

X274/13/02

NATIONAL
QUALIFICATIONS
2013

WEDNESDAY, 15 MAY
1.00 PM – 3.30 PM

BIOLOGY
ADVANCED HIGHER
(REVISED)

SECTION A—Questions 1–25 (25 marks)

Instructions for completion of Section A are given on *Page two*.

SECTION B (65 marks)

The answer to each question should be written in ink in the answer book provided. Any additional paper (if used) should be placed inside the front cover of the answer book.

Rough work should be scored through.

All questions should be attempted. Candidates should note that Question 11 contains a choice.

Question 1 is on Pages 8, 9 and 10. Question 2 is on Page 10 and Question 3 is on Page 11. Pages 10 and 11 are fold-out pages.



Read carefully

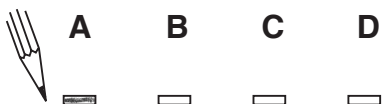
- 1 Check that the answer sheet provided is for **Biology Advanced Higher Revised (Section A)**.
- 2 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.
- 3 Check that the answer sheet you have been given has **your name, date of birth, SCN** (Scottish Candidate Number) and **Centre Name** printed on it.
Do not change any of these details.
- 4 If any of this information is wrong, tell the Invigilator immediately.
- 5 If this information is correct, **print** your name and seat number in the boxes provided.
- 6 The answer to each question is **either** A, B, C or D. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided (see sample question below).
- 7 There is **only one correct** answer to each question.
- 8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.
- 9 At the end of the examination, put the **answer sheet for Section A inside the front cover of the answer book**.

Sample Question

Which of the following molecules contains six carbon atoms?

- A Glucose
- B Pyruvic acid
- C Ribulose biphosphate
- D Acetyl coenzyme A

The correct answer is **A**—Glucose. The answer **A** has been clearly marked in **pencil** with a horizontal line (see below).



Changing an answer

If you decide to change your answer, carefully erase your first answer and using your pencil, fill in the answer you want. The answer below has been changed to **D**.



SECTION A

All questions in this section should be attempted.

Answers should be given on the separate answer sheet provided.

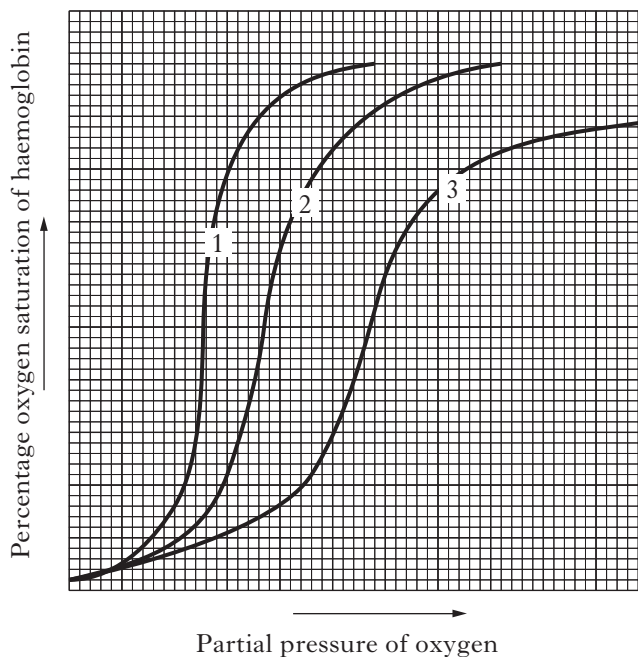
1. Which line in the table below correctly shows the arrangement of R groups in a globular protein found in the cytoplasm of a cell?

	<i>R groups on surface of protein molecule</i>	<i>R groups at centre of protein molecule</i>
A	Hydrophilic	Hydrophilic
B	Hydrophobic	Hydrophilic
C	Hydrophobic	Hydrophobic
D	Hydrophilic	Hydrophobic

2. Each molecule of oxygen that binds to a subunit of haemoglobin has the effect of increasing the affinity of the remaining subunits to oxygen. This type of interaction is known as

- A cooperativity
- B facilitated transport
- C induced fit
- D positive modulation.

3. Temperature influences the binding and release of oxygen in haemoglobin. The graph below shows the percentage oxygen saturation of haemoglobin at three different temperatures, 34 °C, 37 °C and 42 °C.



Which line in the table correctly identifies these temperatures?

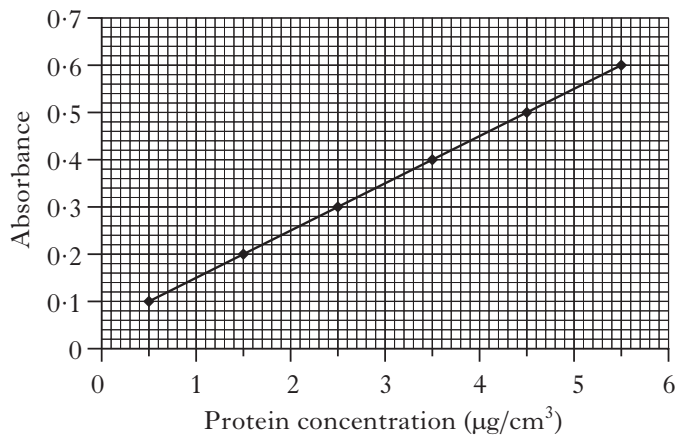
	<i>Curve 1</i>	<i>Curve 2</i>	<i>Curve 3</i>
A	34 °C	37 °C	42 °C
B	37 °C	42 °C	34 °C
C	34 °C	42 °C	37 °C
D	42 °C	37 °C	34 °C

4. In the post-translational modification of a protein, which of the following enzymes would remove a phosphate?

- A proteinase
- B ATPase
- C phosphatase
- D kinase

[Turn over

5. Colorimetry was used to produce the standard curve below.



In an experiment to extract soluble protein from potato tubers, 25 g tissue was ground with 50 cm³ of buffer and centrifuged. The volume of extract produced was 65 cm³. When 1 cm³ of extract was tested, the absorbance was found to be 0.5.

