



FOR OFFICIAL USE

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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

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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.



* X 8 0 7 7 7 0 1 0 1 *

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).

A B C D

<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
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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**.

A B C D

<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>
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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:

A B C D

<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>
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or

A B C D

<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
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SECTION 1 — Answer grid



* O B J 2 0 A D 1 *

A B C D

1	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
16	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



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* X 8 0 7 7 7 0 1 0 5 *

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



* X 8 0 7 7 7 0 1 0 6 *

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

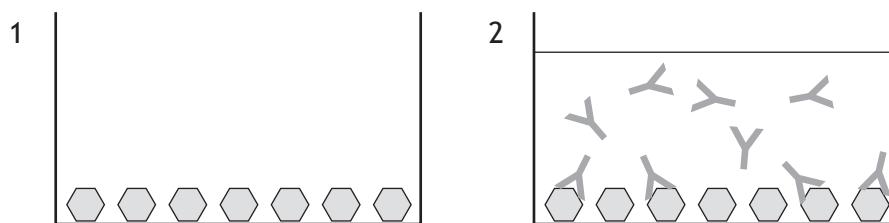


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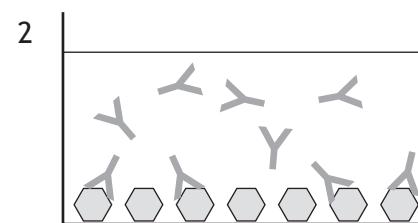
2. Lyme disease is an infectious disease caused by *Borrelia* bacteria and is spread by ticks. It is difficult to diagnose and a two-stage protocol is usually used. The first stage uses an enzyme-linked immunoassay (ELISA), and the second stage uses a Western blot to confirm the diagnosis.

- (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.

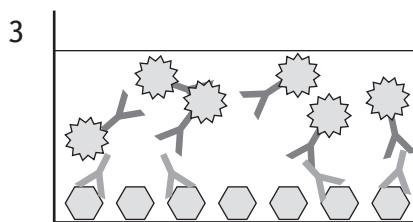
A positive test result for this process is illustrated in the figure.



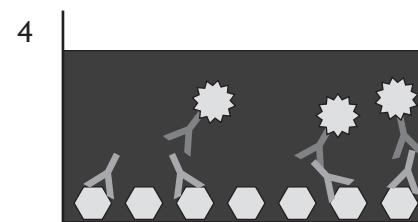
antigens specific to *Borrelia*
are bound to the assay plate



a sample of human serum
is added to the plate



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



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



* X 8 0 7 7 7 0 1 0 8 *

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



* X 8 0 7 7 7 0 1 0 9 *

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	MVQCIIIE	SGEHI
<i>C. albicans</i>	KSDP	CVLTYMSE	SGEHI
<i>S. cerevisiae</i>	KSDP	CVLTYMSE	SGEHI
<i>C. tropicalis</i>	KSDP	CVLTYMSE	SGEHI
<i>C. glabrata</i>	KSDP	CVLTQMSE	SGEHI

sordarin binding region

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

1



* X 8 0 7 7 7 0 1 1 0 *

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.

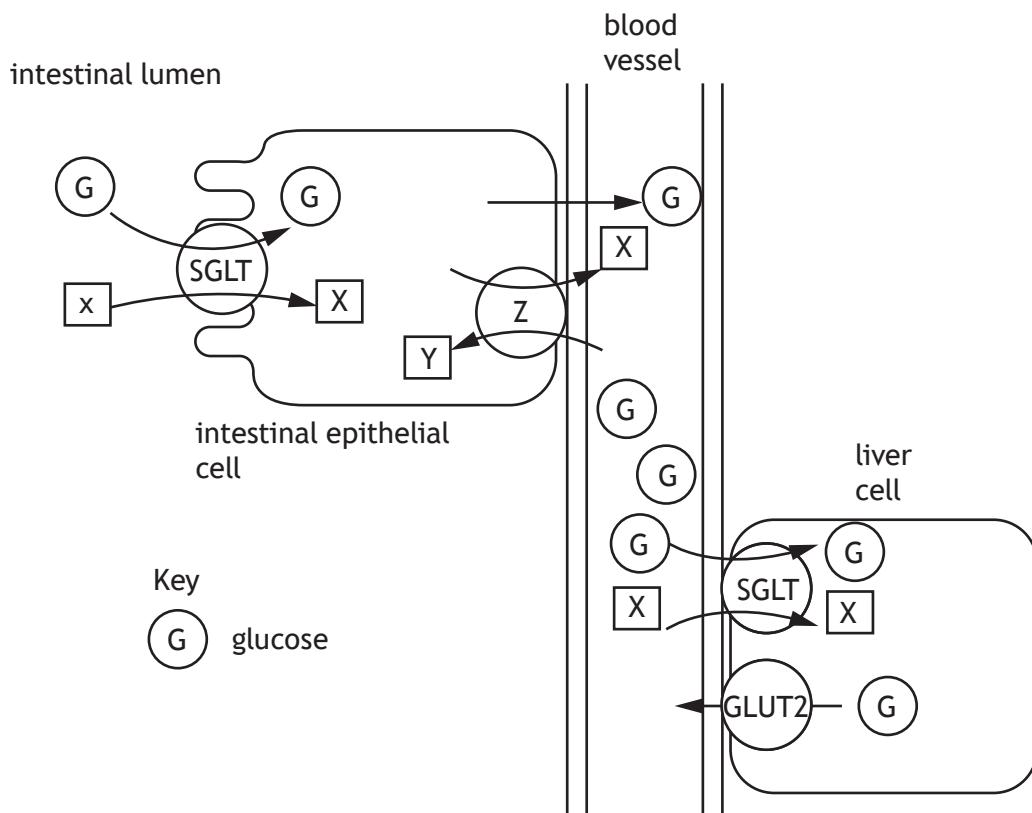
Suggest how this selection bias might have affected the validity of this study.

