Cambridge Pre-U

Cambridge International Examinations
Cambridge Pre-U Certificate

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

9369517383

BIOLOGY (PRINCIPAL) **9790/01**

Paper 1 Structured **May/June 2016**

2 hours 30 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.

Section A
Write your answers in the spaces provided on the Question Paper.

Section B
Write your answers in the spaces provided on the Question Paper.
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
Section A	
21	
22	
23	
24	
25	
26	
Total	

The syllabus is approved for use in England, Wales and Northern Ireland as a Cambridge International Level 3 Pre-U Certificate.

This document consists of **34** printed pages and **2** blank pages.

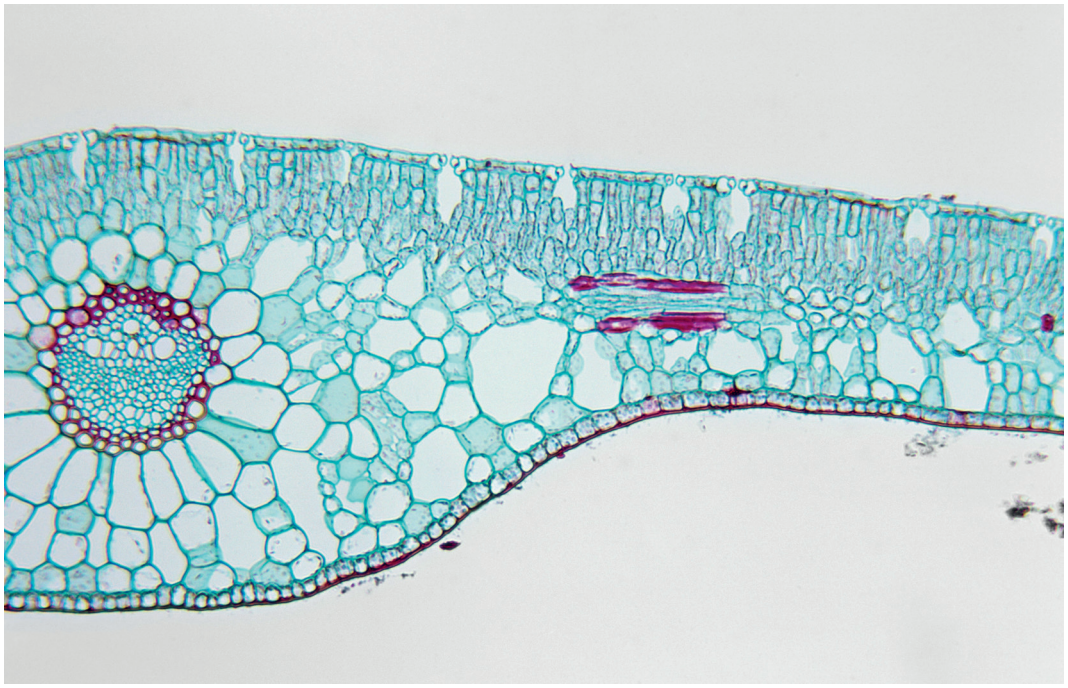
CAMBRIDGE International Examinations

Section A

Answer **all** the questions.

You are advised to spend no more than 30 minutes on this section.

1 The photomicrograph shows a transverse section through a leaf of a hydrophyte that has been removed from a large pond.



Which description matches this leaf?

A The leaf is normally floating and most stomata are found on the lower epidermis to prevent excessive water loss by transpiration.

B The leaf is normally floating and the stomata are on the upper epidermis to allow diffusion of gases into and out of the leaf.

C The leaf is normally submerged and, as the epidermal cells carry out gas exchange, there are no stomata.

D The leaf is normally submerged and there is a thick cuticle on both the lower epidermis and upper epidermis to prevent entry of water.

answer .....[1]

2 Read the following statements.

- Gibberellins belong to a group of chemicals known as terpenoids and are made up of the elements carbon, hydrogen and oxygen only.
- In the pea plants that Mendel studied, the stem length gene, *Le*/*le*, controls the length between nodes.
- Pure-breeding, tall pea plants were crossed with pure-breeding, dwarf pea plants. The F1 generation plants were all of the same height. When these were crossed, the numbers of tall and dwarf plants in the F2 generation were counted. There were 787 tall and 277 dwarf plants.
- The dwarf variety of the pea plant lacks gibberellin.
- Addition of gibberellin to the dwarf plants results in conversion of the dwarf to the tall phenotype.

Which of the following can be concluded from these statements?

A Heterozygous genotypes for the stem length gene are of an intermediate height, as only 50% of the product of gene expression is synthesised.

B The lack of a ratio of 3 tall pea plants to 1 dwarf pea plant in the F2 generation means that there is an environmental effect contributing to height in pea plants.

C The *Le*/*le* gene codes for the protein gibberellin, with only the *LeLe* or *Lele* genotypes expressing gibberellin and with the *lele* genotype unable to express gibberellin.

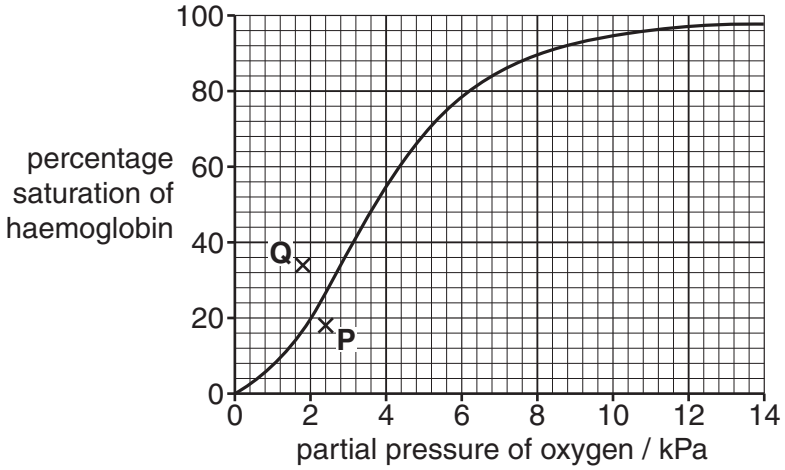
D There is at least one altered triplet code in the dwarf allele of the *Le*/*le* gene, producing a polypeptide with an altered tertiary structure and resulting in a non-functioning protein.

answer ..... [1]

[Turn over

Questions 3, 4 and 5

A student was asked to study a number of different oxygen dissociation curves for haemoglobin. The standard curve for a healthy adult human at sea level is shown below. Two plotted points, **P** and **Q**, are results from other oxygen dissociation curves.



