

SECTION A

Read carefully

- 1 Check that the answer sheet provided is for **Biology Advanced Higher (Section A)**.
- 2 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.
- 3 If any of this information is wrong, tell the Invigilator immediately.
- 4 If this information is correct, **print** your name and seat number in the boxes provided.
- 5 Use **black** or **blue ink** for your answers. **Do not use red ink.**
- 6 The answer to every question is **either** A, B, C or D. Decide what your answer is, then 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 exam, put the **answer sheet for Section A inside the front cover of your answer book.**

Sample Question

Which of the following molecules contains six carbon atoms?

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

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

A B C D

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 **B**.

A B C 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:

A B C D or A B C D
 or

SECTION A

All questions in this section should be attempted.

Answers should be given on the separate answer sheet provided.

1. Cells in a multicellular organism have different structures and functions because they
 - A have different genes
 - B ~~express their genes differently~~
 - C are located in different tissues
 - D have lost genes during development.

2. What is the mitotic index for the following set of results?

Phase of cell cycle	Number of cells
Interphase	1120
Prophase	150
Metaphase	90
Anaphase	20
Telophase	20

- A 8%
- B 20%
- C 25%
- D 32%

3. Animal cells growing in culture are found to spend 20% of their time in the G2 phase of the cell cycle. G2 lasts for 4 hours.

If cells spend 12% of their time in the M phase, how long does this last?

- A 2 hours 4 minutes
- B 2 hours 12 minutes
- C 2 hours 24 minutes
- D 2 hours 40 minutes

4. In starch, glucose molecules are joined by
 - A hydrogen bonds
 - B ester linkages
 - C peptide bonds
 - D glycosidic linkages.
5. One litre of cell culture growth medium containing 15% fetal bovine serum (FBS) can be made by mixing
 - A 850 cm³ of medium + 150 cm³ of FBS
 - B 985 cm³ of medium + 15 cm³ of FBS
 - C 1000 cm³ of medium + 15 cm³ of FBS
 - D 1000 cm³ of medium + 150 cm³ of FBS.

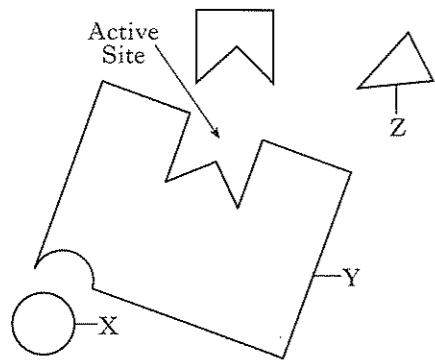
6. The key below can be used to identify carbohydrates.

1. { Sugars..... go to (2)
 Polysaccharides go to (4)
2. { Monosaccharides A
 Disaccharides go to (3)
3. { Contains only one type of monomer B
 Contains two types of monomer..... sucrose
4. { Storage function go to (5)
 Structural function in plants C
5. { Storage function in animals D,
 Storage function in plants..... starch

Which substance could be cellulose?

[Turn over

7. The diagram below shows the molecules involved in an enzyme-controlled reaction.



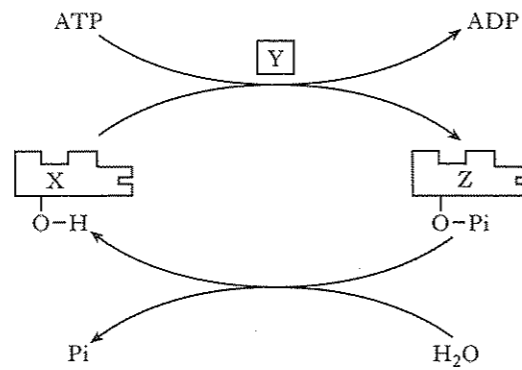
Which line in the table below correctly identifies the molecules?

	X	Y	Z
✓ A	competitive inhibitor ✓	enzyme ✓	non-competitive inhibitor ✓
✓ B	competitive inhibitor	substrate	non-competitive inhibitor ✓
C	non-competitive inhibitor	enzyme ✓	competitive inhibitor
D	non-competitive inhibitor	substrate	competitive inhibitor

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

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

9. The diagram below shows control of enzyme activity by phosphorylation.



Which line in the table below correctly identifies the labels?

	Protein kinase	Phosphorylated enzyme	Dephosphorylated enzyme
A	Z	Y	X
B	Z	X	Y
C	Y	X	Z
D	Y	Z	X

10. Which line in the table below identifies correctly an extracellular hydrophobic signalling molecule and its action?

	Signalling molecule	Action
A	insulin	activates gene regulatory proteins
B	testosterone	activates receptor proteins on the target cell surface
C	insulin	activates receptor proteins on the target cell surface
D	testosterone	activates gene regulatory proteins

11. The genes for wing shape and body colour in the fruitfly *Drosophila* are linked on the same chromosome. A cross between *Drosophila* having curled wings and dark body with others having normal wings and normal body gave the following offspring.

Phenotype	Number
Curled wings, dark body	389
Normal wings, normal body	414
Curled wings, normal body	104
Normal wings, dark body	93

The genetic map distance between the two genes can be calculated using the following formula.

$$\text{Genetic map distance} = \frac{\text{number of recombinants}}{\text{number of recombinants} + \text{parentals}} \times 100$$

The genetic map distance between the genes for wing shape and body colour is

- A 19.7
B 48.2
C 51.8
D 80.3.

12. Which line in the table below correctly identifies features of probes?

	Used in PCR	Single stranded	Labelled eg radioactive	Used in DNA profiling
A	no	yes	yes	yes
B	yes	no	no	no
C	no	no	yes	yes
D	yes	yes	no	no

13. A glucose molecule has a mass of 180 units and a water molecule has a mass of 18 units. What would be the mass of a starch molecule formed from 300 glucose molecules?

