National Qualifications 2023

X807/77/02

Biology
Section 1 — Questions

THURSDAY, 27 APRIL

1:00 PM – 4:00 PM

Instructions for the completion of Section 1 are given on *page 02* of your question and answer booklet X807/77/01.

Record your answers on the answer grid on *page 03* of your question and answer booklet.

Before leaving the examination room you must give your question and answer booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

SECTION 1 — 20 marks

Attempt ALL questions

1. The proteome is

A all the genes expressed as proteins

B the entire set of proteins expressed by the genome

C the number of proteins expressed due to alternative RNA splicing

D the number of proteins expressed due to alternative RNA splicing and post-translational modification.

2. Transmembrane proteins carry a signal sequence, which halts translation and directs the ribosome synthesising the protein to dock with the

A plasma membrane

B endoplasmic reticulum

C transport vesicle

D golgi apparatus.

3. Cell components can be separated by a technique called differential centrifugation.

This technique uses a series of centrifugation steps at specific centrifugation forces (g) for a given time. After each step, the supernatant is removed and the cell components in the pellet identified. The supernatant is re-centrifuged at a higher centrifugation force for a longer time.

The table gives information about a differential centrifugation experiment.

Step	Centrifuge conditions		Cell component(s) in pellet
	Force (g)	Time (minutes)	
1	600	10	nucleus, cytoskeleton
2	15 000	15	mitochondria
3	100 000	60	plasma membrane, endoplasmic reticulum fragments

Plasma membrane would be present in the supernatant of which centrifugation step(s)?

A 1 only

B 2 only

C 1 and 2 only

D 3 only

4. Which row in the table is correct for positive modulators?

	Binding site	**Effect of binding on enzyme affinity for substrate**
A	allosteric	increases
B	active	increases
C	allosteric	decreases
D	active	decreases

5. Which row in the table describes events in signalling by the hormone insulin?

	Location of insulin binding site	**Mechanism of signal transduction**
A	intracellular	G-protein activation
B	intracellular	phosphorylation
C	extracellular	G-protein activation
D	extracellular	phosphorylation

[Turn over

6. A newly identified drug designed to treat cancer by inhibiting cell cycle progression was tested on cancer cells *in vitro*. The distribution of the cancer cells across the different phases of the cell cycle was then investigated by measuring the DNA content of the cells.

Results for untreated cells are shown in **Figure 1** and for treated cells in **Figure 2**. DNA content is displayed with arbitrary units where 2n units represents the DNA content of a non-dividing diploid cell.

Figure 1

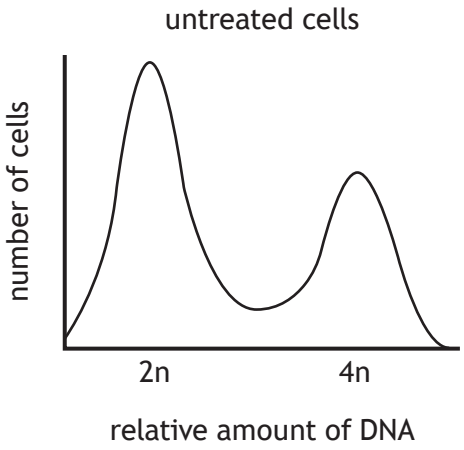
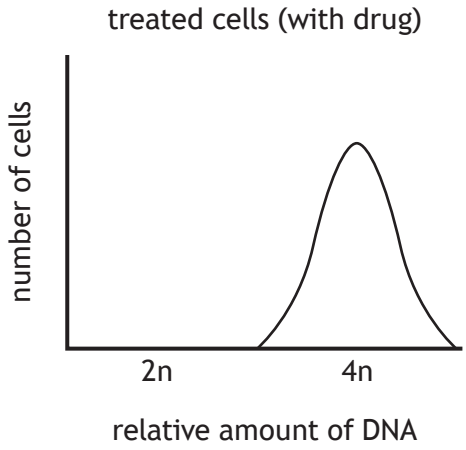


Figure 2



At which phase(s) of the cell cycle does this drug act?

A G1 only

B S only

C G1 and G2

D G2 or M

7. The three Rs of replacement, reduction and refinement are used in animal studies to avoid, reduce or minimise the harm to animals.

Which of the following is an example of replacement?

A Use of most appropriate anaesthetic regimes for pain relief during procedures.

B Smaller mammals such as mice or rats instead of larger mammals.

C Substitution of *in vivo* studies with tissue culture to test the effect of a new drug.

D Less invasive techniques instead of surgical techniques.

8. Active cyclin-CDK complexes regulate the cell cycle by

A phosphorylation of specific proteins

B proteolytic cleavage of specific proteins

C dephosphorylation of specific proteins

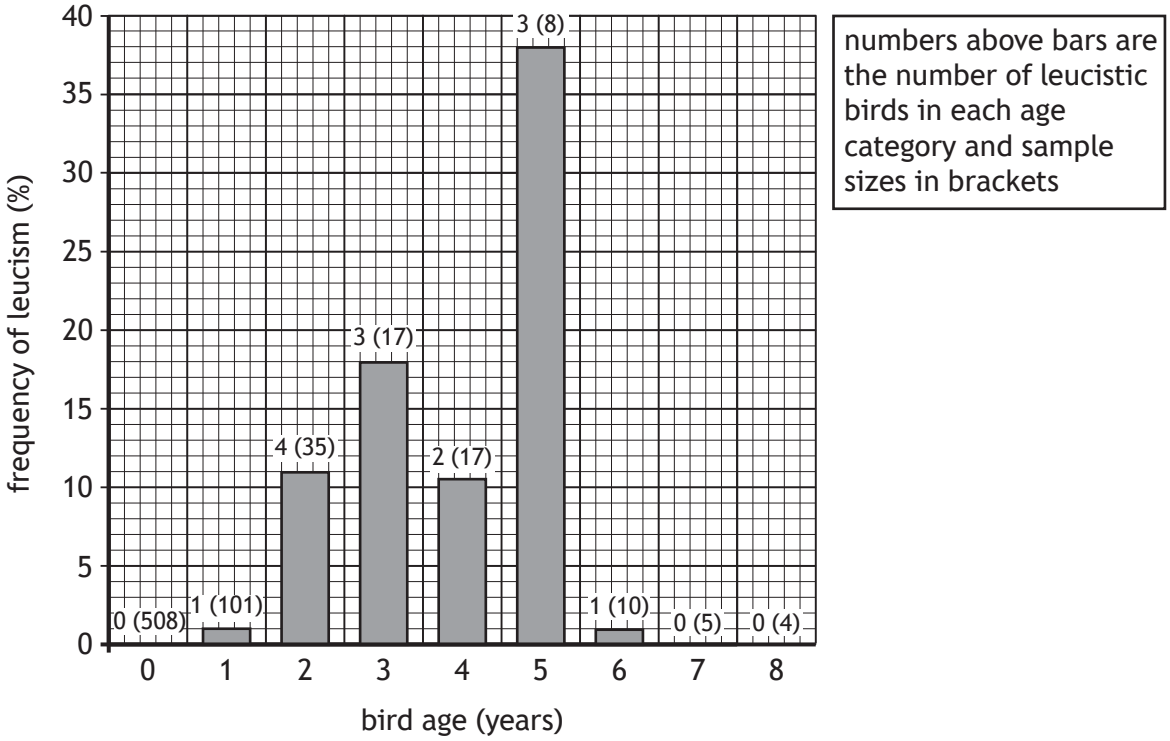
D acting as transcription factors.

