



Cambridge International Examinations
Cambridge Pre-U Certificate

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BIOLOGY

9790/01

Paper 1 Structured Questions

May/June 2014

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

Twenty questions for which you must choose what you consider to be the right answer. Marks will not be deducted for any wrong answers. 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.

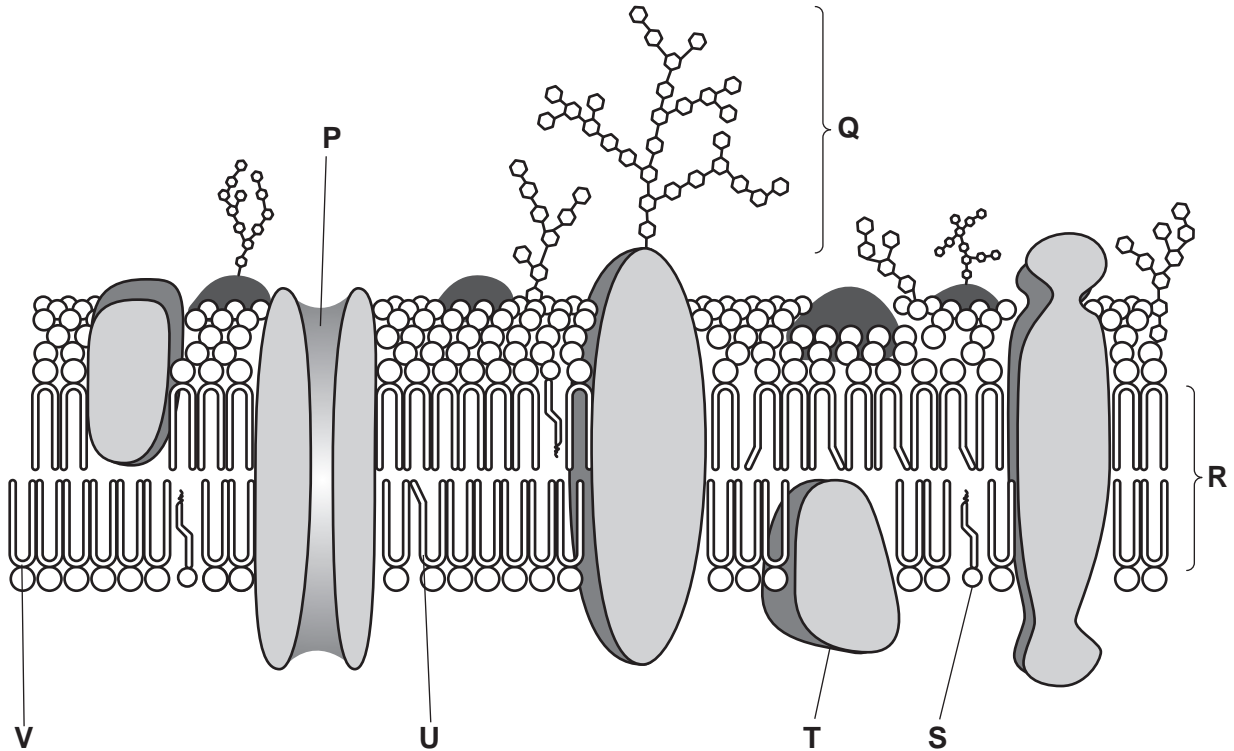
For Examiner's Use	
Section A	
21	
22	
23	
24	
25	
26	
Total	

This document consists of **33** printed pages and **3** blank pages.

Section A

Answer **all** the questions.

- 1 The diagram shows a section through a cell surface membrane from an animal cell.



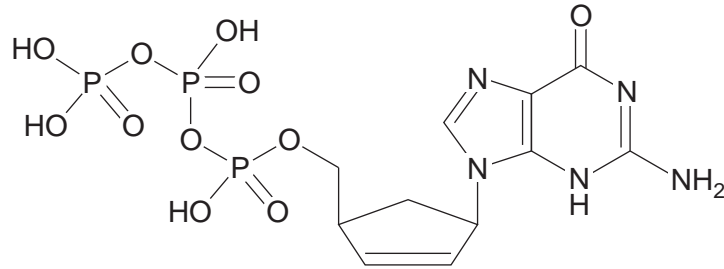
When compared to the more fluid cell surface membrane of a phagocytic cell, a number of differences in the membrane composition can be observed.

Which is the most likely set of differences that will be observed in the phagocytic cell?

- A** a complete absence of component **Q** and a higher proportion of component **P**
- B** a higher proportion of component **S** and a higher proportion of component **T**
- C** a lower proportion of component **V** and a higher proportion of component **U**
- D** an increased distance across **R** and a higher proportion of component **V**

answer [1]

- 2 The diagram shows the molecular structure of a chemical that can inhibit the activity of reverse transcriptase. It is an analogue of a naturally occurring nucleic acid monomer.