- A 43 200 units
B 48 600 units
C 48 618 units
D 54 000 units

14. The difference between gross primary production (GPP) and net primary production (NPP) in an ecosystem is due to

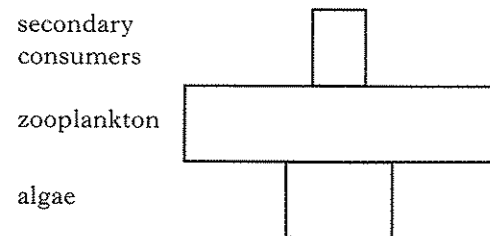
- A photosynthesis by autotrophs
B decomposition by heterotrophs
C death of heterotrophs
D respiration by autotrophs.

15. The total energy fixed by the producers in an ecosystem is $120\,000 \text{ kJ m}^{-2} \text{ year}^{-1}$. The efficiency of energy transfer between the first and second trophic level is 10% and between the second and third is 5%. How much energy ($\text{kJ m}^{-2} \text{ year}^{-1}$) is passed to the secondary consumers?

- A 240
B 600
C 2400
D 6000

[Turn over

16. The diagram shows a pyramid of biomass from a marine community.



The relatively low biomass of algae can support the greater biomass of zooplankton because of

- A rapid reproduction of the algae
 B efficient energy transfer to zooplankton
 C the large number of algae
 D the slow growth rate of zooplankton.
17. Detritivores play an important role in the circulation of nutrients in the soil.

Which line in the table below shows the correct classification of detritivores and the product which they form in the soil?

	Classification	Product
A	invertebrates	ammonia
B	bacteria	humus
C	invertebrates	humus
D	bacteria	ammonia

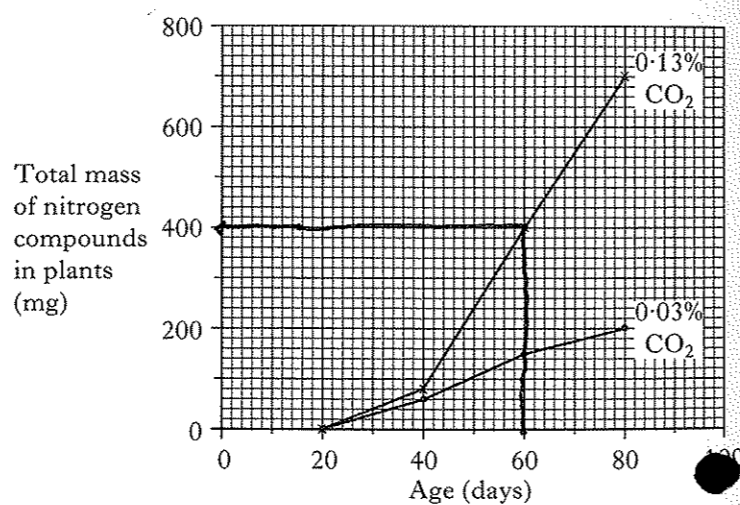
18. Which of the following is an example of Mullerian mimicry?
- A A stick insect that looks like a twig
 B A butterfly with large eyespots on its wings
 C Two harmful species of wasp that look like each other
 D A harmless snake that resembles a poisonous species

19. Two species of barnacle are commonly found on the rocks along the Scottish coast. One species is found on the lower portions of the rocks, the other higher on the rocks.

To determine the fundamental niche of one of the species

- A both species should be removed from the rocks and recolonisation of both species observed
 B both species should be removed from the rocks and recolonisation of one species observed
 C one of the species should be removed from the rocks and its recolonisation observed
 D one of the species should be continuously removed from the rocks and the spread of the other species observed.

Questions 20 and 21 refer to the following graph which shows the uptake of nitrogen by bean seedlings grown in normal air and air enriched with carbon dioxide. Beans are legumes which acquire 60% of their nitrogen compounds by absorption from the soil.



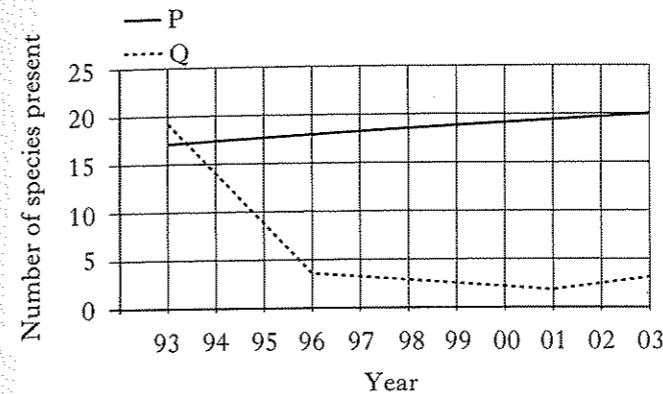
20. What mass of nitrogen had been absorbed from the soil by 60 day old plants grown in an enriched atmosphere?

- A 90 mg
 B 150 mg
 C 240 mg
 D 400 mg

21. How did the beans obtain the remaining 40% of their nitrogen requirements?

- A Nitrogen fixation - from soil air?
 B Denitrification
 C Ammonification
 D Nitrification

22. The Sea Star *Pisaster ochraceus* is a key predator of the rocky intertidal zone on the coast of Washington State, USA and it feeds on mussels and other invertebrates. The graph below shows the effect of removing *Pisaster* from a rock pool in 1993.



Which line in the table below correctly describes the results?