Which of the following is the protein content of the potato tissue in µg/g fresh tissue?

- A 3.9
 B 9.0
 C 11.7
 D 13.5
6. Which of the following describes how genes that increase metabolic rate are activated by a hydrophobic signalling molecule?
- A Thyroxine binds to a receptor protein on DNA and stops it inhibiting transcription.
 B Testosterone binds to a receptor protein on DNA and stops it inhibiting transcription.
 C Thyroxine binds to a receptor protein in the cytosol and the complex regulates transcription.
 D Testosterone binds to a receptor protein in the cytosol and the complex regulates transcription.

7. Which line in the table below correctly describes features of rod cells in humans?

	<i>Function in low light intensity</i>	<i>Contain different forms of opsin</i>
A	no	yes
B	yes	yes
C	no	no
D	yes	no

8. Which of the following is **not** a function of Na⁺/KATPase?

- A Maintaining the osmotic balance in animal cells
 B Phosphorylating channel proteins
 C Generating the ion gradient for glucose symports
 D Maintaining resting potential of membranes

9. Which of the following statements about the sodium-potassium pump is correct?

- A The transport protein has an affinity for sodium ions in the cytoplasm.
 B It results in a higher concentration of sodium ions inside the cell.
 C The transport protein has an affinity for sodium ions in the extracellular fluid.
 D It results in a higher concentration of potassium ions outside the cell.

10. The total surface area of a red blood cell is about 136 µm². A single sodium-potassium ATPase molecule takes up an area of 1 × 10⁻⁴ µm². In total these molecules account for 0.5% of the cell surface area.

Approximately how many of these molecules are there on the surface of one red blood cell?

- A 13 600
 B 6800
 C 3400
 D 680

11. Which line in the table correctly describes the effects of a failure to produce ADH?

	<i>Aquaporin recruitment</i>	<i>Urine production</i>
A	increase	decrease
B	increase	increase
C	decrease	decrease
D	decrease	increase

12. From which stage in the cell cycle could cells switch to G_0 ?

- A M
B G_1
C S
D G_2

13. During the cell cycle, sufficient phosphorylation by G_1 cyclin-dependent kinases allows

- A the cell to pass into M phase
B p53 to be activated
C the cell to be held in G_1 phase
D DNA replication to occur.

14. *Dicrocoelium dendriticum* is a flatworm parasite of grazing vertebrates such as sheep and cattle. Which line in the table shows the phyla to which these species belong?

	<i>Dicrocoelium</i>	<i>Cattle/sheep</i>
A	Nematoda	Chordata
B	Platyhelminthes	Arthropoda
C	Nematoda	Arthropoda
D	Platyhelminthes	Chordata

15. A student observing the behaviour of a female chimpanzee and one of her offspring made the following field notes:

- 1 offspring displayed lower teeth to mother
- 2 offspring begged mother for food
- 3 offspring clung to mother's back
- 4 offspring smiled at mother

Which of the notes demonstrate anthropomorphism?

- A 2 and 3 only
B 2 and 4 only
C 1, 2 and 4 only
D 2, 3 and 4 only

16. Which line in the table correctly identifies genetic drift?

	<i>Type of process</i>	<i>Size of population from which alleles are likely to be lost</i>
A	random	small
B	random	large
C	non-random	small
D	non-random	large

17. Which of the following factors increases the rate of evolution?

- A Longer generation times
B Cold environments
C Horizontal gene transfer
D Low selection pressure

18. In the insect order Hymenoptera (eg ants, bees and wasps), male individuals can be produced by parthenogenesis from an egg cell.

When parthenogenesis does occur, how many sets of chromosomes does a male wasp have in each of its body cells compared to one of his sisters?

- A One extra
B The same number
C One fewer
D Double the number

19. Independent assortment results in the production of gametes with varying combinations of maternal and paternal chromosomes.

How many different combinations are possible in the gametes of an organism whose haploid number is 3?

- A 2
- B 4
- C 8
- D 12

20. Frequency of recombination data were used to determine the relative positions of the linked genes P, Q, R and S on a chromosome. The results are shown in the table:

<i>Gene pair</i>	<i>Percentage recombination</i>
Q and R	14
S and Q	4
R and S	10
R and P	3
P and Q	11

The correct order of genes on the chromosome is

- A RPSQ
- B QSRP
- C SPQR
- D QPSR.

21. An organism's parental investment strategy can be classified as k-selected or r-selected.

Which line in the table correctly describes the characteristics of k-selected organisms compared to r-selected organisms?