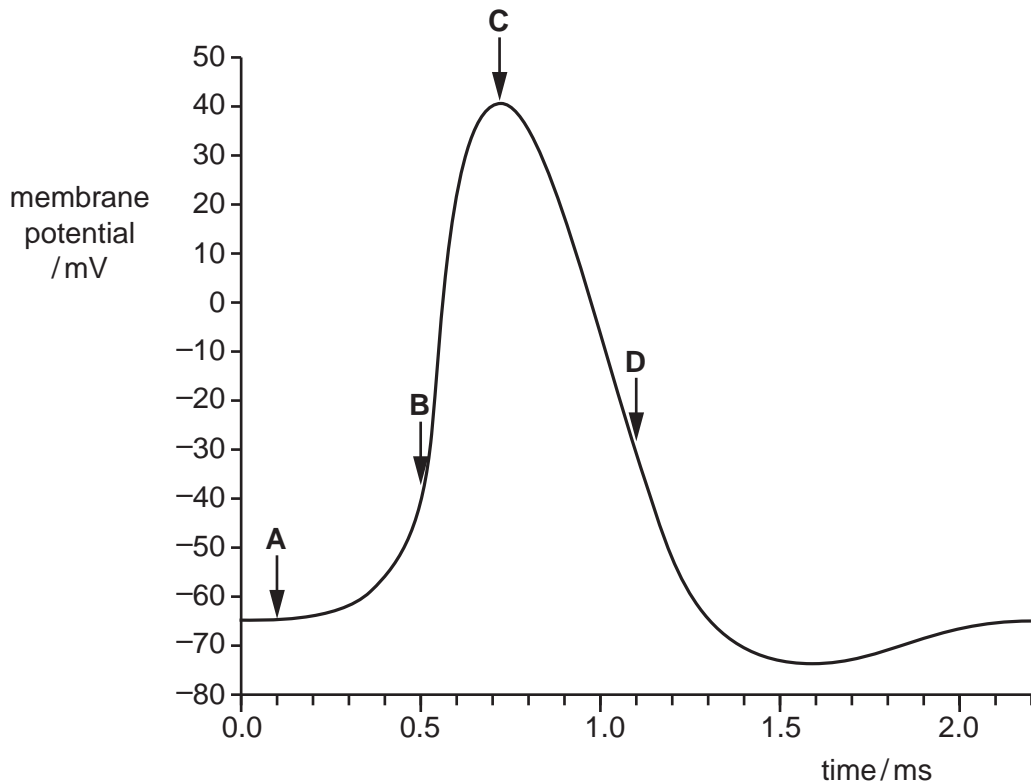
Put a tick (✓) in each box next to a correct statement.

- | | | |
|---|---|--------------------------|
| 1 | The analogue acts as a competitive inhibitor. | <input type="checkbox"/> |
| 2 | The analogue acts as a non-competitive inhibitor. | <input type="checkbox"/> |
| 3 | The naturally occurring monomer contains a purine base. | <input type="checkbox"/> |
| 4 | The naturally occurring monomer contains a pyrimidine base. | <input type="checkbox"/> |
| 5 | The naturally occurring monomer is an activated DNA nucleotide. | <input type="checkbox"/> |
| 6 | The naturally occurring monomer is an activated RNA nucleotide. | <input type="checkbox"/> |

[1]

Questions 3, 4 and 5

The graph shows an action potential in a myelinated motor neurone. The threshold potential for this axon membrane is -55 mV .



Arrows **A**, **B**, **C** and **D** represent times during the action potential shown in the graph.

Match each of the following descriptions to one of the times, **A**, **B**, **C** or **D**.

- 3** More sodium ions enter the axon from the extracellular fluid than are pumped out by the sodium-potassium pump.

answer [1]

- 4** All voltage-gated sodium ion channels are closed and all voltage-gated potassium ion channels are open.

answer [1]

- 5** Voltage-gated sodium ion channels and voltage-gated potassium ion channels are closed and potassium ions move out of the axon through non-voltage-gated potassium ion channels.

answer [1]

- 6 The classification table below is incomplete. In addition, the taxa are not in the correct hierarchical order.

taxon	example
genus	<i>Homo</i>
phylum	P
Q	Hominidae
kingdom	Animalia
species	<i>Homo sapiens</i>
R	S
class	T

Which row correctly completes the classification table?