	Line P	Line Q	Role of Pisaster
A	with <i>Pisaster</i>	without <i>Pisaster</i>	increases species diversity
B	with <i>Pisaster</i>	without <i>Pisaster</i>	decreases species diversity
C	without <i>Pisaster</i>	with <i>Pisaster</i>	increases species diversity
D	without <i>Pisaster</i>	with <i>Pisaster</i>	decreases species diversity

23. Grazing changes the structure of plant communities as a result of

- A reducing autotroph productivity
 B increasing the biomass of herbivores
 C removing plants with basal meristems
 D removing plants without basal meristems.

24. The face mite lives in the hair follicles around the eyelids of some humans. It feeds harmlessly on the oily secretions from the sweat glands. Which type of relationship is being described?

- A Competition
 B Commensalism
 C Mutualism
 D Parasitism

25. The widespread distribution of DDT in the environment is a result of

- A toxicity
 B persistence
 C biotransformation
 D biological magnification.

[END OF SECTION A]

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

[Turn over

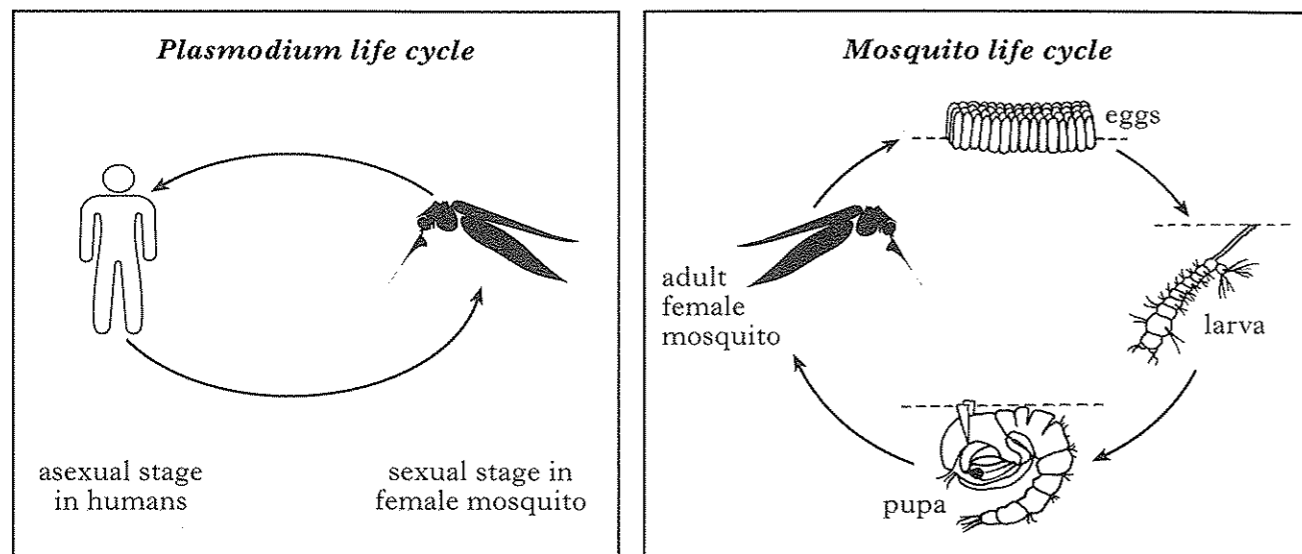
SECTION B

All questions in this section should be attempted.

- Malaria now kills more people than it did thirty years ago despite all the attempts to control it. Studies are under way to determine the link between climatic conditions and the spread of malaria.

Most deaths from malaria are caused by *Plasmodium falciparum*. This unicellular parasite has a life-cycle involving two stages: it reproduces asexually in human liver and red blood cells, while its sexual stage is carried out in female *Anopheles* mosquitoes. Towards the end of its development in the mosquito, it migrates to the insect's salivary glands from where it is transmitted to humans in a bite. Each time the female mosquito is about to lay eggs she must supplement her normal diet of nectar with a meal of blood. The bite introduces cells of *Plasmodium* to start a new infection. These interactions are shown in Figure 1.

Figure 1: Links between *Anopheles* mosquito, human and *Plasmodium*.



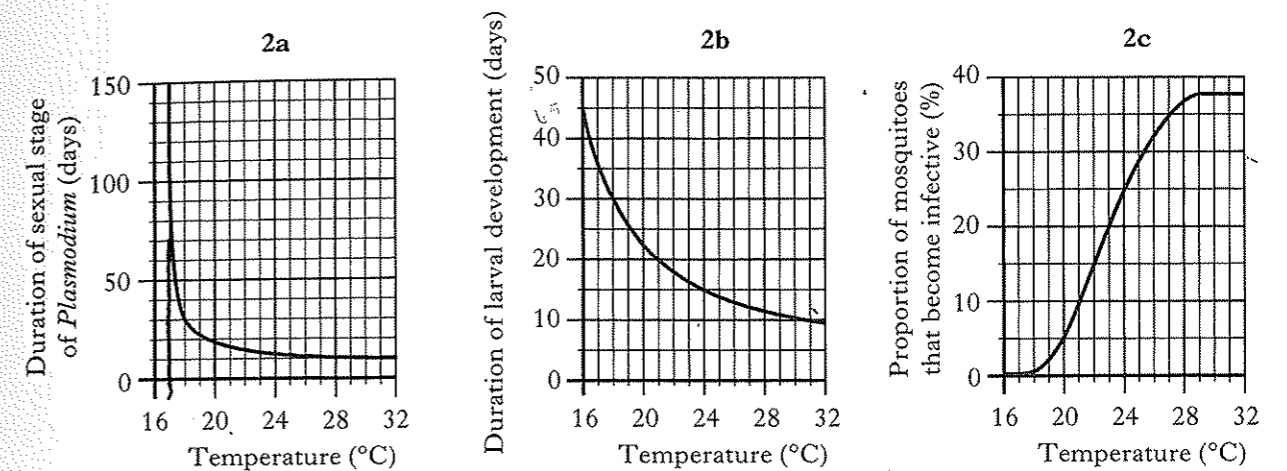
The occurrence of malaria is influenced by temperature through its effects on the life cycles of both *Plasmodium* and *Anopheles*. Figure 2a shows the effects of temperature on the time *Plasmodium* takes to complete the sexual stage of its development. Figure 2b shows the effect of temperature on the duration of the larval stage of the mosquito life cycle. Data from Figures 2a and 2b have been used to produce Figure 2c, which predicts how temperature will affect the proportion of a mosquito population capable of transmitting *Plasmodium*.