	<i>Number of offspring produced</i>	<i>Size of offspring produced</i>
A	larger	larger
B	larger	smaller
C	smaller	larger
D	smaller	smaller

22. Which of the following features of a parasite may be considered a part of its extended phenotype?

- A High genetic variability
- B Alteration of host behaviour
- C Rapid antigen change
- D Virulence

23. *Schistosoma mansoni* is a parasitic worm which causes the disease schistosomiasis in humans. The parasitic worm is found in body organs including the liver and intestines.

Schistosoma mansoni is an example of

- A a microparasite and is ectoparasitic
- B a macroparasite and is ectoparasitic
- C a microparasite and is endoparasitic
- D a macroparasite and is endoparasitic.

24. The information in the table explains terms that might be encountered by a scientist when reading scientific publications.

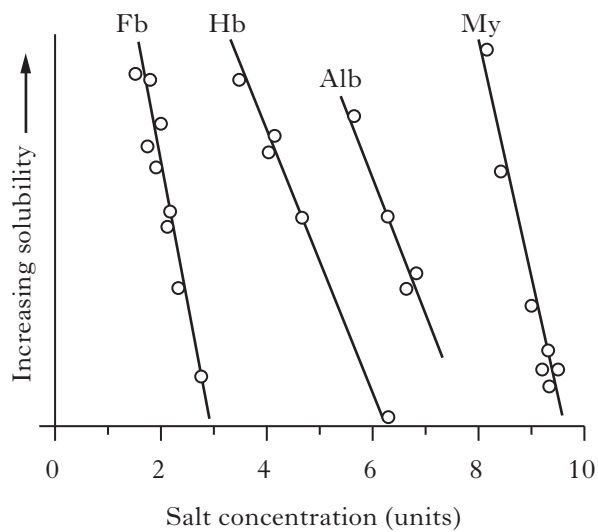
Which line in the table is **not** correct?

	<i>Term</i>	<i>Explanation</i>
A	Pilot study	allows modification of experimental design
B	Hypothesis	proposes an association between independent and dependent variables
C	Positive control	provides results in the absence of the treatment
D	Confidence interval	indicates variability of data around a mean

25. Some characteristics and properties of four proteins are shown below.

<i>Protein</i>	<i>Symbol</i>	<i>Molecular mass</i>	<i>Type</i>
Fibrinogen	Fb	330 000	Fibrous
Haemoglobin	Hb	68 000	Globular
Albumin	Alb	65 000	Globular
Myoglobin	My	17 000	Globular

The solubility of proteins in salt solutions



Which conclusion about the solubility of proteins is valid from this information?

- A Protein solubility increases as salt concentration decreases.
- B Globular proteins are more soluble than fibrous proteins.
- C Fibrous proteins are more soluble than globular proteins at low salt concentrations.
- D Solubility of proteins is not related to molecular mass.

[END OF SECTION A]

Candidates are reminded that the answer sheet MUST be returned INSIDE the front cover of the answer book.

[Turn over for Section B on Page eight

SECTION B

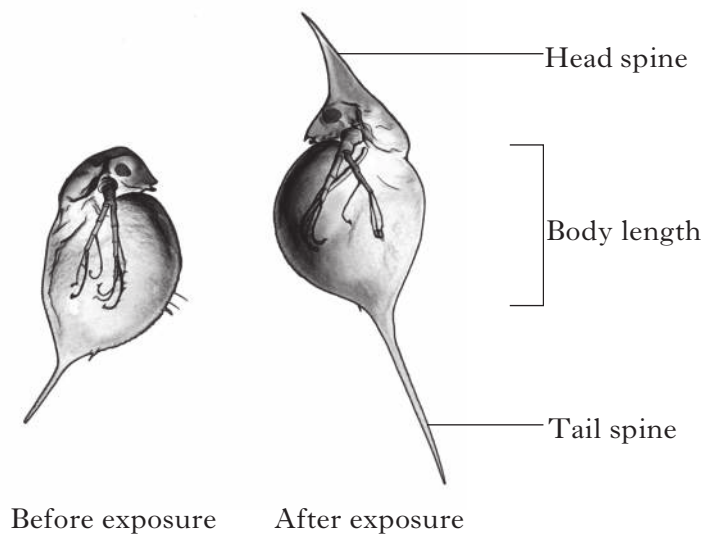
All questions in this section should be attempted.

All answers must be written clearly and legibly in ink.

1. Some species of *Daphnia* (water fleas) are able to develop their head spines and tail spines as structural defences against predators such as fish. These structures can increase in length in response to **kairomones**, chemicals in water where the fish occur.

One species, *Daphnia lumholtzi*, occurs naturally in freshwater habitats in Africa, Asia and Australia. It has now spread throughout North America, first appearing in lakes in the south in 1990 and reaching more northern and western lakes within four years. It is thought to have been introduced when lakes were stocked with African fish species.

Figure 1: Illustration of *Daphnia lumholtzi* before and after exposure to kairomones



The successful spread of *D. lumholtzi* has been attributed to its ability to develop defensive spines. To investigate the relevance of this feature to *Daphnia* survival, laboratory experiments were carried out to compare the population dynamics of *D. lumholtzi* with *Daphnia pulicaria*, the most widely distributed American species.