	P	Q	R	S	T
A	Chordata	family	order	Primates	Mammalia
B	Chordata	order	family	Primates	Vertebrata
C	Vertebrata	family	order	Mammalia	Primates
D	Vertebrata	order	family	Chordata	Mammalia

answer [1]

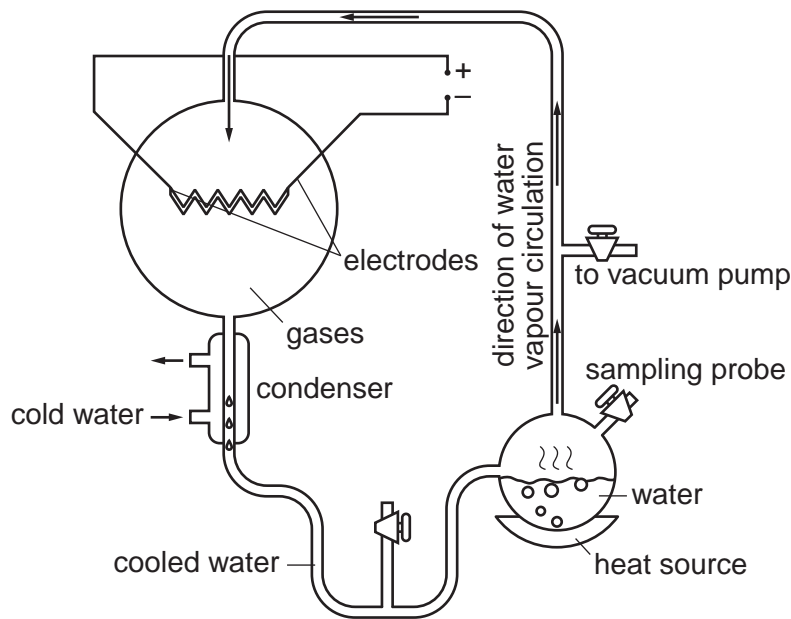
- 7 Some plant species have evolved flowers suited to pollination by certain hawk moths, which are fluid-feeders. These moths have a high energy demand, feed at night and hover in front of the flowers while they feed.

Which of the following flower characteristics is most likely to be possessed by a plant species that is pollinated by these hawk moths?

- A** brightly coloured petals and high pollen production
- B** flower parts shaped to resemble the female hawk moth
- C** production of odours during the day that mimic rotting flesh
- D** white petals with high nectar production

answer [1]

8 The diagram shows the apparatus used in the Miller-Urey experiment.



Which of these was a feature of this experiment?

- A The cold water allowed the gases to dissolve and act as the reactants for the synthesis of organic compounds.
- B The electrodes simulated conditions thought to be created during volcanic action on early Earth.
- C The gases were a mixture of water vapour, ammonia, methane and hydrogen to simulate Earth's early atmosphere.
- D The heated water simulated the hot oceans so that organic compounds could be synthesised.

answer [1]

9 What is meant by the term *proteomics*?

- A The post-translational modification of polypeptides to produce functioning proteins.
- B The process of producing beneficial or valuable proteins based on genomic data.
- C The study of the complete set of proteins expressed in an organism.
- D The study of the part of the genome of an organism that codes for proteins.

answer [1]

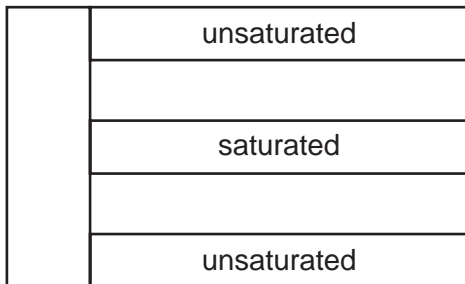
- 10 The lipid content of human milk is 3–5%, of which 98% is triglyceride.

Palmitic and oleic fatty acids are the most common fatty acids, with palmitic acid commonly occupying the central (second) position of the triglyceride.

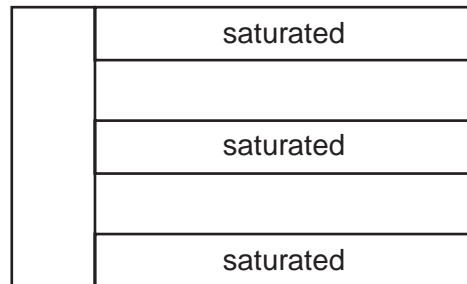
The molecular formula of palmitic acid is $C_{16}H_{32}O_2$, and that of oleic acid is $C_{18}H_{34}O_2$.

Which is likely to be the correct structure of the majority of triglycerides in human milk?