Mosquito life cycles are also affected by rainfall. Each new female will mate on the day she emerges from the pupa and, in optimal conditions, she can lay 300 eggs every two days over a typical adult life of 30 days. Eggs are laid in still water, such as pools that form after rain or floods. There needs to be sufficient rain to maintain these pools long enough for the larvae to change into adults. Figures 3a, 3b and 3c show mean monthly rainfall and temperature values in areas with different patterns of malaria transmission.

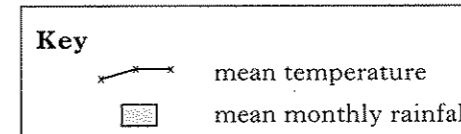
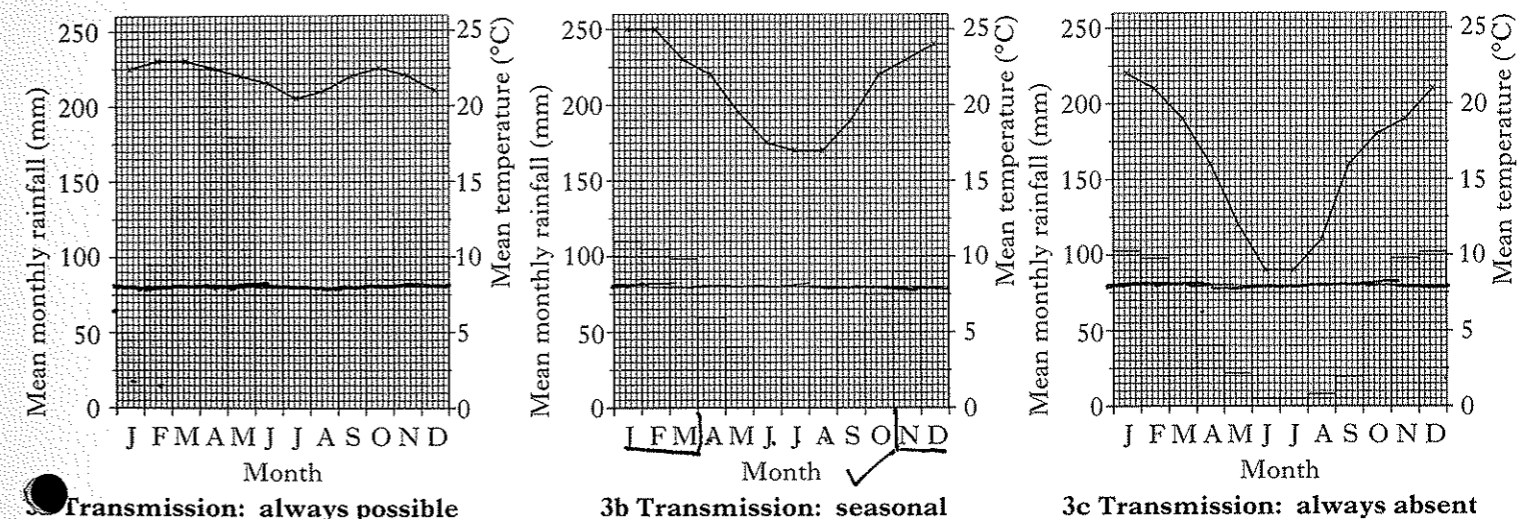
Question 1 (continued)

Figure 2: The effect of temperature on the potential for malarial transmission.

- Duration of the sexual stage of *Plasmodium*
- Duration of mosquito larval development
- Proportion of mosquitoes that become infective



Figures 3a, 3b and 3c: Mean monthly rainfall and temperature associated with regions having different patterns of malarial transmission.



[Question 1 continues on Page ten]

Question 1 (continued)

Marks

- (a) (i) What term is used to describe the role of mosquitoes in spreading malaria? 1
- (ii) *Plasmodium* cannot survive without its host organisms. What term describes this form of parasitism? 1
- (b) Explain why reducing the number of mosquito larvae contributes to the control of malaria. 2
- (c) (i) Referring to Figure 2b, how many times faster is mosquito larval development at 32 °C compared to 16 °C? 1
- (ii) What is the minimum temperature for successful completion of the sexual stage of *Plasmodium* in a typical adult female? 1
- (iii) From the results presented in Figures 2a and 2b, explain why the proportion of mosquitoes that are infective increases with temperature. 2
- (iv) Why does the temperature response of *Plasmodium* not apply to its asexual stage of development? 1
- (d) It has been concluded that a period of five consecutive months of rainfall of 80 mm or more is critical for malarial transmission and that other factors also have an influence.
- (i) Use the data in Figures 3a and 3b to show how this conclusion can be justified. 2
- (ii) Suggest an explanation for the transmission of malaria having a “seasonal” pattern in the conditions shown in Figure 3b. 1
- (e) Mean summer temperature for southern England is predicted to increase to 17 °C from the enhancement of the “greenhouse effect”. Give **two** examples of human activities that contribute to this “enhancement”. 2
- (14)