All the experiments were conducted under standard conditions of temperature (20°C) and light in identical plastic tanks. The culture medium was based on minerals and phosphate buffer made up in water of a very high purity. *Daphnia* were fed with green algae in quantities that maintained constant food availability. The density of each species was the same at the start and populations were left for several days before sampling began.

Figure 2 shows the population changes observed from the first day of sampling in experiments set up as below:

Experiment A: Single species alone without predators

Experiment B: Two species together without predators

Experiment C: Two species together with fish predators.

Figure 3 shows the results of measuring the lengths of head spines and tail spines for the two species in culture medium either containing or lacking kairomones.

Question 1 (continued)

Figure 2: Population changes in Experiments A, B and C

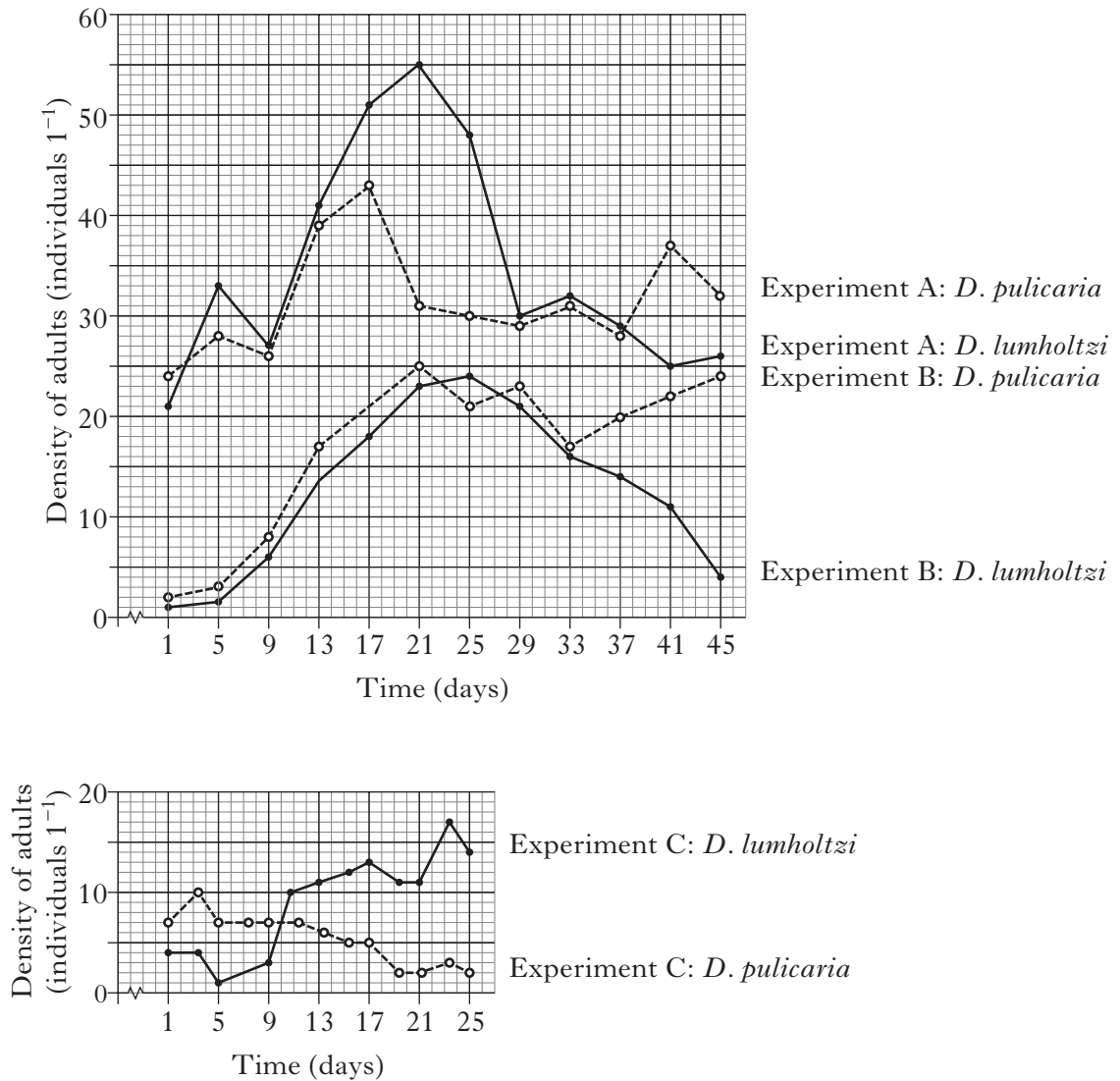
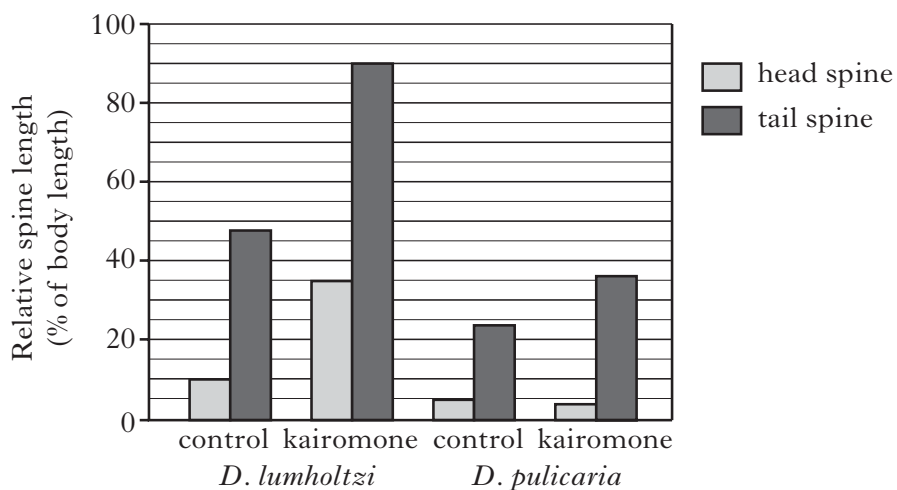