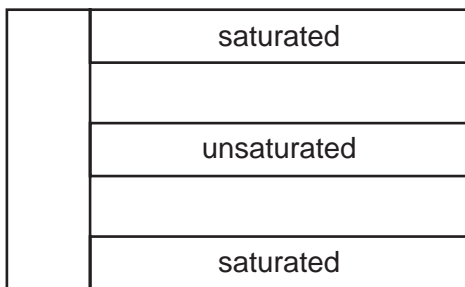
A



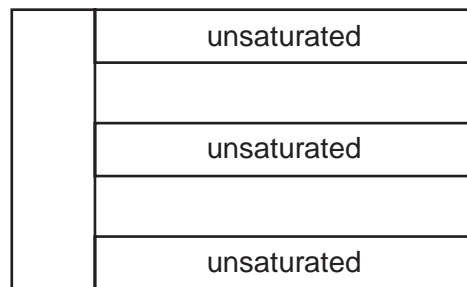
B



C



D



answer [1]

11 Monoclonal antibody production involves the formation of hybridoma cells.

Which of the following steps occur before hybridoma cell formation?

- 1 Culturing B-cells harvested from the spleen, followed by selection of those that secrete the desired antibody.
- 2 Production and selection of myeloma cells that lack one or more enzymes needed for growth in the medium used in culturing hybridoma cells.
- 3 Removal of unnecessary chromosomal material from the two cell types involved in fusion, so that a diploid number of chromosomes is maintained in the resulting hybridoma cell.
- 4 Removal of the tumour-inducing genes in the myeloma cells using restriction endonuclease and DNA ligase enzymes.

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

answer [1]

12 Features of some vascular wilt diseases in plants include:

- 1 caused by a bacterial pathogen that gains entry to xylem tissue
- 2 caused by the movement of spores within the xylem, which germinate and block vessels
- 3 production of long-lasting dormant spores that can pass into the soil when plant tissue dies
- 4 transmission mainly by insect vectors, such as bark beetles, during feeding

Which of these features are shared by the Panama disease of bananas, which is an example of a vascular wilt disease?

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

answer [1]

- 13** Which is **not** a correct comparison of gas exchange and oxygen transport in insects and mammals?
- A** At the gas exchange surface, the tips of insect tracheoles are fluid filled, whereas the alveoli in the mammalian lungs are lined with a fluid surfactant.
 - B** Oxygen that diffuses across the gas exchange surface in mammals is taken up by haemoglobin, whereas in insects, oxygen is transported by haemolymph in the insect circulatory system.
 - C** The insect tracheal system allows oxygen to reach body tissues directly, whereas the mammalian system uses a closed, double circulation to deliver oxygen to body tissues.
 - D** The trachea of the mammalian respiratory system is supported by incomplete rings of cartilage, whereas the tracheae of insects are supported by rings of chitin.

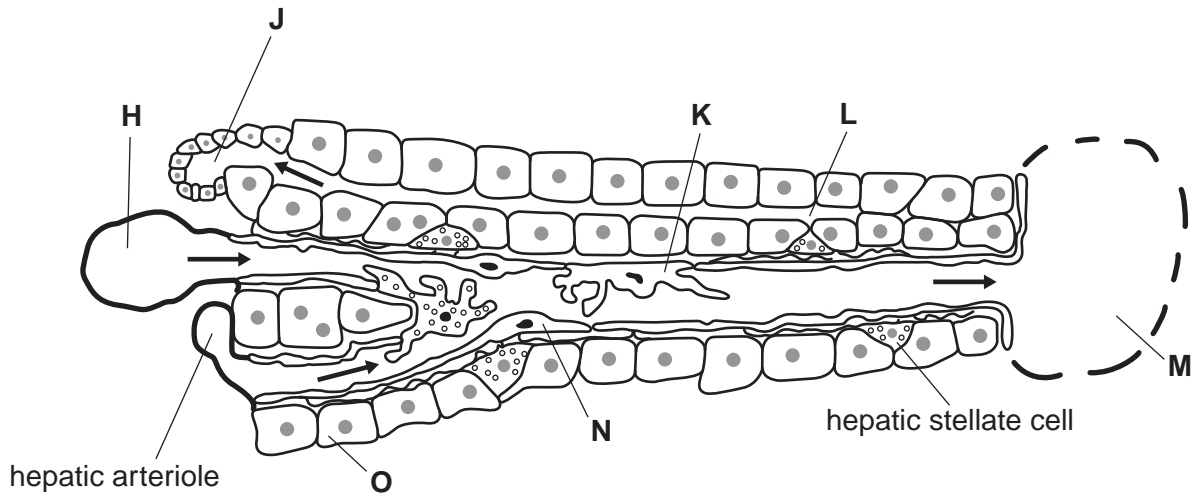
answer [1]

- 14** Which is a correct statement about obtaining human embryonic stem cells for research?
- A** Removal of these cells is considered to be ethically acceptable as normal development of the embryo is not inhibited.
 - B** The cells must be removed at an early stage of development from a region of the blastocyst known as the inner cell mass.
 - C** The cells must be removed within a day following the successful fertilisation of the ovum by the sperm, and after checking for normal mitotic division.
 - D** The region of the blastocyst from where the cells are removed is an area that develops at a later stage into the placenta.

answer [1]

Questions 15, 16 and 17

A diagram of a section through a lobule of the liver is shown below.