9. Leucism is the lack of melanin (dark) pigments in all or part of the skin, hair, or feathers. It is found in many animal species, and in birds it results in the partial or complete absence of melanin in one or more feathers. The figures show data from a study of leucism in a population of red-necked nightjars conducted in a national park in Spain from 2016–2020. Nightjars are considered adults when they are two years old and over.

Figure 1

Year	Number leucistic		Total number		Frequency (%)	
	Males	Females	Males	Females	Males	Females
2016	2	2	64	107	3.13	1.87
2017	2	4	74	98	2.70	4.08
2018	2	0	75	108	2.67	0.00
2019	3	3	78	72	3.85	4.19
2020	0	5	43	88	0.00	5.68

Figure 2



Which of the following conclusions about leucism in nightjars **cannot** be drawn from the data shown?

A Leucism occurs at similar frequencies overall in males and females.

B The frequency of leucism is low in older birds because leucistic individuals have a greater risk of predation.

C The frequency of leucism shows considerable annual variation.

D The frequency of leucism increases markedly from the juvenile to the adult stage.

10. The alveoli of vertebrate lungs have thin walls, constructed of a single layer of epithelial cells, which allow rapid diffusion of gases. The rate of diffusion of oxygen across exchange surfaces can be calculated using the following formula:

$$\text{Rate} = P \times A \times \frac{(C_1 - C_2)}{T}$$

where: P is the permeability constant

A is the surface area

C_1 is the higher concentration

C_2 is the lower concentration

T is the thickness of the exchange surface.

A section of alveolar epithelium has a surface area of 2.2 μm^2 and is 1.0 μm thick. The permeability constant of the epithelium for oxygen is 0.012 s^{-1}. The concentration of oxygen on one side of the epithelium is 2.3×10^{-16} mol μm^{-3} and the concentration on the other side is 9.0×10^{-17} mol μm^{-3}.

What is the rate of diffusion of oxygen across this alveolar epithelium?

A 1.8×10^{-1} mol μm^{-2} s^{-1}

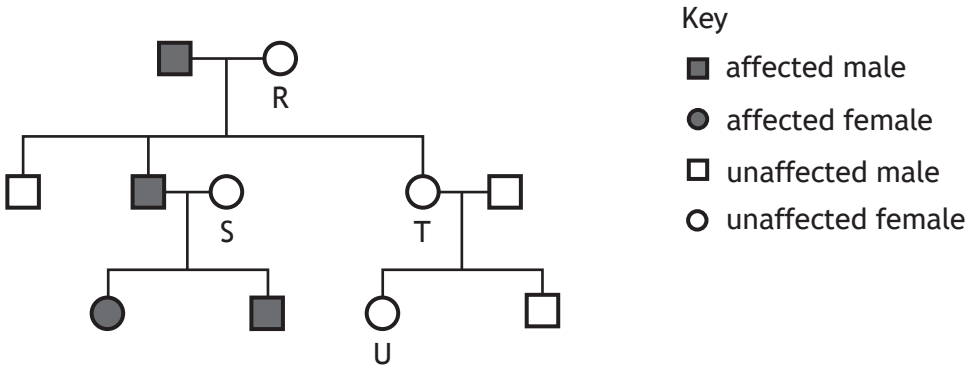
B 2.3×10^{-16} mol μm^{-2} s^{-1}

C 1.8×10^{-18} mol μm^{-2} s^{-1}

D 3.7×10^{-18} mol μm^{-2} s^{-1}

11. Red-green colour deficiency is a sex-linked condition caused by a recessive allele.

The diagram shows the inheritance of this condition in a family.



Using the information given in the diagram, which of the females **must** be carriers of red-green colour deficiency?

A S only

B R and S only

C R, S and T only

D R, S, T and U

12. Steps 1 to 6 describe some events that occur during meiosis. Some terms are represented by the letters J, K, L and M.

1. Chromosomes replicate to form two identical chromatids.
2. Homologous chromosomes pair up and points of contact form between **J** chromatids of a homologous pair.
3. **K** takes place to form new combinations of alleles of linked genes.
4. Chromosomes of each homologous pair attach to spindle fibres and separate to opposite poles.
5. **L** occurs and two daughter cells form.
6. Two daughter cells undergo further division separating **M** chromatids of each chromosome.

Which row in the table identifies J, K, L and M?

	J	**K**	**L**	**M**
A	non-sister	cytokinesis	crossing over	sister
B	sister	crossing over	cytokinesis	non-sister
C	non-sister	crossing over	cytokinesis	sister
D	sister	cytokinesis	crossing over	non-sister

[Turn over

13. Which of the following formulae would allow absolute fitness to be calculated?

A $\frac{\text{number of surviving offspring per individual of a particular genotype}}{\text{number of surviving offspring per individual of the most successful genotype}}$

B $\frac{\text{number of surviving offspring per individual of the most successful genotype}}{\text{number of surviving offspring per individual of a particular genotype}}$

C $\frac{\text{frequency of a particular genotype before selection}}{\text{frequency of a particular genotype after selection}}$

D $\frac{\text{frequency of a particular genotype after selection}}{\text{frequency of a particular genotype before selection}}$

14. In pea plants, the allele for yellow peas is dominant to the allele for green peas.

A sample of 100 peas contained 84 yellow and 16 green peas.

What is the frequency of the yellow allele in this population?