A to **E** are valid statements made by the student after studying all the curves.

A Fetal haemoglobin has a higher affinity for oxygen than adult haemoglobin at partial pressures of oxygen found in respiring body tissues.

B The Bohr shift has been demonstrated.

C Haemoglobin maintains its high affinity for oxygen as blood is transported in the arteries towards the capillary network in active muscles.

D An increase in pH results in impaired unloading of oxygen.

E A higher body temperature results in a lower affinity of haemoglobin for oxygen.

The student was able to support each statement by quoting coordinates from relevant curves.

3 Which **two** statements are only supported by the relevant oxygen dissociation curves that pass through the point plotted at **P**?

answer ..... [1]

4 Which **two** statements are only supported by the relevant oxygen dissociation curves that pass through the point plotted at **Q**?

answer ..... [1]

5 Which statement has been based only on the curve shown?

answer ..... [1]

6 A student carried out a mark-release-recapture exercise and used the Lincoln index to estimate the size of a population of woodlice.

Following release of marked woodlice back into the habitat, the paint used to mark the woodlice proved to be fatal to some individuals.

What consequence would this have on the exercise?

A The estimate of population size would not be affected if the number of woodlice killed was equal to the number of immigrants.

B The total number of woodlice collected in the second sample would decrease, allowing an estimate of the number of killed woodlice to be taken into account.

C There would be an overestimate of the size of the population of woodlice.

D There would be an underestimate of the size of the population of woodlice.

answer ..... [1]

7 In gene regulation in prokaryotes, to which section of DNA does the enzyme RNA polymerase first attach?

A operator

B promoter

C regulator gene

D structural gene

answer ..... [1]

8 Five different microscopes are available to view an organelle with a diameter of 250 nm.

microscope	**1**	**2**	**3**	**4**	**5**
maximum resolution	0.3 mm	30 nm	0.3 μm	0.0005 μm	5 nm

Which is a correct deduction about the microscopes and the ability to view the organelle?

A Microscope **1** is a light microscope with the ability to view the organelle, but with less detail than an electron microscope.

B Microscopes **2** and **3** are electron microscopes that have the same resolving power; the organelle is visible with both.

C The wavelength of the radiation used in microscope **4**, an electron microscope, is about 1 nm and the organelle will be visible.

D The wavelength of the radiation used in microscope **5**, an electron microscope, is the same as that of microscope **4** and the organelle will be visible with both.

answer ..... [1]

9 In order to identify transformed bacterial cells, a researcher decided to use a gene coding for antibiotic resistance as a marker, rather than a gene coding for green fluorescent protein (GFP).

What is a possible reason for this decision?

A GFP has a very short biological half-life.

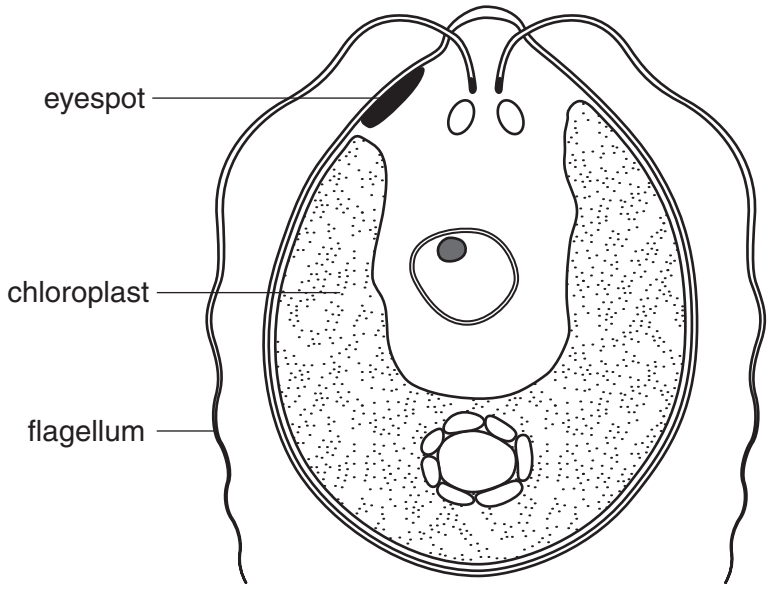
B The gene coding for antibiotic resistance does not produce a protein.

C The gene coding for GFP comes from an animal, not a bacterium.

D The transformed cells were strict anaerobes and GFP needs oxygen for fluorescence.

answer ..... [1]

10 The diagram shows a member of the genus *Chlamydomonas*.



The organism is found in freshwater and uses the eyespot to detect a light stimulus. Stimulation of the eyespot by light causes an influx of calcium ions into the flagella. The organism turns and swims towards the light due to the difference in activity of each flagellum as a result of the calcium ion influx.

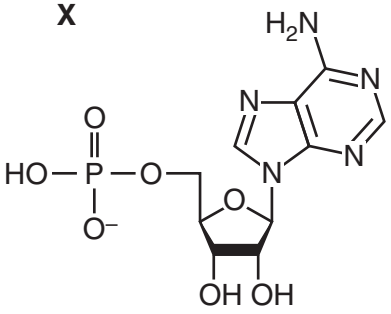
Which is a correct summary of the behaviour displayed?

	innate	photokinesis	positive chemotaxis	positive phototaxis	reflex response
A	✓			✓	
B			✓	✓	
C	✓				✓
D	✓	✓			

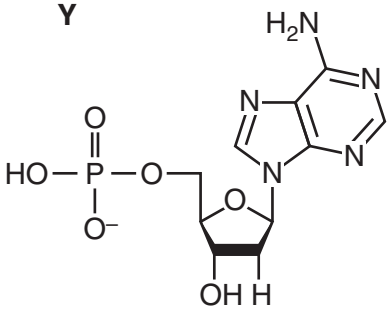
answer ..... [1]

11 The molecular structures of two nucleotides, **X** and **Y**, are shown in the diagram below. The base in each nucleotide is adenine.

X



Y



Which are correct statements about nucleotides **X** and **Y**?