15 Which is a correct set of labels for cells **K**, **N** and **O** shown in the diagram?

	K	N	O
A	hepatocyte	squamous epithelial cell	cuboidal epithelial cell
B	Kupffer cell	hepatocyte	cuboidal epithelial cell
C	Kupffer cell	endothelial cell	hepatocyte
D	neutrophil	endothelial cell	hepatocyte

answer [1]

16 Which are correct statements concerning the vessels shown in the diagram?

- 1 **J** is a sinusoid carrying excess cholesterol and bile salts from red blood cell breakdown to the gall bladder.
- 2 Blood in vessel **M** is at a higher temperature and contains a higher concentration of urea than blood in vessel **H**.
- 3 Blood in the hepatic arteriole has a higher partial pressure of oxygen than blood in vessel **H**, but a lower concentration of dissolved amino acids.
- 4 Excess tissue fluid containing products of detoxification collects as lymph in vessel **L**, a lymph capillary.

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

answer [1]

17 The hepatic stellate cell is activated following liver injury. In continued liver injury, the cells are responsible for an increase in scar tissue and for an increase in the protein content of the extracellular matrix that gives support to cells.

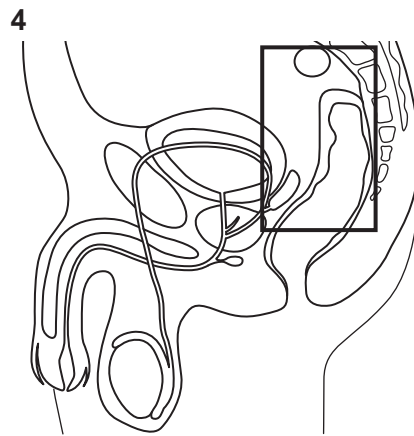
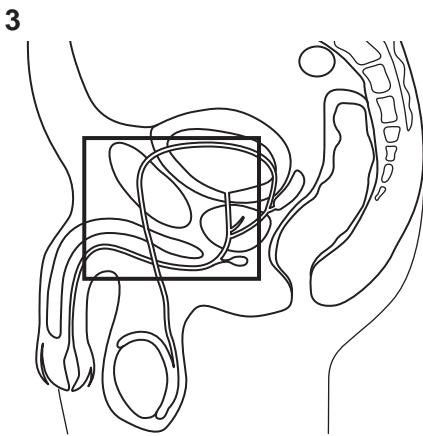
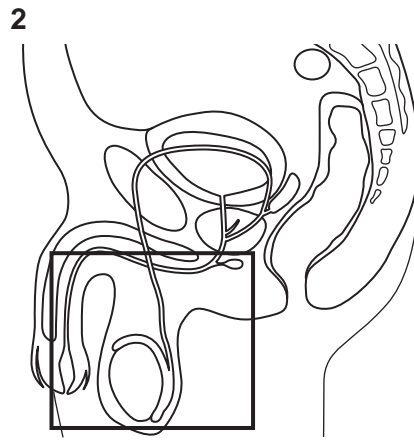
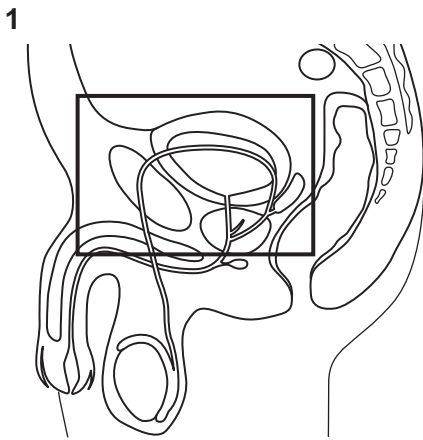
Which biochemical is likely to be produced by hepatic stellate cells after liver injury?

- A** antibody
B collagen
C urea
D plasma protein

answer [1]

18 The diagrams below are of a vertical section through the lower abdomen of a human male. A box has been drawn in each diagram.

In which boxes does all, or a part of, the Cowper's (bulbourethral) gland appear?



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

answer [1]

- 19 The table shows the occurrence of ATP production, NAD reduction and decarboxylation in different stages of aerobic respiration.