A 0.36

B 0.40

C 0.60

D 0.84

15. An experiment investigated the effect of an insecticide on local wild bee populations. Scientists sampled each species of bee in proportion to the contribution its population size made to the total number of bees of all species present in the area.

What name is given to this type of sampling strategy?

A Random sampling

B Stratified sampling

C Systematic sampling

D Point count sampling

16. Eukaryotic chromosomes end in repetitive non-coding sequences of DNA called telomeres.

Telomeres protect the coding DNA but become shorter with each round of DNA replication.

The shortening of telomeres explains why many cells have a limited number of cell divisions and is associated with the ageing processes in organisms.

Rapidly dividing cells may use an enzyme called telomerase to increase the lengths of telomeres.

Parasitic infections often increase the rate of cell division.

A student made the following predictions:

1. Parasitic infections can lead to faster ageing.
2. Telomerase activity will be low in cancer cells.
3. There is a positive correlation between telomere length and age.
4. Telomerase activity will be high in yeast cultures where there is a high reproductive rate.

Which of these predictions are consistent with the information given?

A 1 and 2

B 1 and 4

C 2 and 3

D 3 and 4

[Turn over

17. A student was planning an investigation into the effect of temperature on the rate of respiration in yeast; this was measured using a carbon dioxide probe. As part of their pilot studies, they used the probe to take three readings from one sample.

This would be most useful for checking

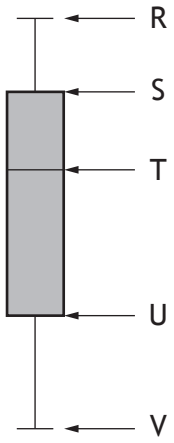
A precision

B accuracy

C reliability

D validity.

18. The diagram shows a boxplot for a set of data.



Which statement about the dataset represented by this boxplot is true?

A T is the mean value

B R minus V is the interquartile range

C 50% of the data are above U

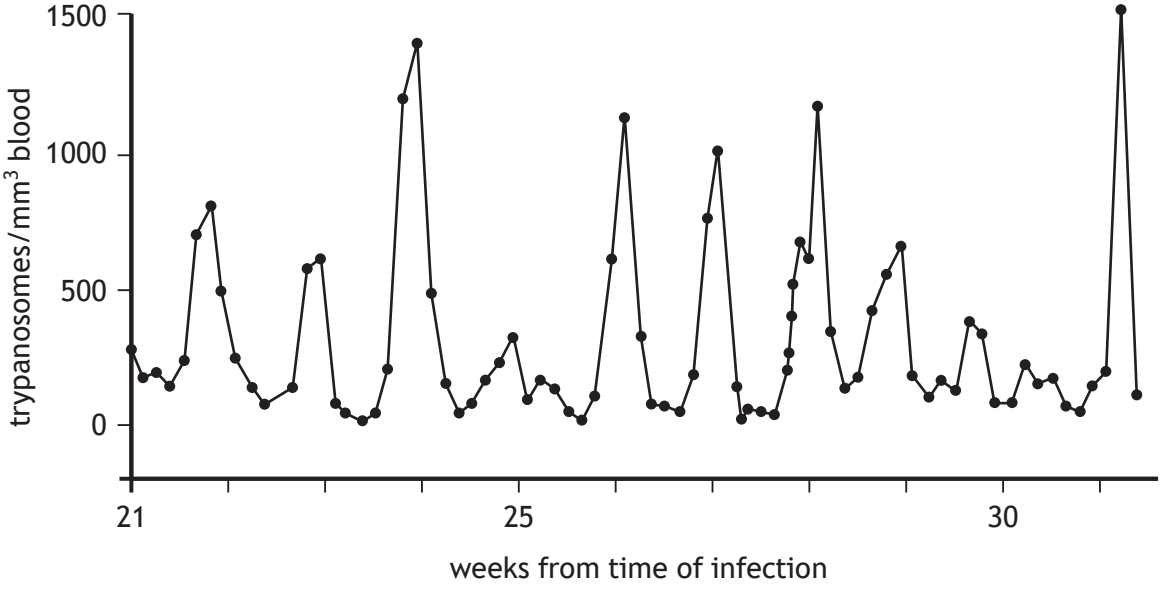
D 75% of the data are below S

19. Which row in the table describes natural killer cells?

	Type of response		Mechanism of action	
	Specific	**Non-specific**	**Induce apoptosis in parasite-infected cells**	**Use enzymes in lysosomes to digest parasites**
A	✓	✗	✓	✗
B	✓	✗	✗	✓
C	✗	✓	✓	✗
D	✗	✓	✗	✓

20. *Trypanosoma gambiense* is a parasite that causes chronic infections in humans and can evade the immune system.

The graph shows the number of trypanosomes over time in a human infected with *Trypanosoma gambiense*.



From the data shown, the most probable mechanism used by this parasite to evade the immune system is

A antigenic variation

B suppression of the host immune system

C mimicry of host antigens

D latency.

[END OF SECTION 1. NOW ATTEMPT THE QUESTIONS IN SECTION 2 OF YOUR QUESTION AND ANSWER BOOKLET.]

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National Qualifications 2023

Mark

X807/77/01

Biology
Section 1 — Answer grid and Section 2

THURSDAY, 27 APRIL
1:00 PM – 4:00 PM

* X 8 0 7 7 7 0 1 *

Fill in these boxes and read what is printed below.

Full name of centre

Town

Forename(s)

Surname

Number of seat

Date of birth

Day	Month	Year

Scottish candidate number

Total marks — 100

SECTION 1 —20 marks
Attempt ALL questions.
Instructions for the completion of Section 1 are given on *page 02*.

SECTION 2 —80 marks
Attempt ALL questions.
A supplementary sheet for question 1 is enclosed inside the front cover of this question paper.
Question 13 contains a choice.
Write your answers clearly in the spaces provided in this booklet. Additional space for answers and rough work is provided at the end of this booklet. If you use this space you must clearly identify the question number you are attempting. Any rough work must be written in this booklet. Score through your rough work when you have written your final copy.
Use **blue** or **black** ink.
Before leaving the examination room you must give this booklet to the Invigilator; if you do not, you may lose all the marks for this paper.

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SECTION 1 — 20 marks

The questions for Section 1 are contained in the question paper X807/77/02.

Read these and record your answers on the answer grid on *page 03* opposite.

Use **blue** or **black** ink. Do NOT use gel pens or pencil.

1. The answer to each question is **either** A, B, C or D. Decide what your answer is, then fill in the appropriate bubble (see sample question below).