[Questions 2 and 3 are on fold-out Page eleven

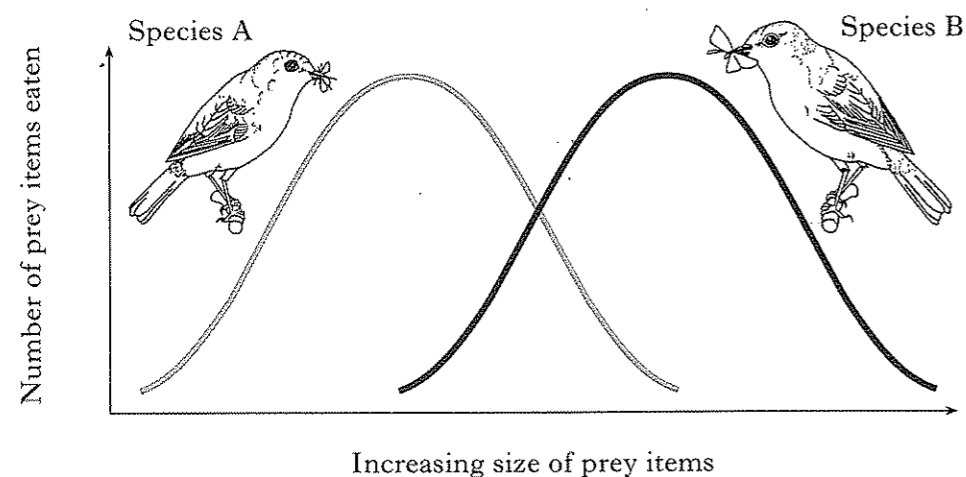
2. The African lungfish lives in swamps that are periodically flooded and then undergo a dry season. When the swamp dries up the lungfish digs a burrow, closes the entrance with mud and enters a state of dormancy. When the rains return, the lungfish emerges from its burrow.

- (a) Explain why dormancy in lungfish is *consequential*.
- (b) What term describes the type of dormancy exhibited by lungfish?
- (c) Lungfish are *poikilothermic*. What does this mean?

Marks

1
1
1
(3)

3. Species A and species B occupy the same habitat. The Figure shows the consumption of prey items of different size by the two species.

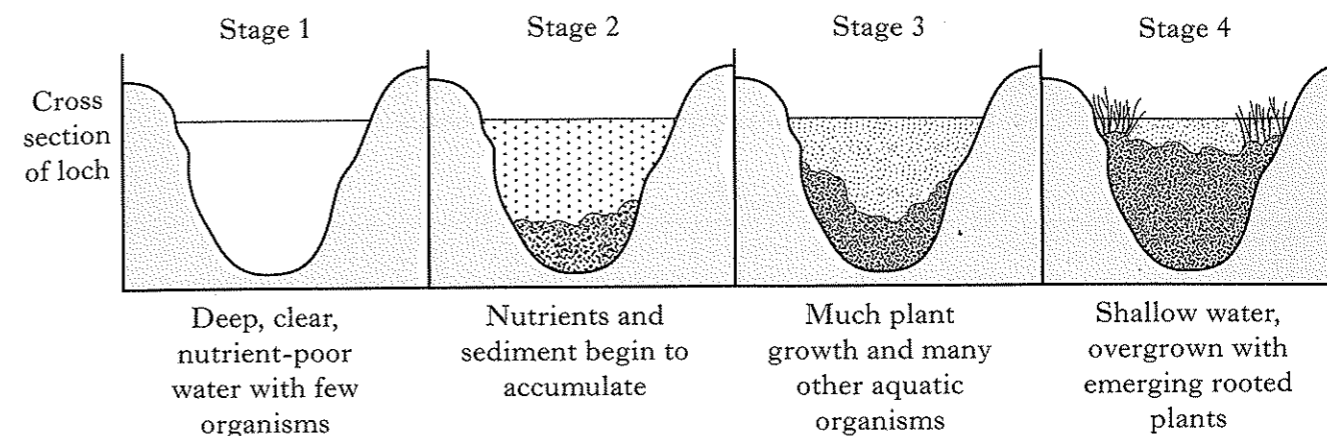


- (a) Neither species is able to occupy its fundamental niche. What evidence in the Figure supports this?
- (b) Explain how *resource partitioning* would allow the two species to coexist.
- (c) Give **one** other biotic interaction, not shown in the Figure, that could influence the population density of either species.

1
1
1
(3)

4. The diagram shows stages of autogenic succession in a freshwater loch.

Marks



- (a) What is meant by *facilitation* in an autogenic succession?
- (b) State three general features this succession has in common with succession in other ecosystems.
- (c) A number of small rivers normally drain into the loch from the surrounding land. Explain how applications of large amounts of nitrate fertiliser to the surrounding land might affect the loch system.

2
2
4
(8)

5. The growth of cells is regulated by two checkpoints in interphase in the cell cycle. The main function of the checkpoint towards the end of G1 is to assess if the cell is large enough to undergo cell division. Mutant yeast cells, called *wee* mutants, lack a component that can stop the cell cycle during G1.

Figures 1 and 2 below show the growth in size of two types of yeast cell, A and B, before and after the level of nutrition is reduced.