Which row is **not** correct?

	stage	ATP production	NAD reduction	decarboxylation
A	alpha-ketoglutarate → oxaloacetate	yes	yes	yes
B	citrate → alpha-ketoglutarate	no	yes	yes
C	oxaloacetate → citrate	no	no	yes
D	pyruvate → acetyl coenzyme A	no	yes	yes

answer [1]

- 20 Which is a correct statement concerning the light-dependent stage of photosynthesis in a C3 plant?

- A Cyclic photophosphorylation involves the emission of excited electrons from photosystem 2.
- B In non-cyclic photophosphorylation, hydrogen ions are pumped into the stroma.
- C Photolysis of water must occur before ATP synthesis by chemiosmosis can proceed.
- D The production of reduced NADP is always coupled with the production of oxygen.

answer [1]

Section B

Answer **all** the questions.

- 21 A long-term study of the medium ground finch, *Geospiza fortis*, has been carried out on the island of Daphne Major in the Galapagos archipelago.

At intervals this island experiences periods of extreme rainfall or severe drought.

Fig. 21.1 shows a male *G. fortis*.



Fig. 21.1

Ground finches have bills particularly suited to eating seeds. Seeds eaten by the population of *G. fortis* are of a variety of sizes from a range of plants. However, in years with good rainfall there is an abundance of small, soft seeds that are favoured by *G. fortis*, especially those individuals with smaller bills.

In years of drought, small seeds are scarce. Individuals of *G. fortis* with small bills are rarely successful in extracting seeds from the large, spiky, tough fruits of *Tribulus cistoides* (Fig. 21.2), which is the main producer of seeds at these times.



Fig. 21.2

- (a) Throughout 1977 a severe drought affected Daphne Major.

The number of different plant species producing seeds on which *G. fortis* was known to feed was recorded before and during the drought period. Seed abundance was also estimated.

Table 21.1 shows how the drought affected seed supplies for the population of *G. fortis*.

Table 21.1

sampling date	number of different plant species producing seeds	seed abundance/ cm ³ m ⁻²
March 1976	20	8.72
June 1977	16	2.23
Dec 1977	11	1.65

- (i) With reference to Table 21.1, describe how the seed supplies changed during the drought.

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- (ii) Suggest why, in Table 21.1, seed abundance was given in terms of volume of seeds rather than number of seeds.

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- (iii) Describe the factors to be considered when estimating seed abundance in an investigation of this type, in order to ensure that the data collected are valid.

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- (b) The population size of *G. fortis* on Daphne Major fell by over 85% as a result of the 1977 drought.

Table 21.2 shows results for mean mass and mean bill size of mature *G. fortis* before and after the drought. The individuals measured after the drought were a subset of the first sample, so allowing a direct comparison of the changes that occurred.

Table 21.2

date of sampling	sample size	phenotypic feature measured			
		mass / g	bill length / mm	bill depth / mm	bill width / mm
1976 (May)	642	15.79	10.68	9.42	8.68
1978 (March)	85	16.85	11.07	9.96	9.01
percentage change		+3.65	+3.80

- (i) Complete Table 21.2 to show the percentage change in mass and bill depth from 1976 (May) to 1978 (March). [1]
- (ii) After the drought, the population of *G. fortis* had significantly higher mean mass and larger mean bill size than the pre-drought population.

Name the type of natural selection that was occurring.

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(c) Explain how the changes that occurred in the population of *G. fortis* on Daphne Major provide support for Darwin's explanation of how natural selection operates.

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[Total: 15]

22 Fig. 22.1 shows a poison ivy plant, *Toxicodendron radicans*. When handled or damaged, the plant releases an oily substance, known as urushiol, onto the outside of its roots, stems, leaves and fruits.

On first skin contact with urushiol, a person will not notice any ill effects, but if the person is sensitive to urushiol, second and subsequent contacts will cause poison ivy rash. This is an itchy, often painful, red rash that can become blistered.



Fig. 22.1

On contact with human skin, urushiol diffuses through to the deeper skin layers, where it stimulates a series of changes.

- It enters skin cells, known as keratinocytes, and immune system cells, known as Langerhans cells, and is oxidised to quinones.
- Quinones become attached to the exterior surface of cell surface membrane proteins of the two cell types, forming complexes known as haptens.
- The Langerhans cells presenting the haptens migrate to nearby lymph nodes, where T-cells are located.
- The keratinocytes presenting the haptens are induced to produce and release cytokines.

The keratinocytes presenting the haptens have a short life span.

These events are summarised in Fig. 22.2.