2. There is **only one correct** answer to each question.

3. Any rough working should be done on the additional space for answers and rough work at the end of this booklet.

Sample question

The thigh bone is called the

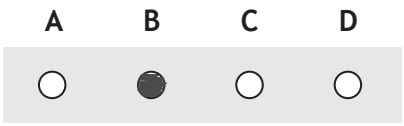
A humerus

B femur

C tibia

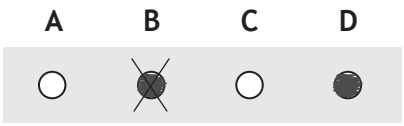
D fibula.

The correct answer is **B** — femur. The answer **B** bubble has been clearly filled in (see below).

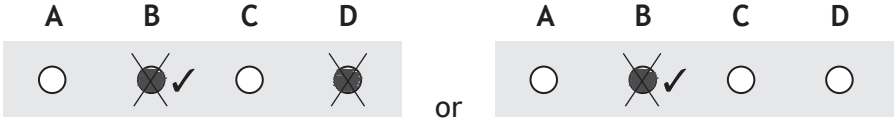


Changing an answer

If you decide to change your answer, cancel your first answer by putting a cross through it (see below) and fill in the answer you want. The answer below has been changed to **D**.



If you then decide to change back to an answer you have already scored out, put a tick (✓) to the **right** of the answer you want, as shown below:



SECTION 1 — Answer grid

OBJ20AD1

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

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SECTION 2 — 80 marks

Attempt ALL questions

Question 13 contains a choice

1. Read through the supplementary sheet for question 1 before attempting this question.

(a) Refer to **Figure 1.**

By considering the life cycle of schistosomes, explain why the study sites were all located close to water. **1**

_____

_____

(b) Suggest how the scientists determined if children were egg-positive in this study. **1**

_____

_____

(c) Calculate the number of PZQ tablets required for a child with a body mass of 11.25 kg to receive a **double dose**. **1**

Space for calculation

_____ tablets

(d) Refer to **Figure 2**.

(i) What conclusion can be drawn about pre-treatment intensity on the effectiveness of PZQ? **1**

_____

_____

1. (d) (continued)

(ii) It has been suggested that there would be little benefit in providing children with a double dose of PZQ.

State whether you agree or disagree with this suggestion.

Justify your answer. **1**

(e) Refer to **Figure 3**.

Identify the two months that indicate the beginning and end of the re-infection period. **1**

_____ and _____

(f) Refer to **Figure 4**.

(i) What general conclusion can be drawn from these results? **1**

(ii) The score differences shown were adjusted for a number of variables such as age, sex, nutritional status and socio-economic status.

Why did the authors describe these as confounding variables? **1**

(iii) Explain why the authors recommended ongoing de-worming treatments to combat the harmful effects of schistosomiasis on cognitive function. **1**

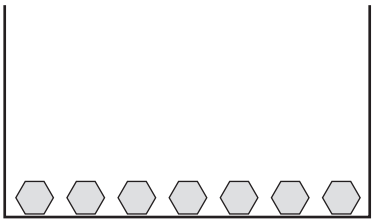
[Turn over

2. Lyme disease is an infectious disease caused by *Borrelia* bacteria and is spread by ticks. It is difficult to diagnose and a two-stage protocol is usually used. The first stage uses an enzyme-linked immunoassay (ELISA), and the second stage uses a Western blot to confirm the diagnosis.

(a) In this particular ELISA, antigens from the bacteria are bound to an assay plate and serum from the person being tested is added. After incubation and washing, an antibody specific to **all** human antibodies is added. This antibody is bound to a reporter enzyme that causes a colour change in a substrate.

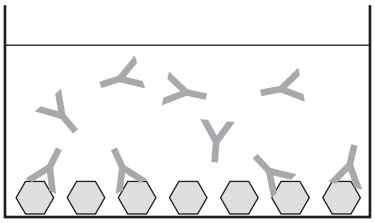
A positive test result for this process is illustrated in the figure.

1



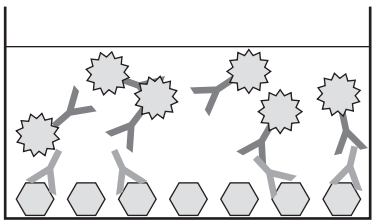
antigens specific to *Borrelia* are bound to the assay plate

2



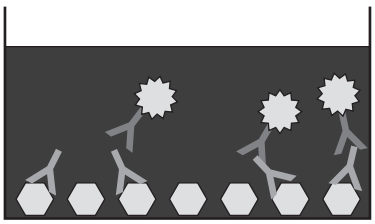
a sample of human serum is added to the plate

3



the plate is washed with a buffer and a second monoclonal antibody, specific to **all** human antibodies and linked to an enzyme, is added

4



the plate is washed with a buffer and the substrate for the enzyme is added

(i) Describe how a test for a person not infected by *Borrelia* would differ from the positive test illustrated. **2**

_____

_____

_____

_____

_____

2. (a) (continued)

(ii) The label in this ELISA is a reporter enzyme that results in a colour change in a substrate.

Name another type of label that can be used in immunoassays. **1**

(b) If a positive or inconclusive test result is obtained in the ELISA, proteins in the blood are electrophoresed on an SDS-PAGE gel.

(i) In an SDS-PAGE gel, proteins are separated by size alone.

Describe how SDS-PAGE separates proteins on the basis of size. **2**

(ii) Specific antibodies are used to detect proteins from *Borrelia* bacteria. This cannot be done directly on the SDS-PAGE gel.

State what must happen after electrophoresis to make detection by antibodies possible during Western blotting. **1**

[Turn over

MARKS DO NOT WRITE IN THIS MARGIN

3. The eukaryotic organism *Candida albicans* is one of the most common fungal pathogens of humans. One treatment for *C.albicans* infection is a compound called *sordarin*, which is isolated from a different fungus. Sordarin works by binding to highly specific sites on a protein called eukaryotic elongation factor 2 (eEF-2). eEF-2 causes the elongation of polypeptide chains during translation, by binding to a section of the ribosome.

(a) eEF-2 becomes inactive when phosphorylated.

Name the enzyme that catalyses the transfer of a phosphate group to proteins. **1**

(b) Explain why sordarin can be described as a ligand. **1**

(c) Explain why binding of sordarin to eEF-2 would change the function of the protein. **1**

(d) The gene for the protein eEF-2 is highly conserved across eukaryote species.