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



* X 8 0 7 7 7 0 1 1 4 *

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

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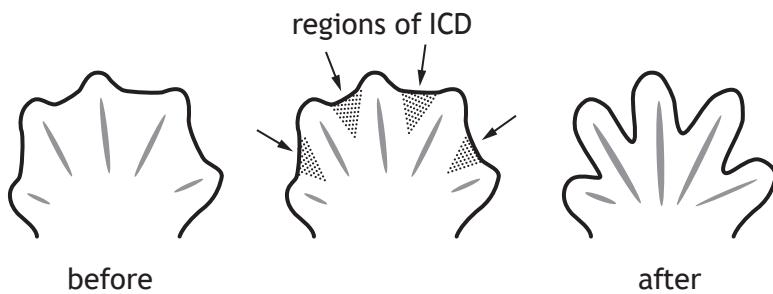
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* X 8 0 7 7 7 0 1 1 6 *

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

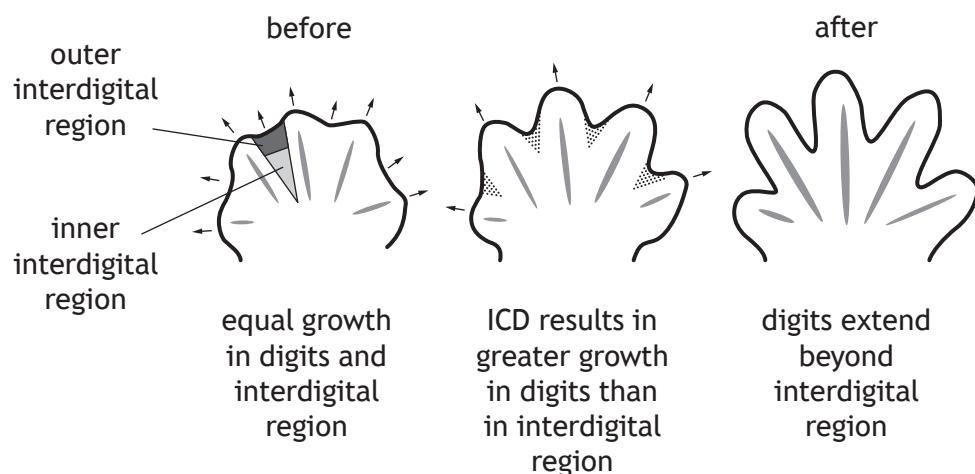
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6. (continued)

- (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.

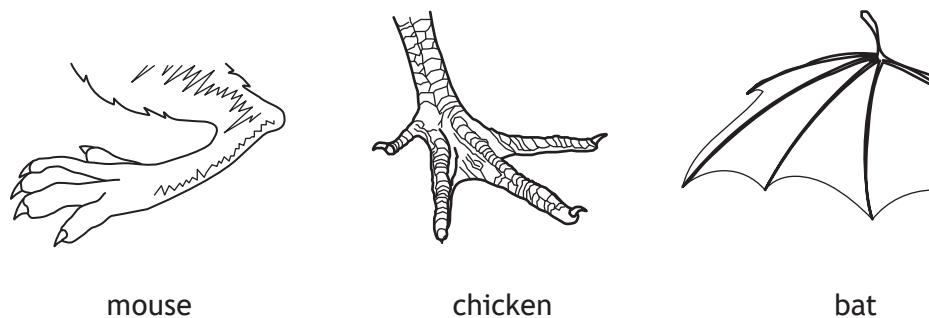
Where there is extensive ICD at the outer edge of the interdigital region, this leads to the digits increasing in length relative to the interdigital region. This is illustrated in **Figure 2**.