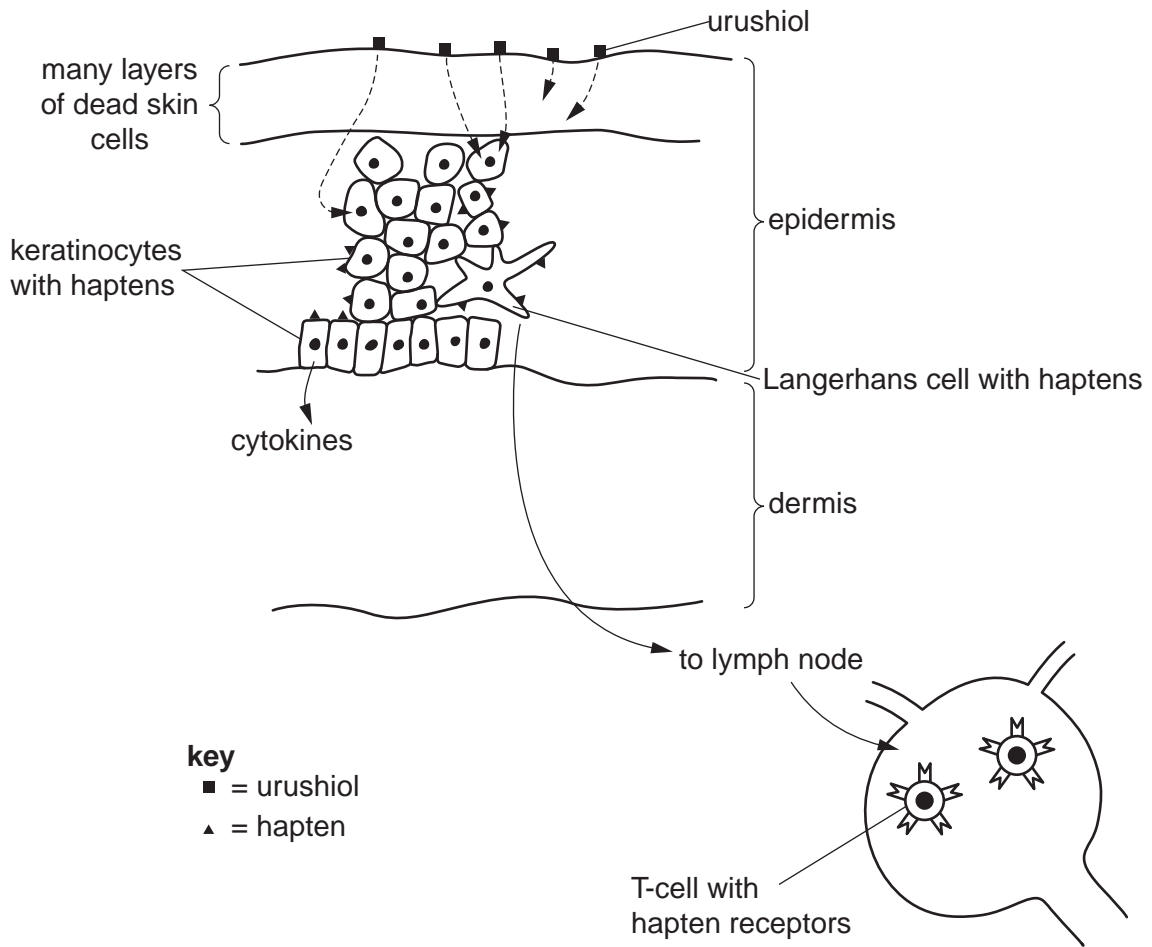


Fig. 22.2

(a) Outline **one** possible mechanism by which urushiol could enter the keratinocytes and Langerhans cells.

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- (b) (i) In the keratinocytes presenting haptens, genes coding for cytokines are activated and mRNA transcripts are produced.

Explain why the mRNA transcripts leaving the nucleus have fewer nucleotides than the RNA initially produced by DNA transcription.

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- (ii) Explain why translation, leading to cytokine polypeptide formation, is likely to occur on ribosomes that will become attached to the rough endoplasmic reticulum (RER) and **not** on ribosomes free in the cytoplasm.

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- (d) A student, who had previously experienced a painful poison ivy rash, accidentally brushed against some poison ivy.

The student had read that:

- an enzyme found in banana peel, catechol oxidase, could act on urushiol, thereby preventing its entry into the skin
- one recommendation to avoid a rash is to use alcohol to dissolve the urushiol.

The student decided to rub banana peel soaked in red wine on to the affected skin to decrease the chance of developing a rash, but unfortunately a rash still developed.

In the laboratory, the student made some catechol oxidase solution and measured the rate of reaction at different urushiol concentrations, with and without red wine added to the reaction mixture.

The results are shown in Fig. 22.3.