(i) Suggest what concerns there may have been in treating *C.albicans* infections in humans with sordarin. **1**

(ii) The table shows part of the amino acid sequence for the eEF-2 protein in humans and four different species of yeast. Each letter represents a different amino acid. The region of eEF-2 where sordarin binds is highlighted.

Organism	Amino acid sequence		
Human	KSDP	MVQCIIEE	SGEHI
C.albicans	KSDP	CVLTYMSE	SGEHI
S.cerevisiae	KSDP	CVLTYMSE	SGEHI
C.tropicalis	KSDP	CVLTYMSE	SGEHI
C.glabrata	KSDP	CVLTQMSE	SGEHI

sordarin binding region

Explain why it would be safe to use sordarin to treat *C.albicans* infections in humans. **1**

4. Homeopathy is a form of alternative medicine based on the concept that a substance that causes symptoms of a specific condition in healthy people can cure people with that same condition. Despite opposition from the scientific community, homeopathy is widely used in many parts of the world.

When preparing these remedies, homeopathic dilution is used. In this process, the selected substance is repeatedly diluted until the final product is so dilute that often not even a single molecule of the original substance can be expected to remain in the remedy.

In an attempt to examine the effectiveness of homeopathic remedies, one author searched available electronic databases of articles on the subject and analysed the data. They concluded that there are no homeopathic remedies that produce clinical effects convincingly different from placebo, and that these remedies should not be used in clinical practice.

(a) What name is given to a scientific article that summarises current knowledge and recent findings in a particular field? **1**

_____

(b) Homeopathic remedies are often supplied as sugar pills to which a small volume of remedy has been added.

Describe a suitable placebo to be used in comparing the clinical effect of a homeopathic remedy with that of the placebo. **1**

_____

_____

[Turn over

4. (continued)

(c) Another article presented data from a study of three patients who had been given homeopathic remedies following a heart attack. Each patient had been given different remedies according to the symptoms that they were suffering at the time. Conventional medicines were prescribed alongside the homeopathic remedies. Their recovery was monitored over a number of months.

The table summarises the treatments given during the period of review.

Patient	Number of homeopathic remedies	Number of conventional medicines
1	9	7
2	1	8
3	1	12

(i) Explain why it would have been unethical to discontinue the use of conventional medicines. **1**

_____

_____

(ii) Identify one aspect of this study that indicates low reliability. **1**

_____

(iii) As homeopathic remedies and conventional medicines needed to be prescribed to patients on the basis of need, it was not possible to identify a single independent variable.

What name is given to studies like this, which involve combinations of treatments? **1**

_____

4. (c) (continued)

(iv) Over the course of the review period, patients 1 and 3 showed an improvement in heart function as measured by conventional medicine and there was no deterioration in patient 2. The authors concluded that the three cases presented provided evidence of positive outcomes for homeopathic therapy.

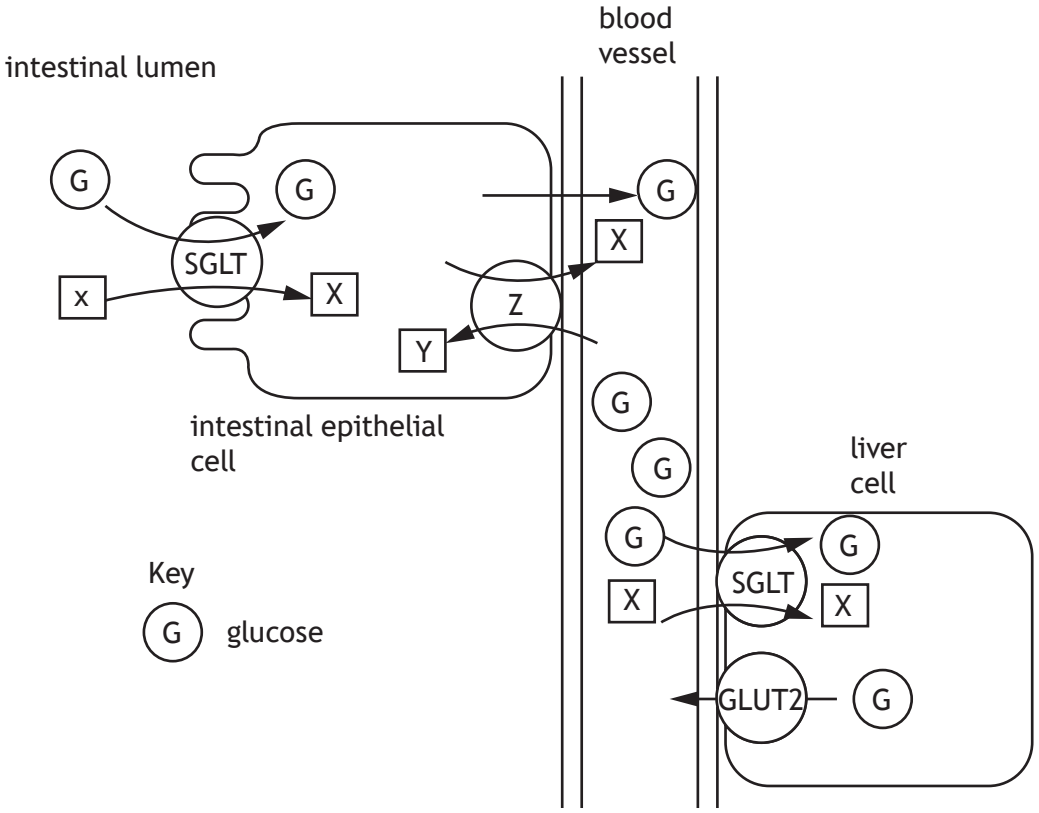
Apart from the issues relating to reliability, give one reason why this may not be a valid conclusion. **1**

(v) The authors reported that the patients had been selected as they were family members of homeopathic therapists.

Suggest how this selection bias might have affected the validity of this study. **1**

[Turn over

5. SGLT is a membrane protein that transports glucose against its concentration gradient across the membranes of cells in the small intestine and the liver. GLUT2 proteins allow diffusion of glucose out of liver cells.



(a) (i) During glucose symport, SGLT transports substance X at the same time as the glucose molecules.

Name substance X. **1**

_____

(ii) Protein Z moves X and Y against their concentration gradients.

Explain how the action of protein Z supplies the energy for the active transport of glucose during symport. **1**

_____

_____

5. (continued)

(b) Glucose moves out of liver cells back into the blood by facilitated diffusion.