Figure 3: Relative lengths of spines before and after exposure to kairomones



Question 1 (continued)

- (a) Refer to Figure 2.
- (i) Use the data at Day 41 to demonstrate that competition is a negative interaction for both species. 2
- (ii) Suggest how long it takes for spine formation to affect predator behaviour. Justify your answer. 1
- (b) Refer to Figure 3.
- (i) What appears to be *D. pulicaria*'s defence against fish predation? 1
- (ii) For *D. lumholtzi*, with a mean body length of 1.6 mm, what was the difference in length between the head spines in the control and kairomone cultures? 1
- (c) Explain why the researchers believed the formation of head spines to be critical in the survival of *D. lumholtzi* in competition with *D. pulicaria*. 2
- (7)**

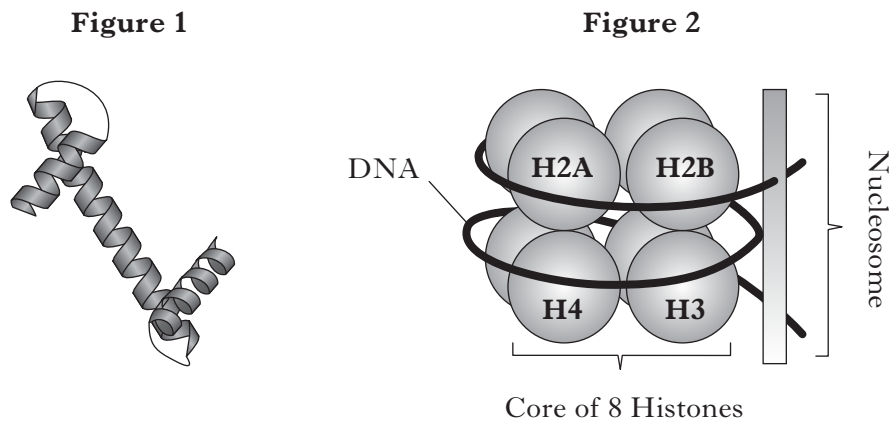
2. The table below shows data comparing some stages in the purification of an enzyme from a tissue sample. Total protein and enzyme activity are measured at the end of each stage.

	<i>Stage</i>	<i>Total protein</i> (mg)	<i>Enzyme activity</i> (units)
1	Liquidised tissue	10 000	2 000 000
2	Precipitation by salts	3000	1 500 000
3	Iso-electric separation	500	500 000
4	Affinity chromatography	30	42 000

- (a) (i) By the end of the purification process, what percentage of the original protein has been removed? 1
- (ii) Enzyme purity can be calculated from these values as the *activity per mg of protein*.
By how many times has the enzyme purity increased by the end of stage 4? 2
- (b) Explain the principle of iso-electric separation. 2
- (c) In affinity chromatography, a ligand specific to the enzyme was bonded to beads in a burette.
Explain how this method can improve purity. 2
- (7)**

[Question 3 is on fold-out Page eleven

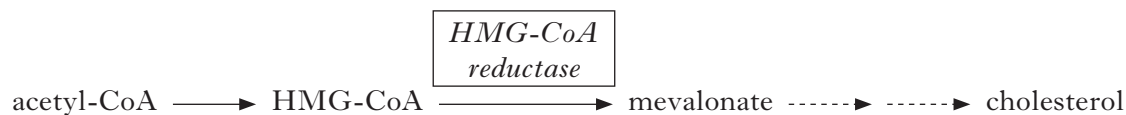
3. Figure 1 below shows the structure of a histone protein molecule, histone 4 (H4). Figure 2 represents a nucleosome showing the arrangement of the histones that make up its core.



- (a) Name the type of bonding that maintains the shape of an alpha helix in a protein. **1**
- (b) What level of protein structure is shown in Figure 1? **1**
- (c) What is the importance of DNA being bound in nucleosomes? **1**
- (d) Over 20% of the amino acids in histones are lysine and arginine.
 Explain why the high abundance of these positively charged amino acids is significant in the formation of a nucleosome. **1**
- (4)**

4. When cholesterol accumulates in the wall of an artery, the plaque that forms reduces the internal diameter of the vessel. Plaque formation (atherosclerosis) is a major cause of heart disease. *Statins* are taken to reduce blood cholesterol and are among the most commonly prescribed medications.

Cholesterol is synthesised by cells in a sequence of steps starting with acetyl-CoA from the citric acid (Krebs) cycle. The step that limits the rate of production is near the start and is catalysed by the enzyme *HMG-CoA reductase*, as illustrated below.



