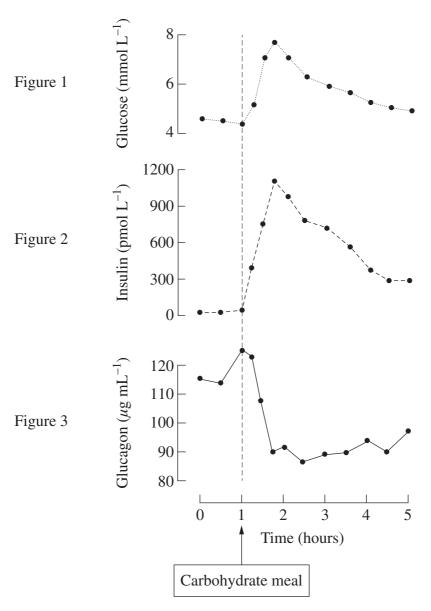
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## Question 31 (9 marks)

(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



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## 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

3

# Question 31 (continued)

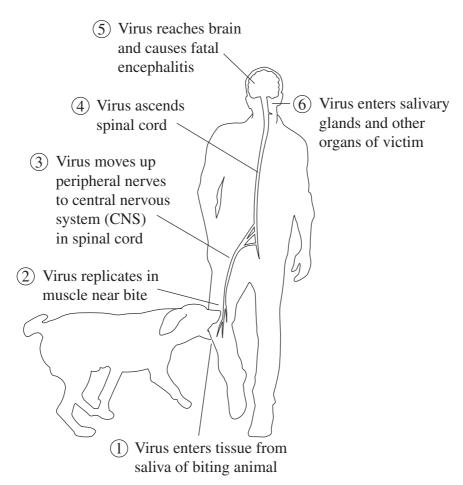
"	glucose is controlled.

**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

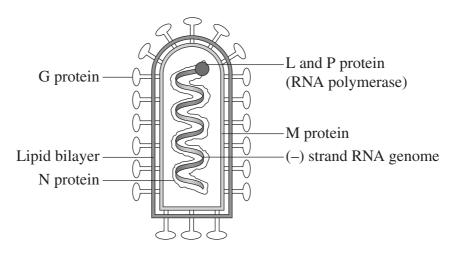
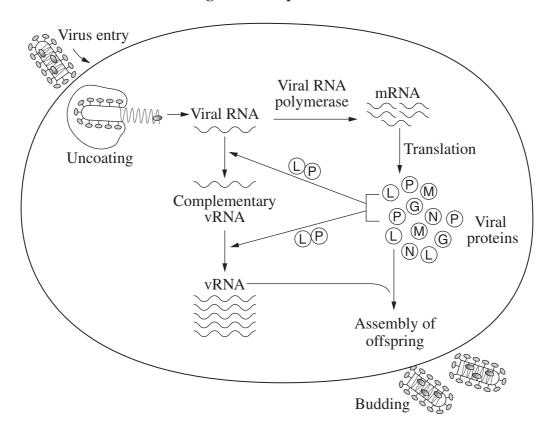


Diagram 2 - reproduction



Question 32 continues on page 33

Question	32	(continued)
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(i)	Use the information provided in Diagram 1 to explain why the rabies virus cannot be classified as a cellular pathogen.	
(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

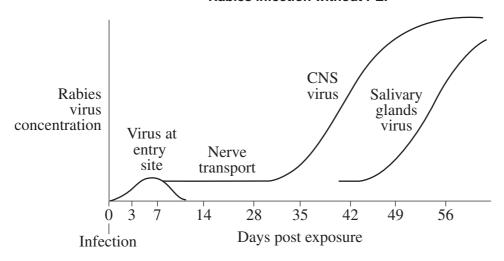
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Post exposure prophylaxis (PEP) is given to patients who have been bitten by a rabid animal.

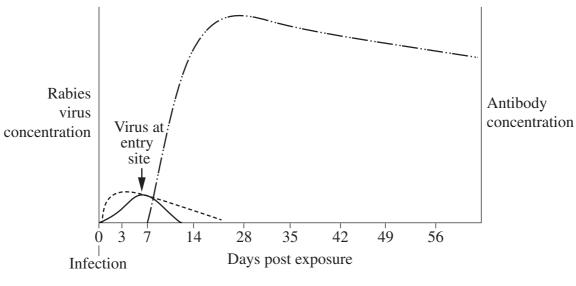
PEP includes an injection of human rabies antibodies (HRIG) as well as injections of a rabies vaccine at 0, 3, 7 and 14 days after exposure to the virus.

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