1 **X** is adenosine monophosphate and forms 2 hydrogen bonds with its complementary nucleotide during transcription.

2 **X** is a DNA nucleotide and forms a complementary base pair with a uracil nucleotide during transcription.

3 **X** is found in RNA and **Y** is a product of the hydrolysis of an ATP molecule.

4 **Y** is found in DNA and forms a complementary base pair with a uracil nucleotide during replication.

A 1 only

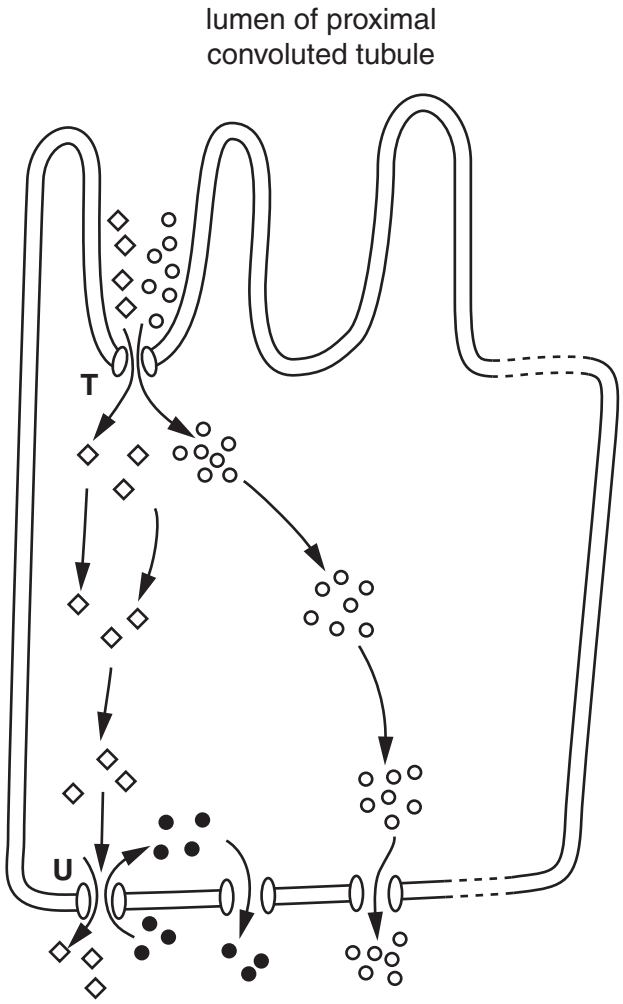
B 1 and 3

C 2 only

D 2 and 4

answer ..... [1]

12 The diagram represents events occurring in a cell of the proximal convoluted tubule that result in the selective reabsorption of glucose.



Membrane proteins **T** and **U** are each able to transport two substances across the membrane of the proximal convoluted tubule cell.

Which row of the table is correct?

	membrane protein **T**		membrane protein **U**	
	example of substance transported	mechanism used to transport substance across membrane	example of substance transported	mechanism used to transport substance across membrane
A	glucose molecules	active transport	glucose molecules	facilitated diffusion
B	glucose molecules	facilitated diffusion	glucose molecules	active transport
C	sodium ions	active transport	potassium ions	facilitated diffusion
D	sodium ions	facilitated diffusion	potassium ions	active transport

answer ..... [1]

13 Some of the water in the glomerular filtrate is reabsorbed in the proximal convoluted tubule.

Which statements are correct?

1 The movement of solutes into the proximal convoluted tubule cell causes water to move into the cell by osmosis down a water potential gradient.

2 The movement of water down the water potential gradient through aquaporins creates a diffusion gradient for the movement of solutes from the proximal convoluted tubule cell to the capillary.

3 The movement of water out of the proximal convoluted tubule cell is controlled by the presence of ADH, which regulates the number of aquaporins present.

4 The presence of plasma proteins in the capillary enhances the movement of water from a more negative water potential outside the capillary to a less negative water potential in the capillary.

A 1 only

B 1 and 4

C 2 and 3

D 3 only

answer ..... [1]

14 Where does most reabsorption of water occur in the kidney in humans?

A collecting ducts

B distal convoluted tubules

C loops of Henle

D proximal convoluted tubules

answer ..... [1]

15 A student recorded the shell colour and banding pattern of all empty shells of the brown-lipped snail, *Cepaea nemoralis*, found in a small deciduous wood. Wide variation in shell colour and banding pattern, which are genetically controlled, was shown. Of the shells collected, 38% were damaged and 62% were intact.

Gene **C** codes for the colour of the shell. There are six alleles.

$\mathbf{C}^{B}$	$\mathbf{C}^{DP}$	$\mathbf{C}^{PP}$	$\mathbf{C}^{FP}$	$\mathbf{C}^{DY}$	$\mathbf{C}^{PY}$
brown	dark pink	pale pink	faint pink	dark yellow	pale yellow

most dominant ⟶ least dominant

Gene **B** codes for the presence or absence of bands. There are two alleles.

$\mathbf{B}^{0}$ = unbanded, dominant allele
$\mathbf{B}^{B}$ = banded, recessive allele

Which conclusion drawn from this information is valid?

A In the wood, brown, unbanded phenotypes will occur in the highest frequency and banded, pale yellow phenotypes will occur in the lowest frequency.

B More than one selection pressure is likely to be acting to maintain the polymorphism shown in shell colour and banding pattern in the wood.

C Predation by birds, such as the song thrush, is the only selection pressure acting on *C. nemoralis* in the small deciduous wood.

D The proportion of each phenotype in the population of *C. nemoralis* in the wood will be similar to the proportion of each phenotype recorded for the empty shells.

answer ..... [1]

16 Humans are members of the Hominidae.

Of which taxonomic group is this an example?

A family

B genus

C order

D phylum

answer ..... [1]

17 Which immunological response is an indication of myasthenia gravis?

A Binding of specific antibody to self-antigen on the external cell surface membranes of muscle cells.

B Lysis of muscle cells following recognition and binding of specific cytotoxic T cells.

C Non-specific stimulation and activation of macrophages leading to phagocytosis of muscle cells.

D Secretion of cytokine by helper T cells increasing phagocytosis of muscle cells by macrophages.

answer ..... [1]

18 Which structure is **not** located in the hind brain?

A cerebellum

B medulla oblongata

C pons varolii

D thalamus

answer ..... [1]

19 Different types of reaction occur in the sequence of chemical reactions known as the Calvin cycle.

Which reaction of the Calvin cycle is correctly described?