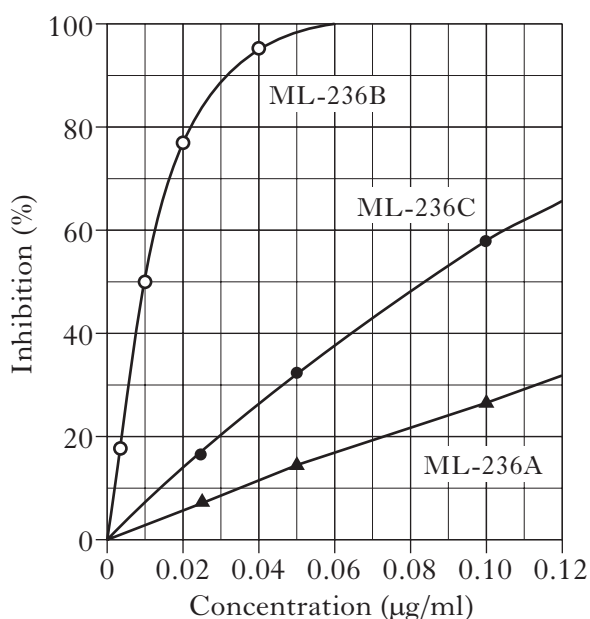
- (a) In this pathway, a form of end-product inhibition occurs in which increasing cholesterol promotes the destruction of HMG-CoA reductase.

Describe how end-product inhibition would be achieved if the enzyme was allosteric. 2

- (b) Statins inhibit HMG-CoA reductase by competing for the active site of the enzyme.

Explain why this would reduce cholesterol formation. 1

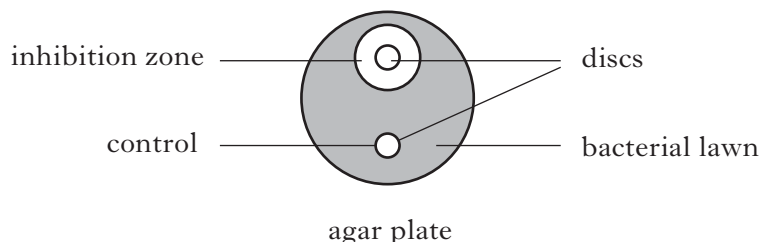
- (c) The graph below shows results of an experiment carried out in 1976 on three forms of a substance, ML-236, extracted from a fungal culture. The experiment was assessing how well these substances inhibit cholesterol formation, the key requirement for a potential statin.



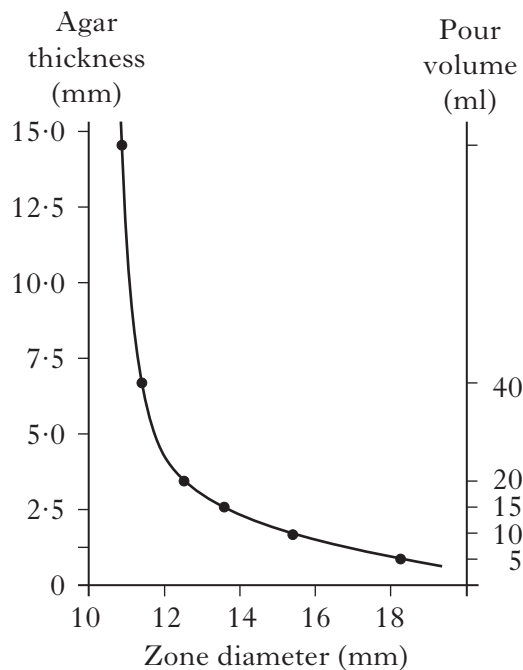
Use data for 50% inhibition to compare the effectiveness of the three molecules as potential statins. 2

(5)

5. Substances can be screened for antibiotic effects using the *diffusion plate* method. In this method, filter paper discs soaked in the test substance are laid on a “lawn” of bacterial culture freshly spread on a nutrient agar plate. A clear zone in the lawn around the disc occurs where the diffusing antibiotic stops growth.



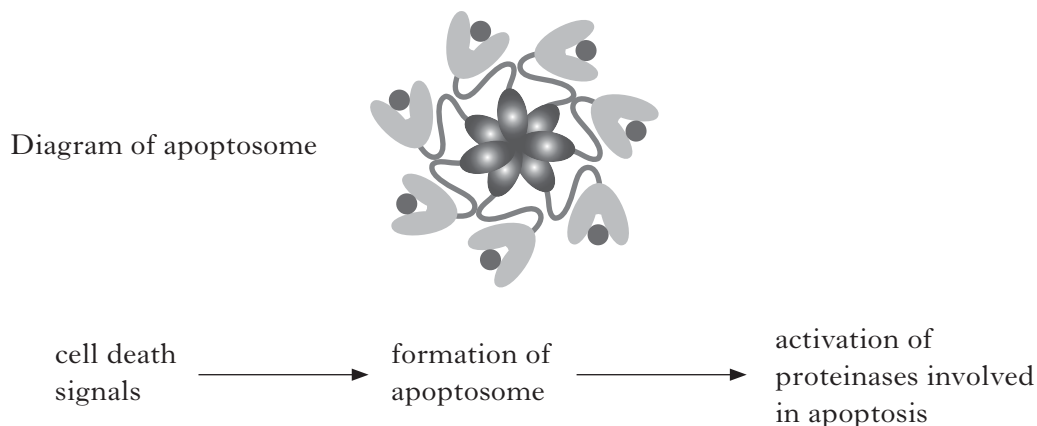
The distance any substance travels in the agar depends on a range of factors that affect its rate of diffusion: these factors are confounding variables. In an experiment to evaluate one of these confounding variables, plates were made up by pouring different volumes of nutrient agar, creating different agar thicknesses. The results graph from the research paper is shown below.