Figure 1: Cell type A

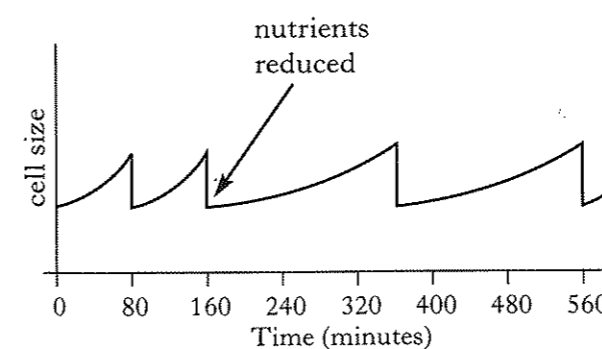
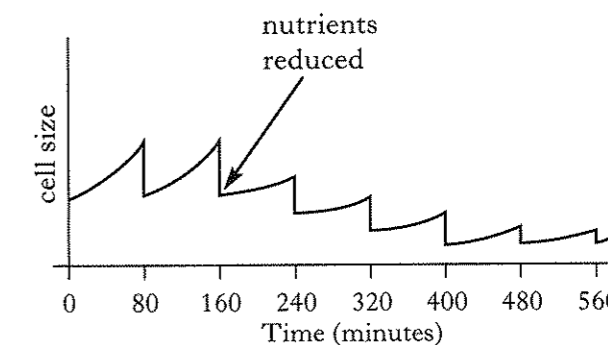


Figure 2: Cell type B



- (a) Apart from checking size, what is the main purpose of the G2 checkpoint?
- (b) How many cycles will type A cells have completed in 24 hours after the reduction in nutrient levels?
- (c) Give **two** pieces of evidence to support the conclusion that cell type B has the *wee* mutation.

1
1
1
(3)

6. During the polymerase chain reaction (PCR), a solution of DNA molecules is heated to separate the double helix into single strands. This “melting” of DNA can be monitored by measuring how much UV light the solution absorbs. By the time the melting is complete and all the double stranded DNA is unpaired, UV absorption almost doubles (Figure 1). The melting temperature (T_m) of the DNA is taken to be the one where half the base pairs have separated. T_m depends on the number of G–C base pairs in the sample (Figure 2).

Figure 1

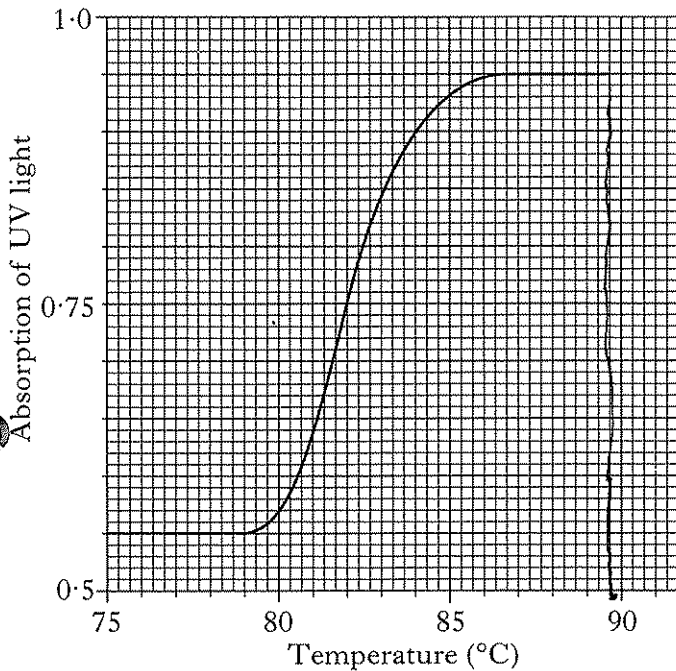
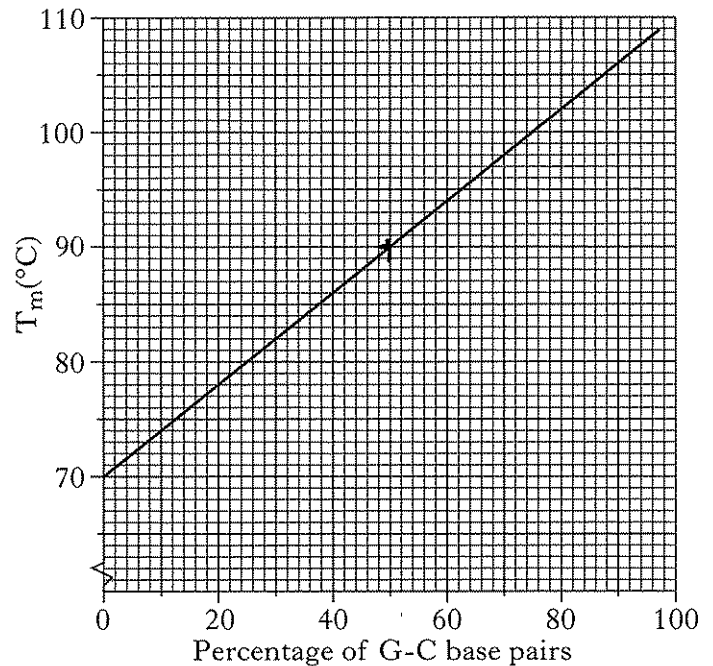


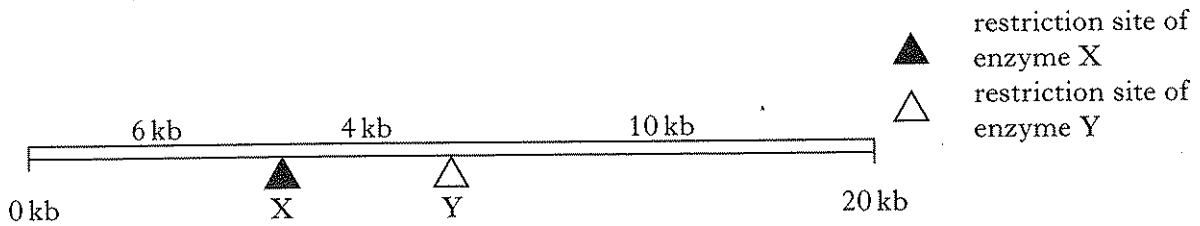
Figure 2



- (a) What is the function of the polymerase chain reaction? 1
- (b) (i) What is the value of T_m for the sample shown? 1
- (ii) What percentage of A–T base pairs does the sample contain? 1
- (c) (i) What evidence is there that G–C base pairs confer stability on the DNA double helix? 1
- (ii) Why should each G–C base pair have more influence on DNA stability than each A–T base pair? 1
- (5)

[Turn over

7. Restriction enzymes cut strands of DNA double helix at specific sites called *restriction sites*. The effect of using the enzymes is to cut the DNA into fragments, which can be separated by electrophoresis. *Restriction maps* can be created from the fragment information to show the relative positions of the restriction sites in kilobase (kb) lengths, as shown in the following example.