A Carboxylation occurs in the conversion of triose phosphate to RuBP.

B Decarboxylation occurs in the conversion of RuBP to GP.

C Phosphorylation occurs in the conversion of RuBP to GP.

D Reduction occurs in the conversion of GP to triose phosphate.

answer ..... [1]

20 Of four students who were asked to state a feature of the genetic disease phenylketonuria, only one gave a correct answer.

Which is the correct statement?

A A diet low in phenylalanine may reduce the effects caused by the mutation of the gene coding for phenylalanine hydroxylase.

B A diet low in tyrosine may help to prevent damage to the developing nervous system.

C A mutation of the gene coding for phenylalanine hydroxylase leads to overproduction of the enzyme and an excess of the amino acid phenylalanine.

D There is a failure to convert tyrosine to the amino acid phenylalanine, which is required for healthy development of the nervous system.

answer ..... [1]

[Turn over

Section B

Answer **all** the questions.

You are advised to spend no more than 2 hours on this section.

21 Parasitic angiosperms are flowering plants that obtain some or all of their carbon, water, mineral ions and other nutrients from the vascular tissue of a host plant. A major adaptation shown by all parasitic plants is a haustorium, an organ that enables the transfer of nutrients from the host to the parasite.

Fig. 21.1 shows one way to categorise parasitic angiosperms. An example of a species from each category is also included.

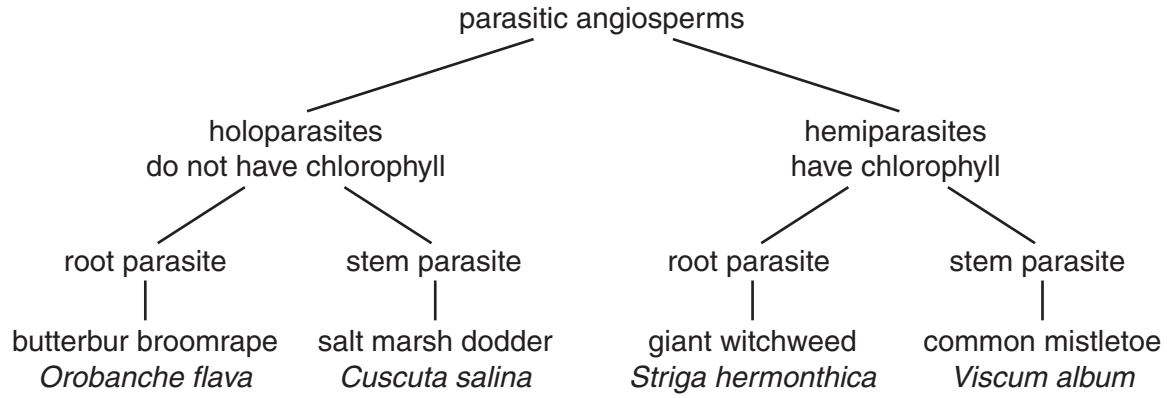


Fig. 21.1

(a) Suggest why holoparasitic plants, such as *O. flava*, do not need chlorophyll.

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(b) *S. hermonthica* has stomata that are permanently open.

(i) With reference to the properties of water, suggest how this physiological adaptation facilitates extraction of water and mineral ions from the xylem of the host plant.

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(ii) The leaf epidermis of *S. hermonthica* has been shown to have high potassium ion content. This is thought to be linked to the permanent opening of stomata shown by the parasite.

Outline the role of potassium ions in stomatal opening.

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Parish's glasswort, *Arthrocnemum subterminale* and American glasswort, *Salicornia virginica*, are two species of perennial salt marsh plants that can be parasitised by *C. salina.*

Fig. 21.2 shows the general pattern of distribution of the three plant species along a transect in an area of salt marsh.

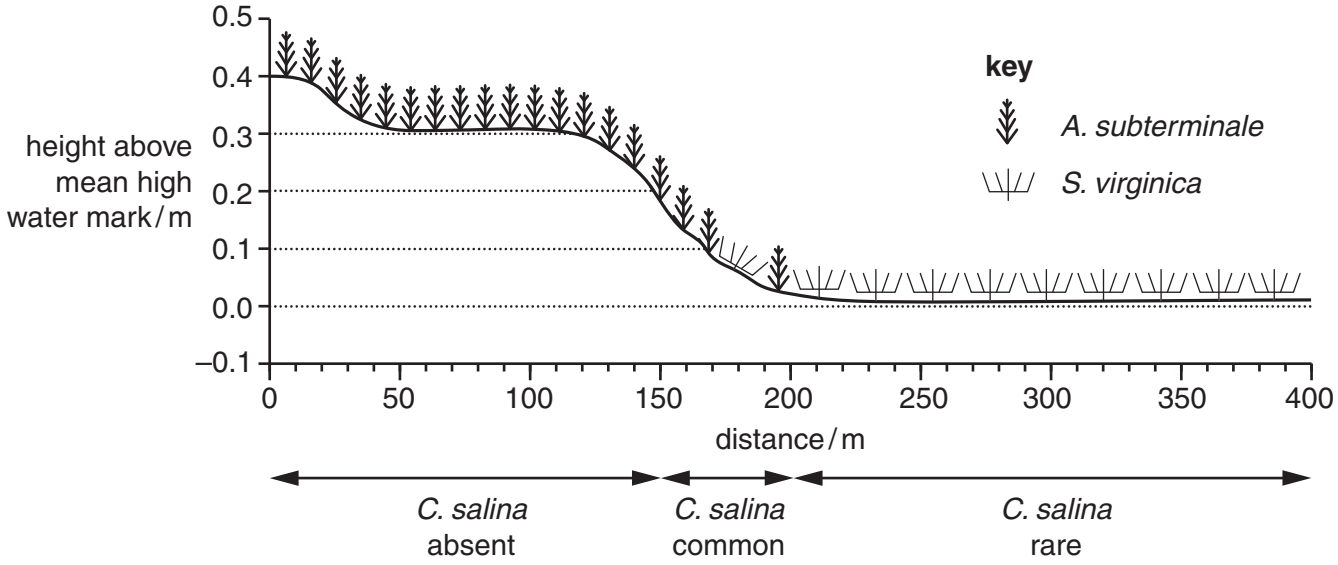

Fig. 21.2

(c) With reference to Fig. 21.2, describe the distribution of the three plant species.