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



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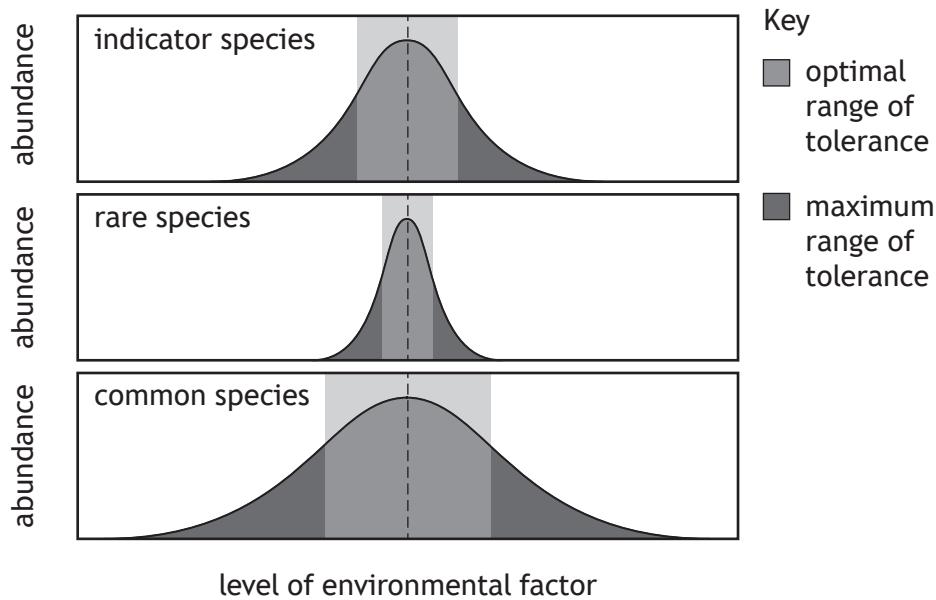


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8. Many parts of the environment have been damaged by human activities. Indicator species can be used to assess how the environment has been impacted, and how it changes over time. Not all species are useful as indicators of environmental change.

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

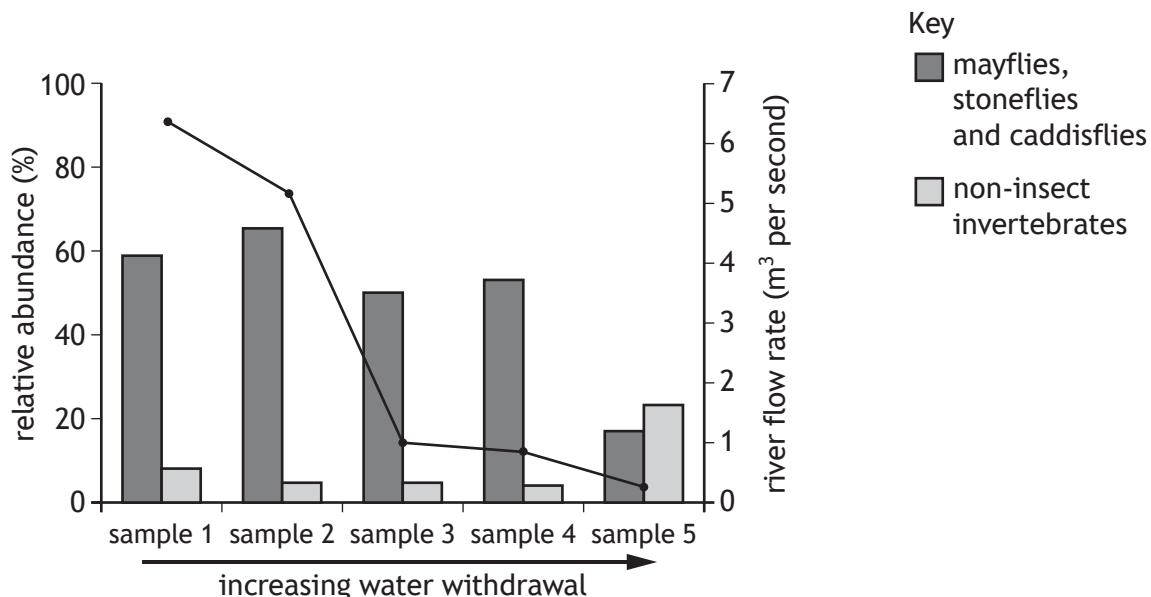


8. (continued)

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



* X 8 0 7 7 7 0 1 2 6 *

10. (continued)

- (b) Clownfish reproduction involves external fertilisation.