- (a) What sizes of fragment would be produced if the 20 kb piece of DNA shown in the map above was cut with enzyme X only? 1
- (b) The table shows the number and sizes of fragments from a digest of a 10 kb DNA sample using two restriction enzymes, A and B.

Enzymes added	Fragment size (kb)		
A only	8	2	—
B only	7	3	—
A and B together	5	3	2

Draw a restriction map for the digest, labelling where the restriction sites are in relation to each other. 1

- (c) Explain why electrophoresis can be used to separate fragments of DNA. 2

(4)

8. Answer **either A or B**.

- A. (i) Describe the organisation of genetic material in prokaryotic and eukaryotic cells. 4
- (ii) Describe how plasmids are modified and used in the production of transgenic plants. 11

(15)

OR

B. Give an account of enzyme activity under the following headings:

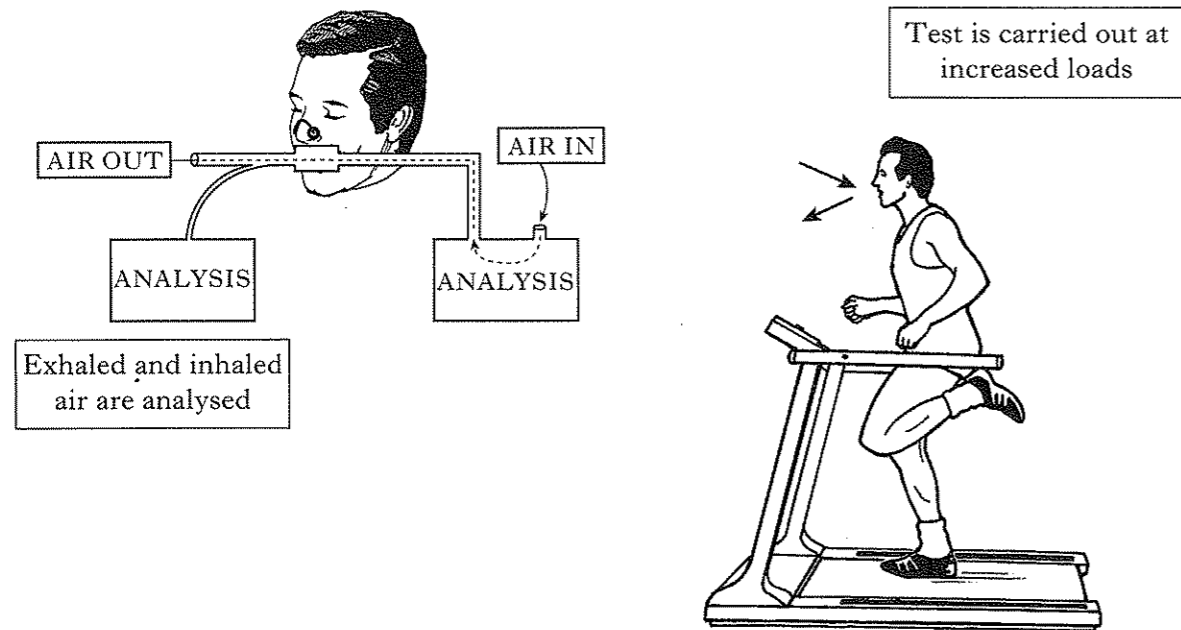
- (i) induced fit; 4
- (ii) enzyme activation; 6
- (iii) end-product inhibition. 5

(15)

SECTION C (continued)