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(d) A study was carried out into the effect of parasitism by *C. salina* on *A. subterminale* and *S. virginica* growing in the ecotone of the salt marsh. The ecotone is the zone where the two species of glasswort meet.

Some permanent 0.5 m × 0.5 m quadrats were set up at the ecotone. Only half of the quadrats showed evidence of parasitism by *C. salina*. The mean percentage cover of each of the host plant species in the quadrats with and without *C. salina* was estimated each year for three years.

The results are shown in Fig. 21.3.

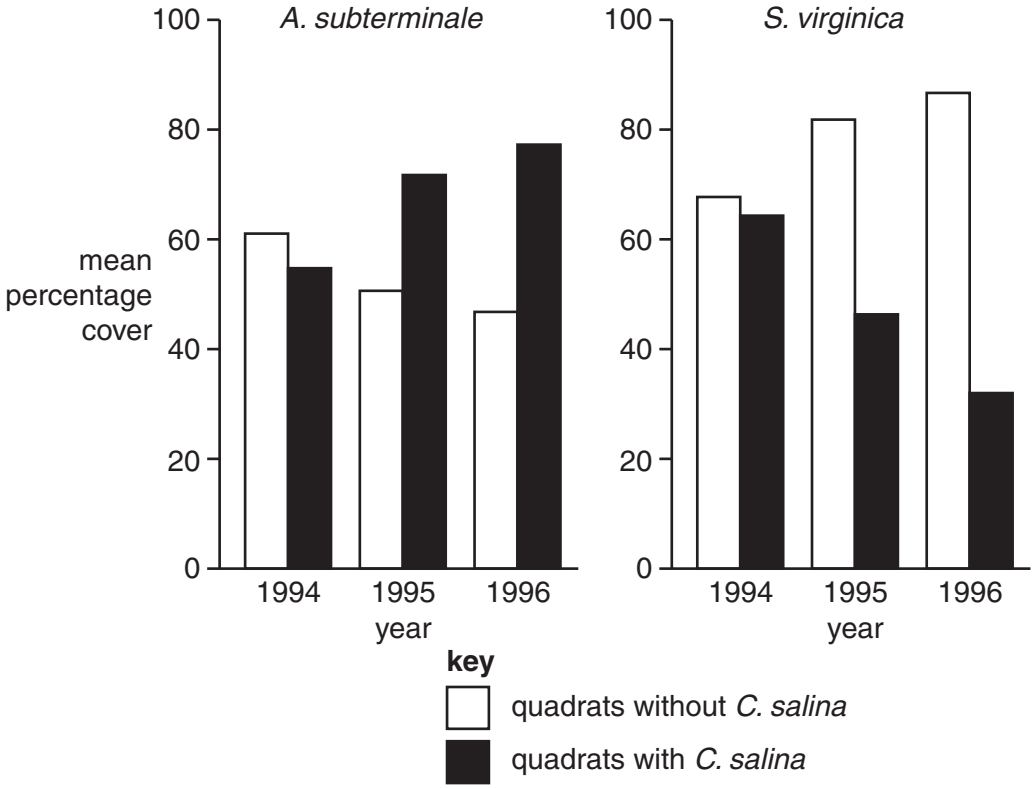

Fig. 21.3

Describe the trends in the data shown in Fig. 21.3 over the three years of the study.

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(e) Suggest how, and explain why, the presence of *C. salina* in the salt marsh changes the distribution and abundance of *A. subterminale* and *S. virginica* at the ecotone.

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(f) Suggest why some species of parasitic plants have been described as keystone species.

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[Total: 20]

22 Cholesterol is a type of lipid that has a number of roles in living organisms.

(a) Cholesterol is an important component of the membranes of eukaryotic cells. Fig. 22.1 shows the structural formula of a cholesterol molecule. It has a hydrophilic and a hydrophobic portion.

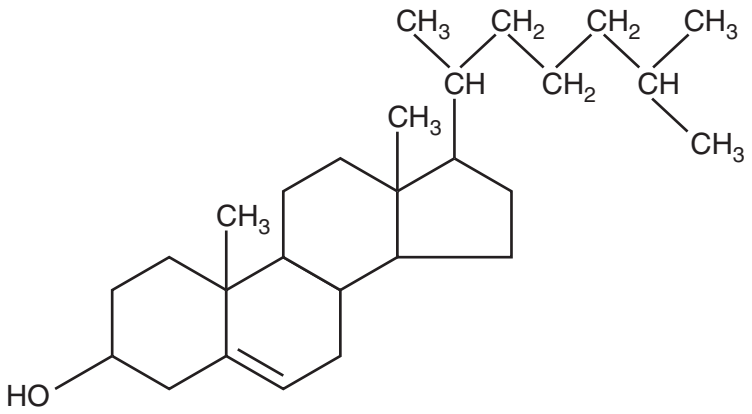

Fig. 22.1

(i) On Fig. 22.1, draw a box around the hydrophilic portion of cholesterol. [1]

(ii) Describe how cholesterol is arranged within a membrane **and** how this relates to its role in cell membranes.

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(b) One source of cholesterol for mammals is their food. Cholesterol is absorbed in the small intestine.

Describe how the small intestine is adapted for its role of absorption.

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(c) In the lumen of the small intestine, cholesterol is taken to the surface of the intestinal epithelial cells within micelles. Cholesterol uptake into these cells involves passive and active mechanisms. Once in these cells, cholesterol enters the internal membrane network where a high proportion is converted into cholesteryl esters. The cholesteryl esters are packaged with other molecules to form chylomicrons, which can then be released from the cell.

Fig. 22.2 summarises these events.