Describe how facilitated diffusion takes place. **3**

(c) Liver cells store glucose as insoluble glycogen. In response to low blood glucose concentrations the liver converts the glycogen back into glucose.

A mutation of the gene coding for GLUT2 protein leads to a failure of its function.

Explain why individuals with the GLUT2 gene mutation may experience hypoglycaemia (very low blood glucose levels) despite having a balanced diet, and not being diabetic. **1**

[Turn over

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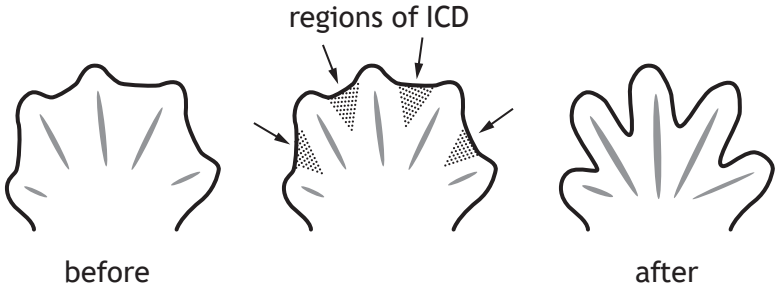
6. Interdigital cell death (ICD) is one of the best studied examples of apoptosis (programmed cell death) in vertebrates. It is the process by which digits (fingers and toes) are formed during embryonic development. ICD involves the self-destruction of the interdigital cells (cells between the digits) leaving the separated digits behind. The earliest model of the process is illustrated in **Figure 1.**

Figure 1



(a) (i) Apoptosis in these cells is triggered by an external signal.

Give an example of an external death signal. **1**

_____

(ii) Name the type of protease enzyme that causes the destruction of cells undergoing apoptosis. **1**

_____

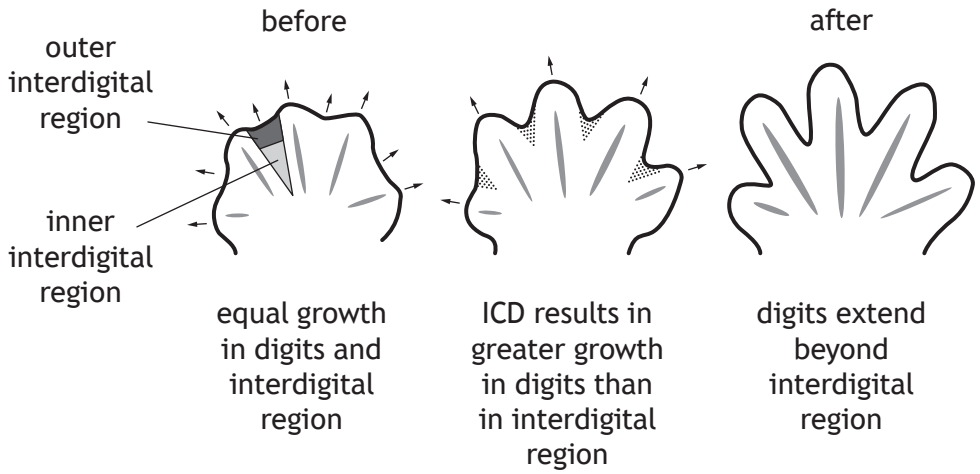
[Turn over

6. (continued)

(b) A more recent model for limb development suggests ICD (interdigital cell death) is not the only process involved. This model proposes a process involving a balance between cell death and cell proliferation. In this model ICD removes interdigital cells both at the inner and outer edge of the interdigital region. This is combined with a more rapid rate of growth in the cells of the digits compared to the interdigital cells.

Where there is extensive ICD at the outer edge of the interdigital region, this leads to the digits increasing in length relative to the interdigital region. This is illustrated in **Figure 2.**

Figure 2

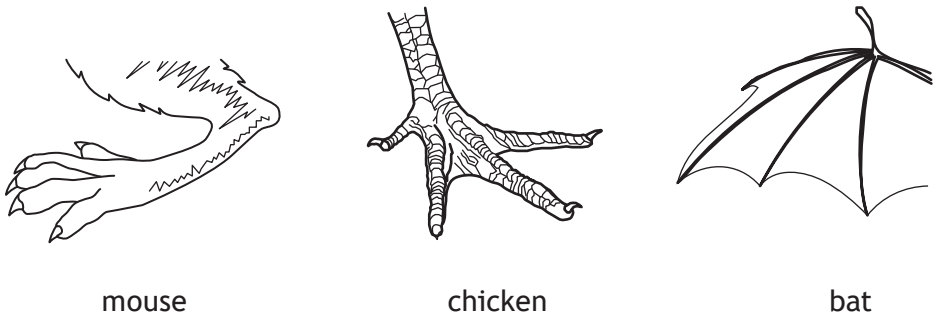


The authors also proposed that ICD in the inner region instead results in separation of already formed digits as described in the earliest model.

The relative importance of digital growth and ICD in the outer and inner interdigital regions varies between vertebrate species.

Figure 3 shows the limbs of three vertebrates (not to scale).

Figure 3



6. (b) (continued)

(i) In chickens, ICD appears to be essential for digit formation whilst in mice it plays a minimal role.

What does this suggest about the role of proliferation of digit cells in the formation of digits in mice compared to chickens? **1**

(ii) Bats have wings with large areas of skin joining the digits, as shown in **Figure 3.** In the bat wing it was found that certain proteins, which promoted cell proliferation, were expressed at higher levels in the interdigital region than in many other species.

Suggest why this might be important for limb development in this species. **1**

(c) Apoptosis is essential during development of an organism to remove cells no longer required as development progresses.