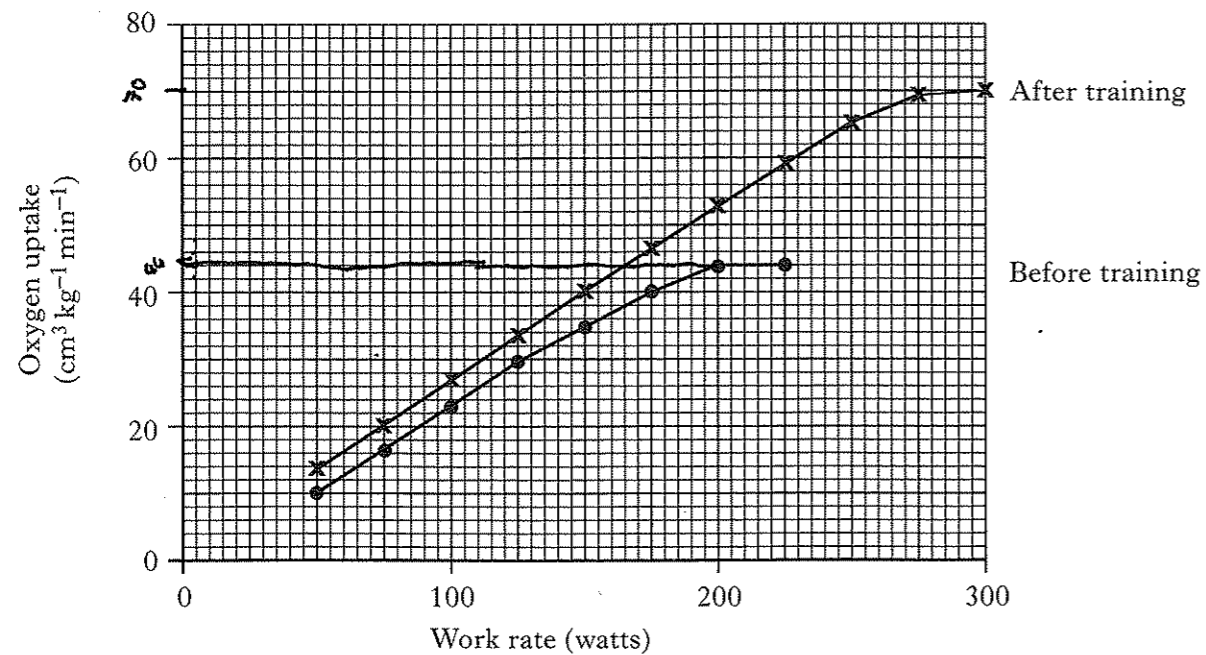
Physiology, Health and Exercise

1. The diagrams below show the apparatus used in exercise testing to determine $VO_{2\max}$. In this procedure a subject is made to run on a treadmill at constant speed. Work rate (watts) is increased by increasing the incline of the treadmill.



During the test, the total volume of air and the percentage of oxygen are determined for both inhaled and exhaled air. The Figure below shows the results of such a test carried out on a person preparing for a marathon, before and after a six-month period of endurance training.

Figure



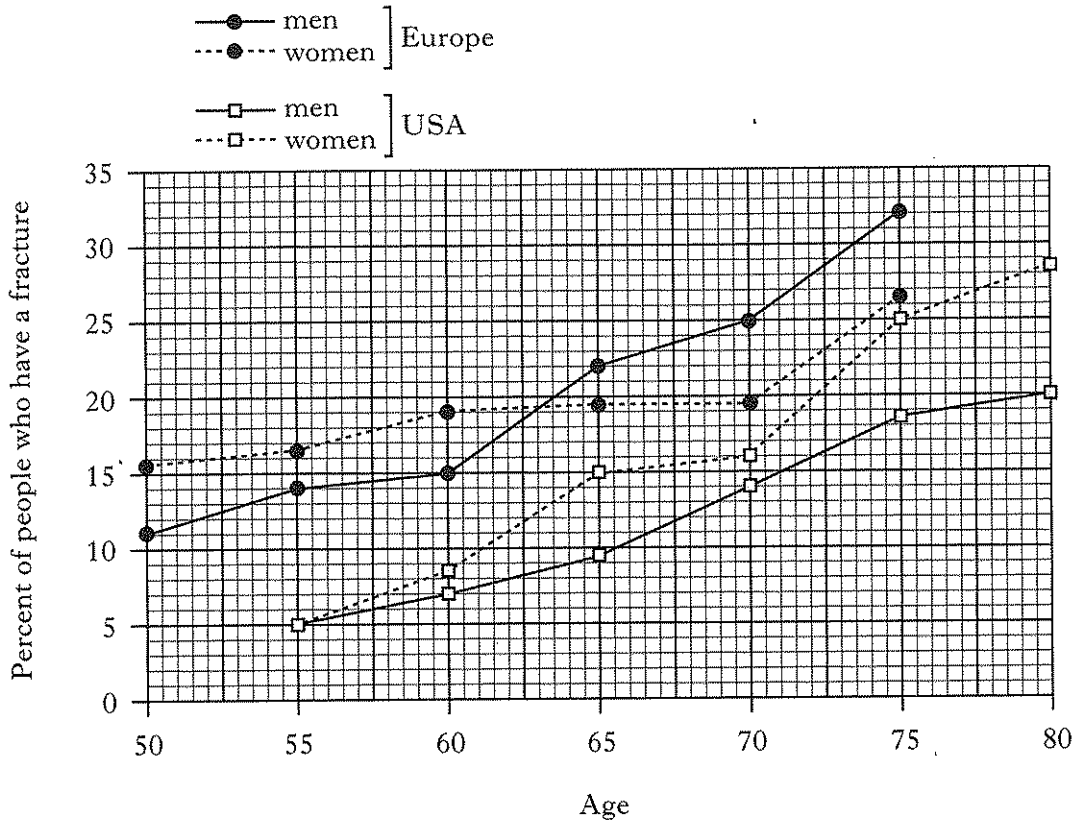
Physiology, Health and Exercise Question 1 (continued)

Marks

- (a) (i) What is meant by $VO_{2\max}$? 1
- (ii) From the information given, identify the two other measurements required to calculate $VO_{2\max}$. 1
- (iii) What is the percentage improvement in $VO_{2\max}$ resulting from the training? 1
- (iv) Explain why the improvement in $VO_{2\max}$ will lead to an improved performance in the marathon. 2
- (b) (i) How does endurance training affect the structure of an athlete's heart? 1
- (ii) Explain how the changes in performance of the heart arising from endurance training lead to a reduction in resting heart rate. 2
2. Blood lipid profiling is carried out as part of routine health checks to give an indication of the risk of cardiovascular disease. The profile includes measurements of the concentrations of the lipoproteins HDL and LDL.
- (a) What is the role of lipoprotein in the development of atherosclerosis? 2
- (b) Describe the effect of regular exercise on blood lipid profiles. 1

[Turn over for Questions 3 and 4 on Page twenty-two]

3. The Figure shows the results of two studies carried out in 1996 into the occurrence of vertebral fractures.



- (a) Explain why the results suggest that vertebral fractures in older people may be associated with osteoporosis. 2
 - (b) What evidence indicates that there is geographical variation in the occurrence of osteoporosis? 1
 - (c) Identify **two** factors that could account for the geographical variation. 1
4. Outline the factors that bring about variations in total energy expenditure. 5

(20)

[END OF QUESTION PAPER]