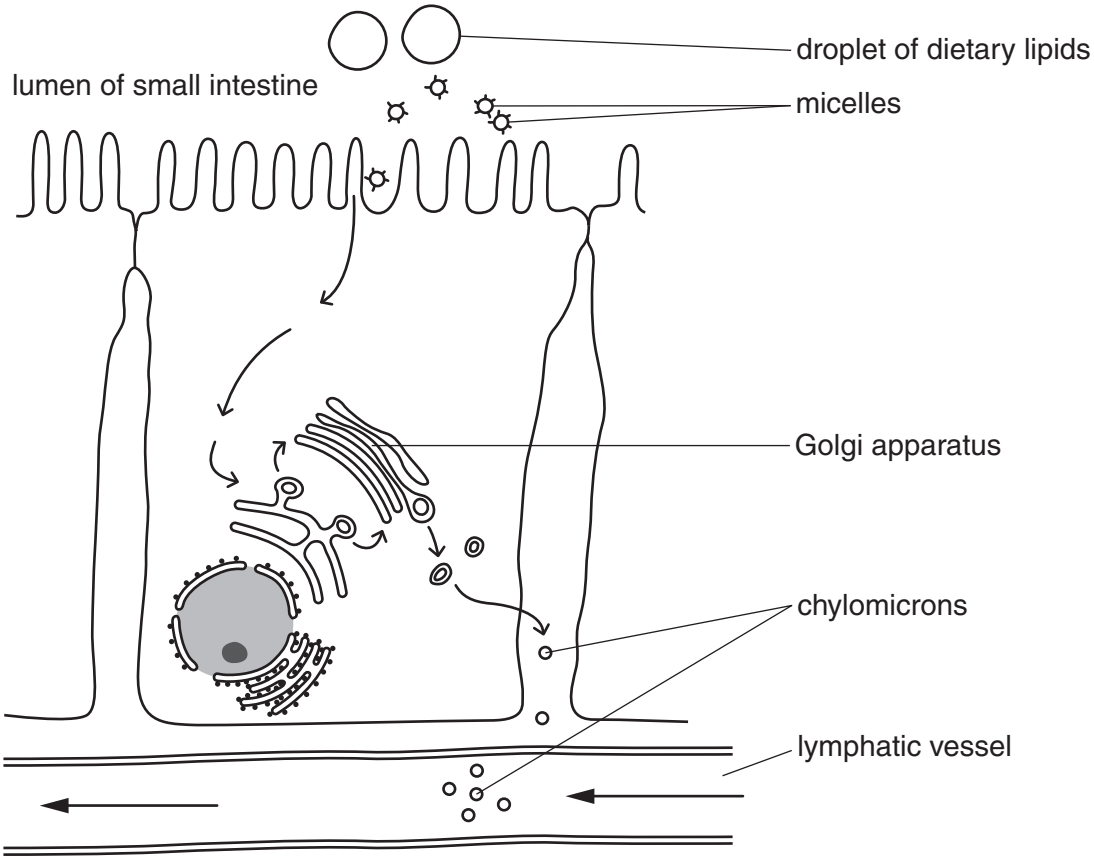

Fig. 22.2

With reference to the transport mechanisms and cell structures involved, describe the pathway taken by cholesterol as it passes from the lumen of the small intestine to a lymphatic vessel.

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(d) There is considerable variation between people in the rate at which cholesterol in the intestinal lumen passes into the circulatory system.

Fig. 22.3 shows the variation in the rate at which cholesterol in the intestinal lumen passes into the blood in a population of humans.

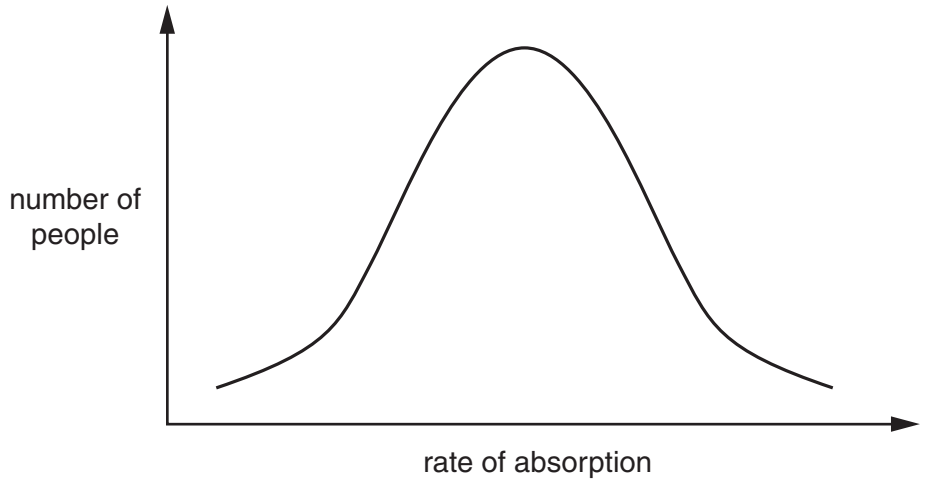

Fig. 22.3

Suggest how environmental and genetic factors contribute to the variation shown in Fig. 22.3.

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(e) In addition to dietary intake, cholesterol is synthesised in the human body in a number of steps, as outlined in Fig. 22.4.

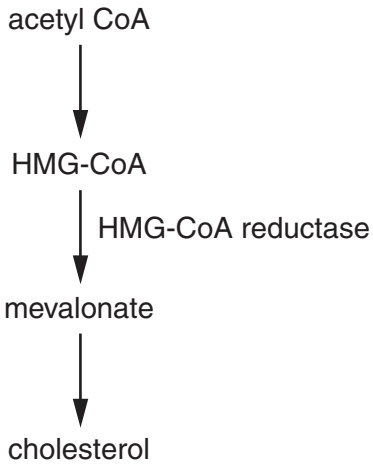

Fig. 22.4

A person with cardiovascular disease may be prescribed drugs known as statins to inhibit HMG-CoA reductase.

Explain the benefits of taking statins for people with cardiovascular disease.

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[Total: 20]

23 During the cell cycle, semi-conservative replication of DNA occurs.

(a) Name the stage during the cell cycle in which replication of DNA occurs.

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(b) State the importance of DNA replication as part of the cell cycle.

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..... [1]

(c) In 1957, Matthew Meselson and Franklin Stahl carried out an experiment that provided the evidence that DNA replicates semi-conservatively.

The experiment started with bacteria that had been cultured for many generations in a medium containing the heavy isotope of nitrogen, ^{15}N, as the only source of nitrogen. This meant that the bacteria incorporated the heavy isotope into the bases A, T, C and G and so produced 'heavy' DNA.