State another process in which apoptosis is essential. **1**

[Turn over

7. Describe the structure of viruses, and explain why they are classified as parasites. **5**

[Turn over for next question

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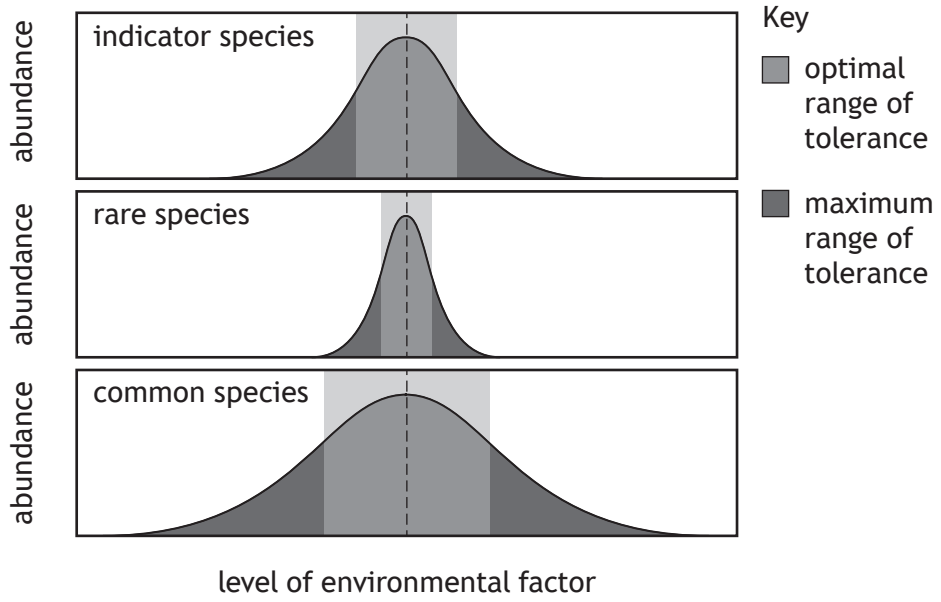
8. Many parts of the environment have been damaged by human activities. Indicator species can be used to assess how the environment has been impacted, and how it changes over time. Not all species are useful as indicators of environmental change.

Figure 1 shows the abundance of indicator species compared to rare and common species in response to a change in an environmental factor.

Figure 1



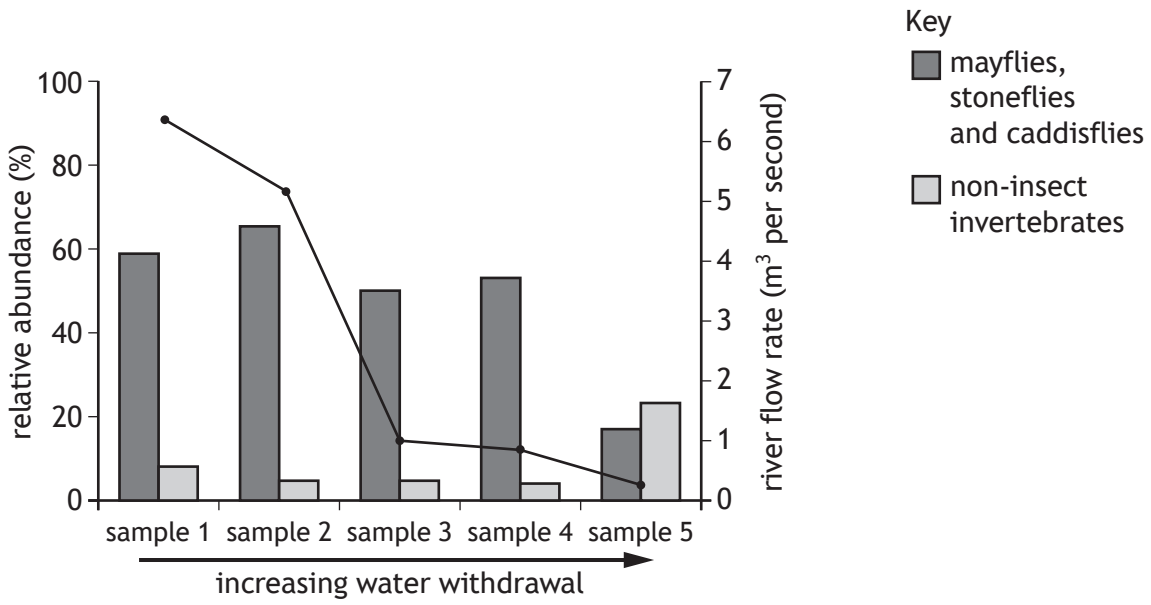
(a) Use the information in **Figure 1** to explain why very common and very rare species are not useful as indicator species. **1**

8. (continued)

One human activity that can damage freshwater ecosystems, such as rivers and lakes, is the withdrawal of water for drinking and the irrigation of crops.

Figure 2 shows the relative abundance of two groups of indicator species at five sampling points along a stretch of a river in the USA, from which water is withdrawn for irrigation. The line represents the river flow rate: the volume of water flowing through the river at a given point.

Figure 2



(b) Explain the changes in the relative abundances of the indicator species between sampling points four and five. **2**

(c) Suggest how data from monitoring rivers in this way could be used to predict how much water can be removed for irrigation whilst minimising the environmental impact. **1**

9. Rocky Mountain bighorn sheep (*Ovis canadensis canadensis*) were common throughout western North America until hunting, loss of habitat, and disease from domesticated sheep caused their population to be drastically reduced. The remaining bighorn sheep now live in fragmented and isolated populations.

(a) Explain why genetic drift is likely to have occurred in the gene pool of Rocky Mountain bighorn sheep. **2**

9. (continued)

(b) The amount of genetic drift can be estimated by calculating the *variance in allelic frequency* (VAF). This is a measure of the variance in allele frequencies among populations undergoing genetic drift. A larger VAF indicates more genetic drift.

$$\text{variance in allelic frequency} = \frac{pq}{2N}$$

p and q are the frequencies of two alleles at a genetic locus

N is the number of individuals in a population

Assuming two alleles have a frequency of 0.5 at a genetic locus, compare the extent of genetic drift in populations with 50 individuals compared to populations with 10 individuals. **2**

Space for calculation

(c) Rocky Mountain bighorn sheep are the largest wild sheep in North America. Males are approximately twice the mass of females and have much larger horns.

Explain how large horns in bighorn sheep could have evolved through sexual selection. **2**

[Turn over

10. Social life in clownfish depends on a size-based hierarchy. At the top is the largest, most aggressive female. Below her is the largest male. Moving down the hierarchy, size decreases and this helps to reduce conflict. Only the largest male and female reproduce. Clownfish develop into males first and may become females as they mature. If the breeding female dies the breeding male becomes female to replace her.

(a) (i) Explain why the clownfish may be described as a *sequential* hermaphrodite. **2**

_____

_____

_____

(ii) What seems to be the main benefit of the social hierarchy established by clownfish? **1**

_____

(iii) In clownfish, size is an important factor in sex change.