- (a) What is meant by the term *confounding variable*? 1
- (b) In this experiment identify the independent variable. 1
- (c) Describe the results of the experiment. 1
- (d) Plates poured and stored for use at a later date gradually lose water by evaporation. Explain why results of experiments involving the diffusion plate method may be invalid when using stored plates. 1

(4)

6. *Apoptosomes* are large protein structures formed inside cells during the process of apoptosis. Apoptosomes are formed in response to cell death signals.



- (a) Name the type of proteinase activated by apoptosomes. 1
- (b) Give **one** reason why cell death must be carefully controlled in a multicellular organism. 1
- (c) Cell death signals can originate within the cell (intrinsic) or outwith the cell (extrinsic).
- (i) Give **one** example of an event that would trigger an intrinsic cell death signal. 1
- (ii) Describe how an extrinsic cell death signal initiates apoptosis. 2
- (d) Bcl-2 is a protein that regulates apoptosis by binding to apoptosomes, preventing them from activating proteinase. 2
- Some mutations cause an increase in the level of Bcl-2 protein.
- Suggest why these mutations are associated with tumour growth. 2
- (7)**

7. (a) Describe how insulin stimulates the uptake of glucose into cells.

2

(b) Research has shown that fatty (adipose) tissue secretes a number of signalling molecules that regulate a variety of metabolic processes. One of these molecules, *adiponectin*, is thought to increase the sensitivity of cells to the hormone insulin.

Table 1 shows the results of a study that compared the concentration of adiponectin in patients having type 2 diabetes with non-diabetic subjects.

Table 1

<i>Subjects</i>	<i>Average plasma adiponectin concentration</i> ($\mu\text{g cm}^{-3} \pm \text{SE}$)
type 2 diabetes	6.6 ± 0.4
non-diabetics	7.9 ± 0.5

Use the information to explain the relationship between type 2 diabetes and the average plasma concentration of adiponectin.

2

(c) Table 2 below shows the results of a second study that measured changes in adiponectin following treatment of individuals at risk of developing type 2 diabetes.

Table 2

<i>Treatment</i>	<i>Average increase in adiponectin concentration</i> ($\mu\text{g cm}^{-3} \pm \text{SE}$)
drug treatment	0.83 ± 0.05
lifestyle changes	0.23 ± 0.05
none	0.10 ± 0.05

How do the data in Table 2 **confirm** that both treatments were effective in increasing adiponectin concentration?

1

(d) Both studies used human subjects. For this type of research:

(i) give **one** important ethical consideration;

1

(ii) explain why a large sample size is required to produce valid conclusions.

1

(7)**[Turn over**

8. Figure 1 shows chromosomes of a gamete mother cell at the start of meiosis. The cell has three pairs of chromosomes, labelled A, B and C.

Figure 1

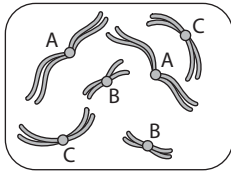
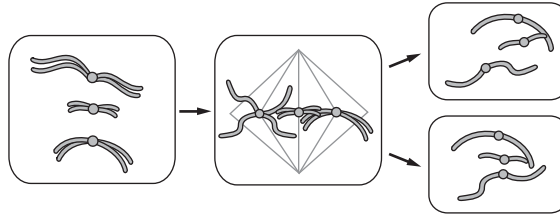
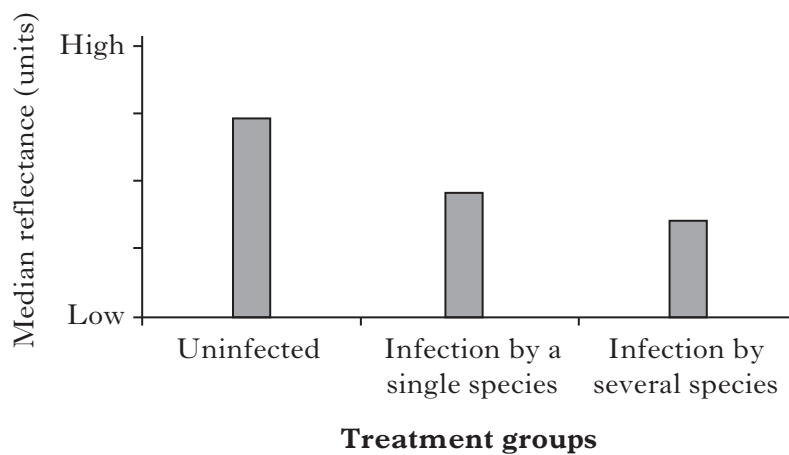


Figure 2



- (a) The chromosomes of each pair are described as homologous.
 Apart from being the same size, give **two** other features that are characteristic of homologous chromosomes. 2
- (b) Explain how members of a homologous pair may differ genetically. 1
- (c) Select **two** features from Figure 2 that show meiosis II is taking place. 2
- (5)**

9. The North American wild turkey (*Meleagris gallopavo*) shows distinct differences between males and females. The males have vividly-coloured, iridescent plumage. An experiment was carried out to investigate the effect of parasite infections on the amount of light reflected by the males' plumage. Results are shown in the chart below: lower reflectance scores indicate duller plumage.