A sample of these bacteria was inoculated into a culture medium containing the normal light ^{14}N isotope of nitrogen. After the time required for the bacterial population to reproduce once, a sample of the bacteria was taken. This consisted of the first generation of new bacteria. After a time interval allowing one more round of cell division to occur, a second sample was removed. This consisted of bacteria of the second generation.

The DNA extracted from the first and second bacterial generations was subjected to density gradient centrifugation, which separates molecules according to their density. The results were compared to DNA extracted from samples of the original ^{15}N culture and a normal ^{14}N bacterial culture.

Fig. 23.1 shows the results obtained by Meselson and Stahl. The first generation DNA molecules were all 'hybrid', consisting of one original 'heavy' and one newly synthesised 'light' strand. This produced a DNA band positioned half-way between those of the original and normal cultures.

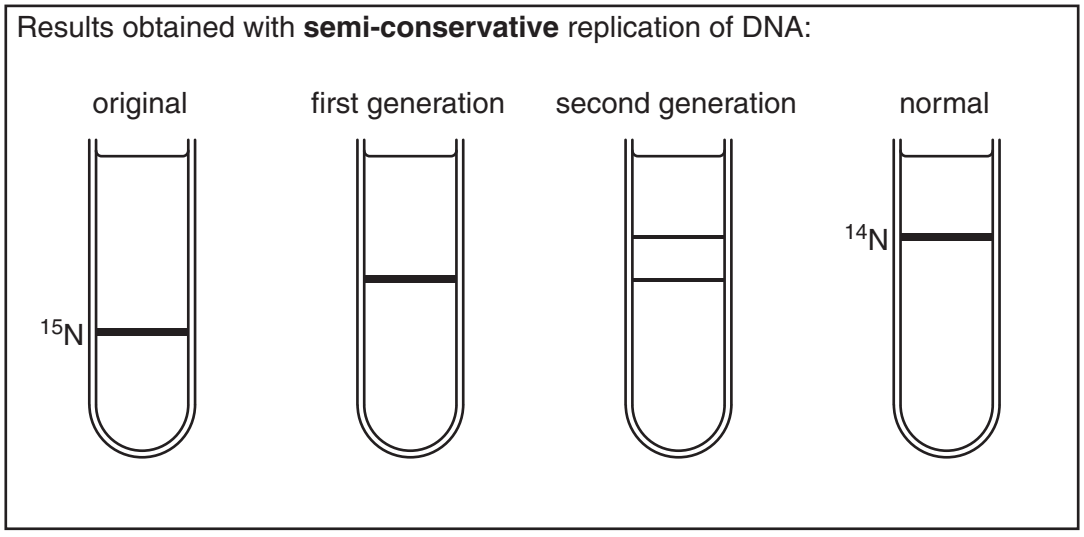

Fig. 23.1

Explain the results shown in Fig. 23.1 for the second generation.

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(d) DNA replication begins at a site known as an 'origin of replication'. Here, the separation of the two strands forms a 'replication bubble' in which DNA replication takes place.

Fig. 23.2 shows a transmission electron micrograph of a replication bubble.

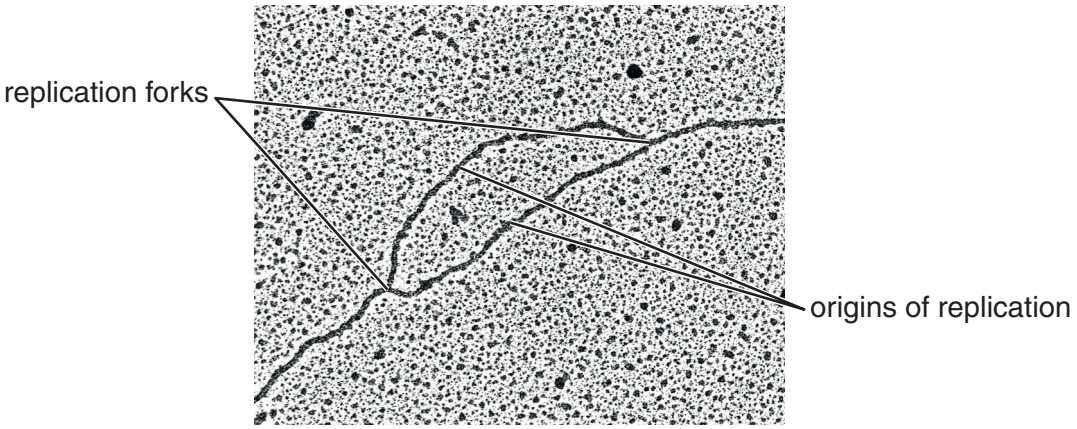

Fig. 23.2

(i) In eukaryotic cells, there are many sites of origin of replication for each DNA molecule.

Suggest an advantage of having many sites of origin of replication, rather than only one site.

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(ii) A feature of the structure of origins of replication is a higher proportion of A-T base pairs than C-G base pairs.

Suggest why this is so.

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(iii) Describe how DNA is replicated in a replication bubble.

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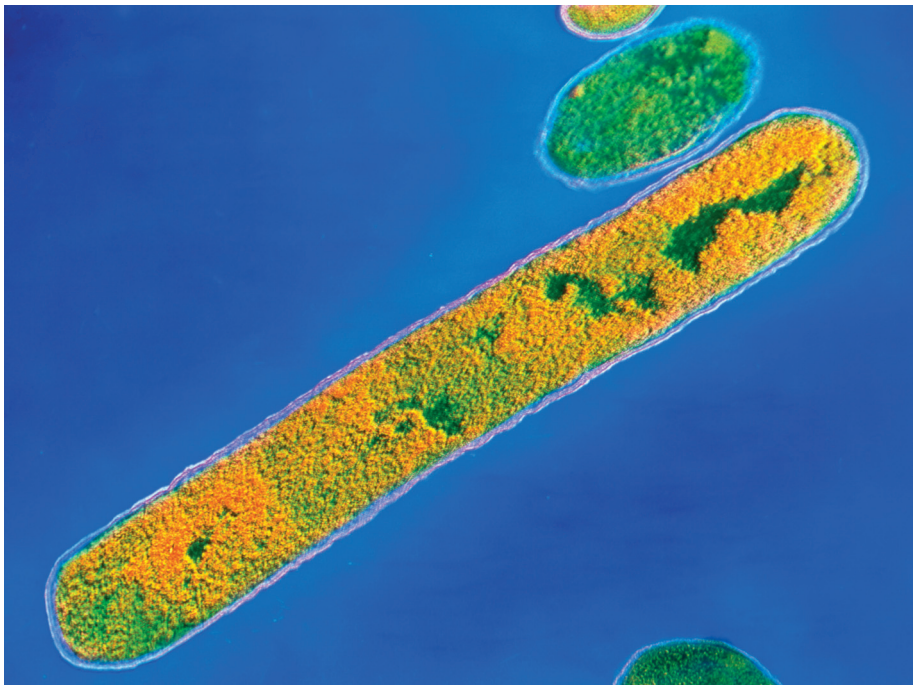
[Total: 13]

24 *Clostridium tetani* is the bacterium that causes the disease tetanus. Symptoms of the disease are caused by the release of a toxin, tetanospasmin.