State another environmental factor that may be important in sex change in other animal species. **1**

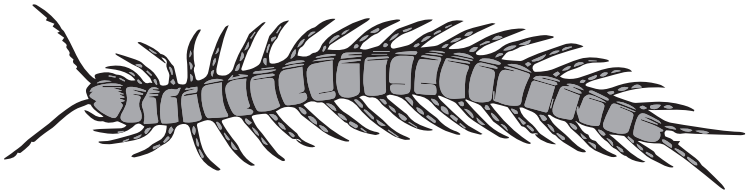
_____

10. (continued)

(b) Clownfish reproduction involves external fertilisation.
Describe the costs of external fertilisation. **3**

[Turn over

11. Centipedes belong to a class of predatory arthropods. They secrete and inject a venom into prey species such as earthworms. This venom, unlike that of many other arthropods, such as scorpions, spiders and wasps, is generally not dangerous to humans.



Recent research into the protein components of centipede venom has shown that centipede venom toxins may have evolved in species other than their phylogenetic ancestors. It is thought that their venoms have repeatedly acquired proteins that have evolved independently in bacteria and fungi. How this has happened is not well understood.

(a) Name the process that allows genes to move from bacteria and fungi into other species. **1**

(b) Explain how protein analysis could be used to determine that centipede venom did not evolve in their phylogenetic ancestors. **1**

(c) Some species of centipede are parthenogenetic and produce only female offspring.

Explain why parthenogenesis is more common in cooler climates. **2**

12. Since its introduction into Ireland in 1911, the invasive North American grey squirrel (*Sciurus carolinensis*) has threatened the survival of the native red squirrel (*Sciurus vulgaris*). The grey squirrel has been an important factor in changing the realised niche of the red squirrel in many areas.

(a) (i) Name the interaction between grey and red squirrels that has brought about the change in the realised niche of the red squirrel. **1**

_____

(ii) State the term used to describe the local extinction of red squirrels in the presence of grey squirrels. **1**

_____

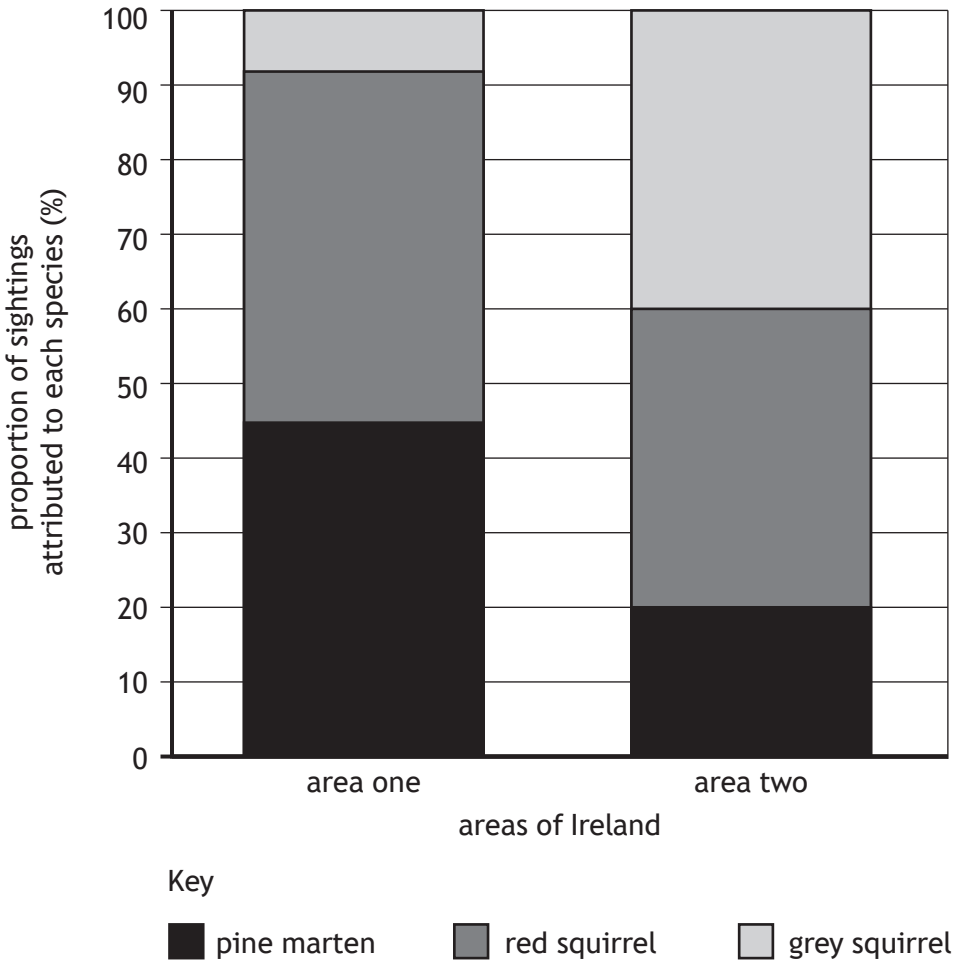
Over large areas of Ireland, grey squirrel populations have declined dramatically whilst red squirrels have become common again after an absence of 30 years. This has been attributed to recovery in the population of the native pine marten (*Martes martes*) after many years of habitat loss (deforestation) and persecution from hunters and gamekeepers.

Pine marten (*Martes martes*)

[Turn over

12. (continued)

(b) Percentage sightings of grey squirrels, red squirrels and pine martens in two different areas of Ireland are shown in the graph.



Use information from the graph to support the hypothesis that the spread of pine martens suppresses grey squirrel populations. **1**

12. (continued)

(c) Pine martens are an elusive species. In addition to sightings, population data were also obtained using scat sampling and hair traps (fur-snagging devices).

Suggest why these additional sampling methods would improve the validity of conclusions. **1**

It has been observed that red squirrels are better adapted to survive predation by pine martens since they are small and light enough to get to the ends of branches where pine martens cannot go. Grey squirrels are slower and heavier than red squirrels and more dependent on foraging on the woodland floor.

(d) In terms of the Red Queen hypothesis and co-evolution, explain why grey squirrels are more susceptible to pine marten predation than red squirrels. **2**

(e) The following headline appeared in a newspaper:

'How to eradicate grey squirrels without firing a shot'.

Use the information given to suggest a strategy to achieve this. **1**

[Turn over

13. Attempt **either A or B**. Write your answer in the space below and on *page 33*.

A Discuss the structure of amino acids and the four levels of protein structure. **9**

OR

B Describe the generation and transmission of a nerve impulse in a neuron. **9**

MARKS | DO NOT WRITE IN THIS MARGIN

ADDITIONAL SPACE FOR ANSWER to question 13

[END OF QUESTION PAPER]

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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK

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