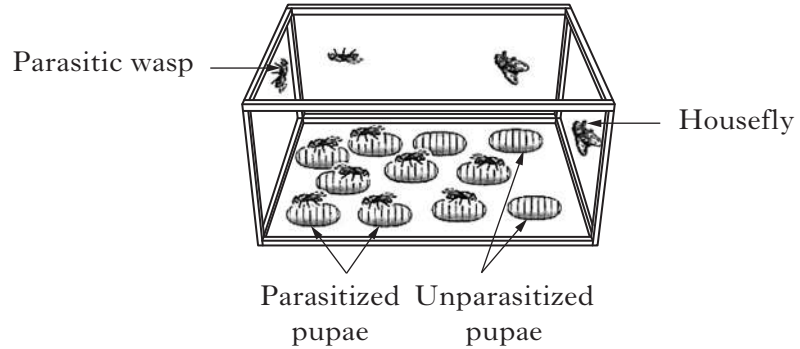
- (a) What term is used to describe the differences between males and females? 1
- (b) Describe the relationship between parasitic infection and the male birds' plumage. 1
- (c) The researchers have suggested that iridescent coloration in wild turkeys serves as an honest signal to females.
 How will this influence mating success? 2
- (4)**

10. The parasitic wasp, *Nasonia vitripennis*, lays its eggs inside the pupa stage of the housefly, *Musca domestica* (Figure 1). Wasp eggs hatch into larvae that consume the housefly pupae. Figure 2 shows a cage set up with populations of the wasp and the housefly.

Figure 1

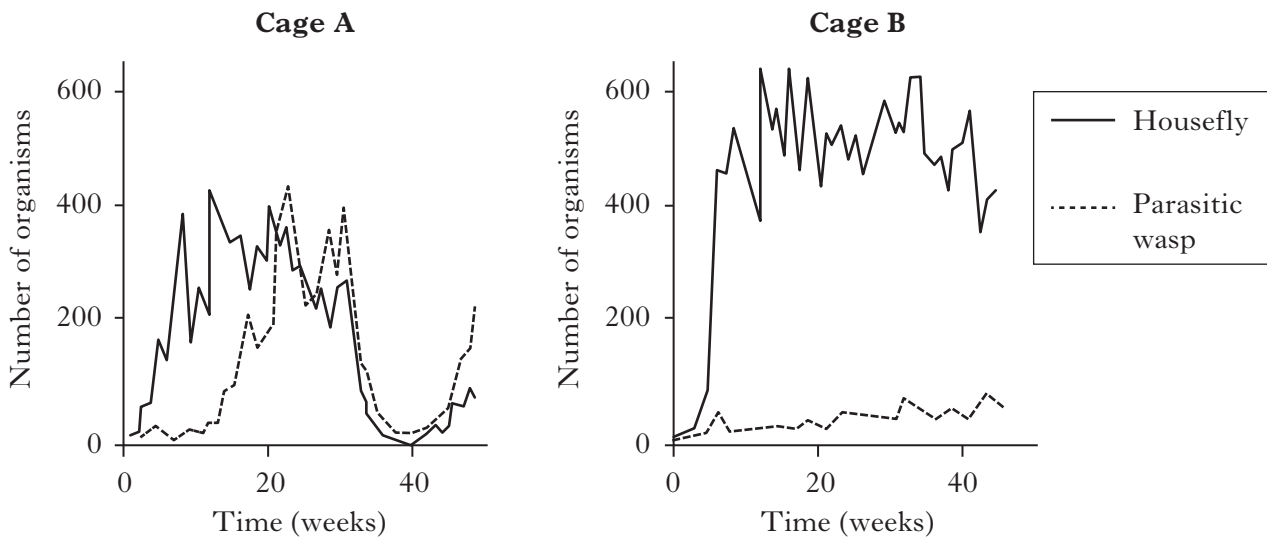


Figure 2



In a study to test the host's evolutionary response to the parasite, two cages were set up. In Cage A the housefly population had no previous exposure to wasps; in Cage B the housefly population had already been exposed to wasp parasitism for three years.

The graphs below show population changes in both species in the two cages over a 40 week time period.



- (a) (i) How do the results support the general conclusion that the houseflies had developed resistance to wasp parasitism? 1
- (ii) Explain how the resistance would have evolved. 2
- (b) The response of the housefly is an example of co-evolution.
- (i) What is meant by the term co-evolution? 1
- (ii) According to the Red Queen hypothesis, what population change would be expected in Cage B if it is now left undisturbed? 1
- (5)**

[Turn over for Question 11 on Page eighteen

11. Answer **either A or B**.

A. Discuss factors that maximise the transmission of parasites.

(10)

OR

B. Discuss how host immune responses minimise the impact of parasites in mammals.

(10)

[END OF SECTION B]

[END OF QUESTION PAPER]