Fig. 24.1 is a false-colour transmission electron micrograph of cells of *Clostridium tetani*.



× 26 500

Fig. 24.1

(a) State **two** features shown in Fig. 24.1 that are characteristic of prokaryotic cells such as *C. tetani*.

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[Turn over

(b) Although *C. tetani* bacteria usually stain Gram-positive, an increasing number of bacteria undergo changes and stain Gram-negative as a culture of these bacteria ages.

Explain how the differences between Gram-positive and Gram-negative *C. tetani* may lead to different outcomes when treated with the antibiotic, penicillin.

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(c) Explain why penicillin does not affect viruses.

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(d) The muscular spasms that are characteristic of tetanus result from an imbalance in the regulation of excitatory and inhibitory synapses in the central nervous system (CNS). This imbalance is caused by the presence of tetanospasmin, which is released by *C. tetani* and transported along axons to the CNS.

Tetanospasmin can be taken up by neurones containing the neurotransmitter GABA. The toxin is responsible for the hydrolysis of a membrane protein of synaptic vesicles that is involved in the fusion of the vesicle with the pre-synaptic membrane.

Describe the likely effect that tetanospasmin will have on the events that normally occur at the synapse **and** explain briefly how this could result in muscular spasms.

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[Total: 12]

25 Plants and animals are multicellular organisms.

(a) State one benefit and one disadvantage of being multicellular.

benefit .....

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disadvantage .....

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[2]

(b) The transport of substances by mass flow is a feature of many plants and animals.

Explain the need for mass flow systems in animals.

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..... [2]

(c) Most plants and animals reproduce sexually. This involves fertilisation.

State **one** way in which *in vitro* fertilisation differs from *in vivo* fertilisation in mammals.

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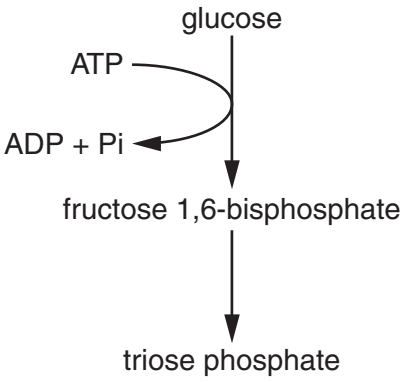
..... [1]

(d) The biochemicals listed alphabetically in the first column in Table 25.1 can be arranged to show reactions occurring during the process of respiration.

Using the headings shown, complete Table 25.1. You should use only the biochemicals listed in the first column to complete column two. The first row has been completed as an example.

Table 25.1

biochemicals involved	arrangement of biochemicals in metabolic pathway	name of pathway
ADP ATP fructose 1,6-bisphosphate glucose Pi triose phosphate (TP)		glycolysis
α-keto glutarate citrate oxaloacetate		
acetyl co-enzyme A CO_2 co-enzyme A NAD pyruvate reduced NAD		

[4]

[Total: 9]

26 Biosensors can be used by people with diabetes to measure their blood glucose concentration. Fig. 26.1 represents a glucose biosensor.

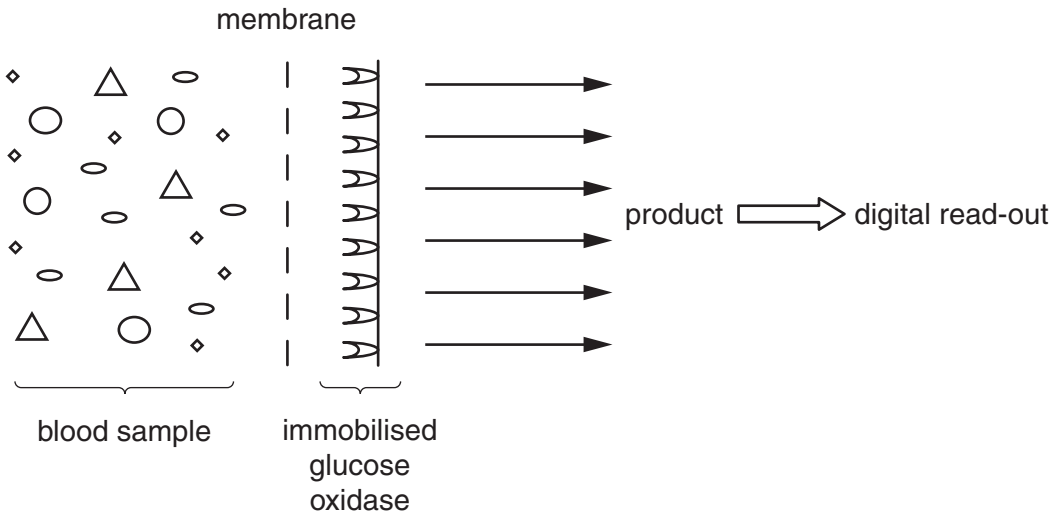


Fig. 26.1

(a) With reference to Fig. 26.1, explain how the design of the biosensor ensures that only glucose molecules give a positive reading when a blood sample is tested.

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..... [2]

(b) Complete the word equation to show the reaction catalysed by glucose oxidase.

glucose + [ ] $\xrightarrow{\text{glucose oxidase}}$ [ ] + hydrogen peroxide

[1]

(c) Type 1 and type 2 diabetes are both characterised by higher than normal concentrations of blood glucose.

Describe how, and explain why, the treatment of a person with type 2 diabetes may differ from that of a person with type 1 diabetes.

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..... [3]

[Total: 6]

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