Describe the costs of external fertilisation.

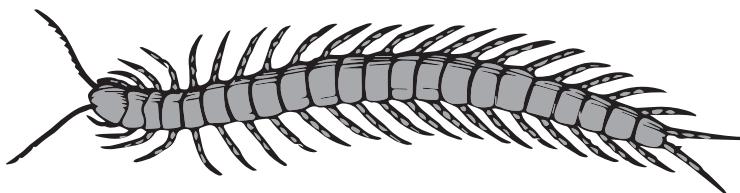
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* X 8 0 7 7 7 0 1 2 7 *

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



* X 8 0 7 7 7 0 1 2 8 *

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.



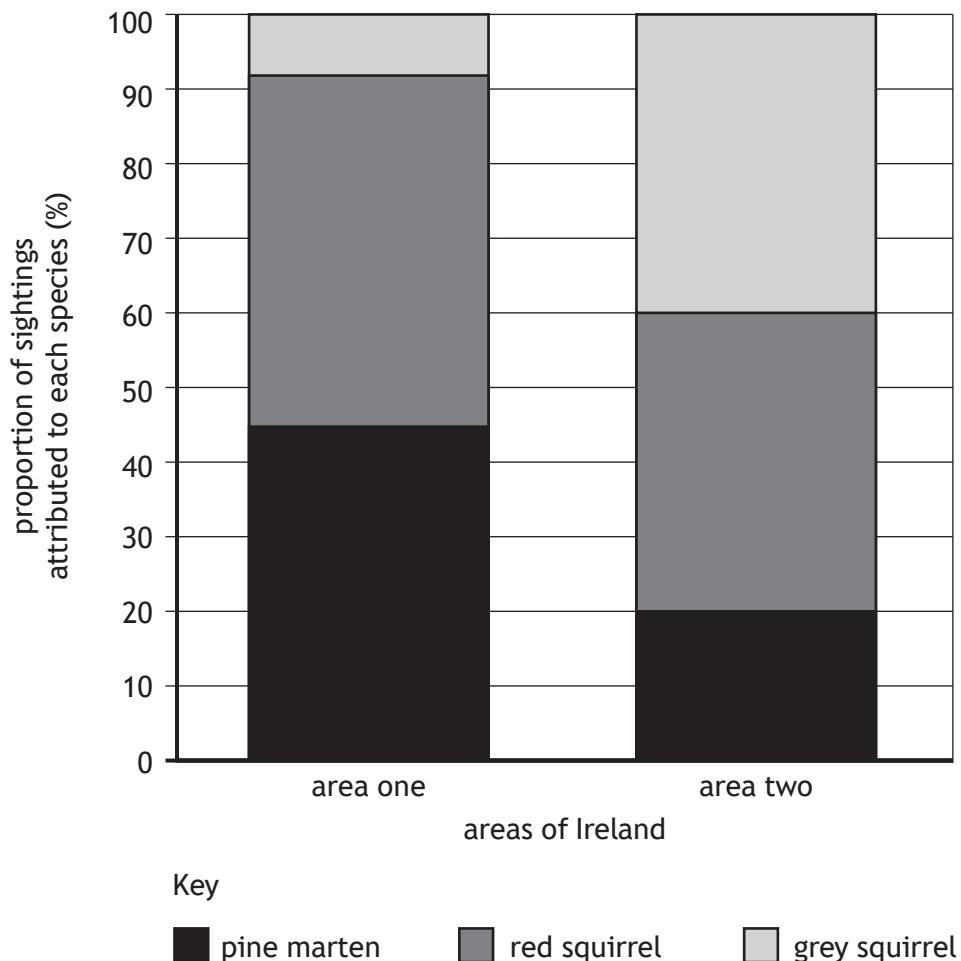
Pine marten (*Martes martes*)

[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



* X 8 0 7 7 7 0 1 3 1 *

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



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MARKS DO NOT
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MARGIN

ADDITIONAL SPACE FOR ANSWER to question 13

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MARKS DO NOT
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ADDITIONAL SPACE FOR ANSWERS AND ROUGH WORK



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