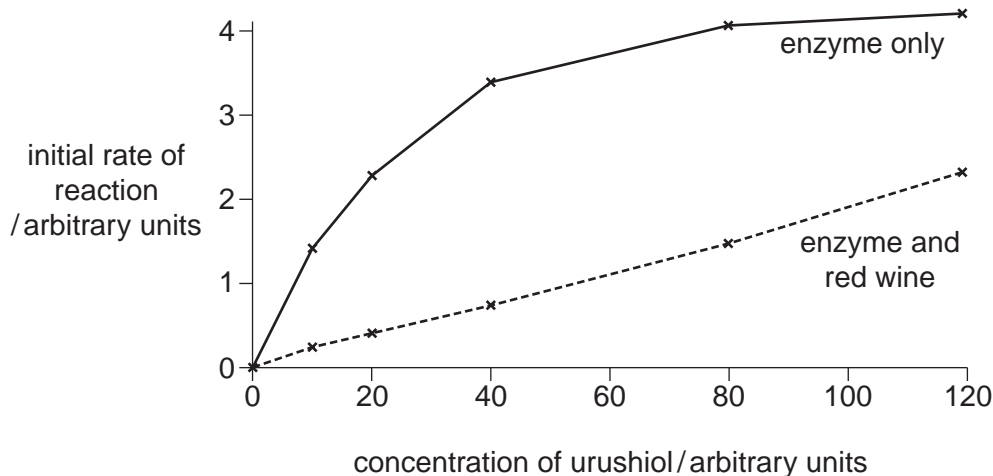


Fig. 22.3

With reference to the mode of action of enzymes and Fig. 22.3, explain why it might have been better for the student if banana peel had been rubbed onto the skin without first soaking the banana peel in red wine.

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- (e) Poison ivy plants can be killed using glyphosate, a systemic herbicide that acts at growing regions. Glyphosate can be applied to leaves and is effective at killing the entire plant in a short time.

Suggest how glyphosate applied to leaves can reach the roots of the poison ivy plant.

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[Total: 20]

23 Statements (a), (b) and (c) are about photosynthesis and chloroplasts.

Explain statements (a), (b) and (c).

(a) None of the light-independent reactions require light, but in C3 plants the light-independent stage of photosynthesis only occurs when light is available.

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(b) Only six RuBP molecules, with a total of 30 carbon atoms, are regenerated from six successive 'turns' of the Calvin cycle even though twelve molecules of GP, with a total of 36 carbon atoms, are generated.

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(c) Chloroplasts are a feature of plant cells and not of photosynthetic prokaryotes. However, 70S ribosomes, rather than 80S ribosomes, are found in the chloroplasts of plant cells.

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[Total: 6]

24 The primary structure of a collagen polypeptide has a repeating pattern of three amino acids. Fig. 24.1 shows the two forms of this pattern.

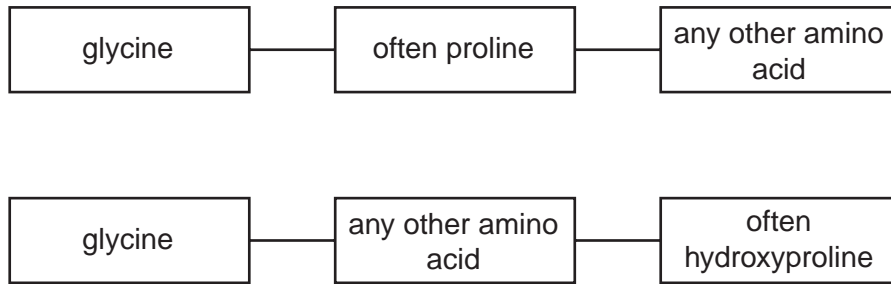


Fig. 24.1

Hydroxyproline is a proline molecule that has a hydroxyl (-OH) group added to its R-group. The hydroxyl groups can become involved in hydrogen bonding.

(a) Glycine makes up approximately 30% of the total amino acid composition of collagen.

Explain how glycine plays an essential role in the structure of collagen.

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- (b) Many of the lysine amino acids in a collagen polypeptide are also hydroxylated.

Fig. 24.2 shows hydroxylysine.

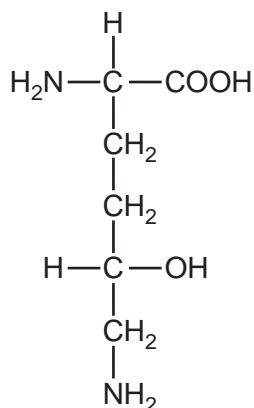


Fig. 24.2

- (i) On Fig. 24.2, draw a box around the R-group of hydroxylysine. [1]
- (ii) The hydroxyl group of hydroxylysine is important as a possible attachment site for a β -galactose molecule. Glycosylated hydroxylysine is thought to be essential for the close packing of collagen molecules into collagen fibrils.

The molecular ring structure of β -galactose is shown in Fig. 24.3.

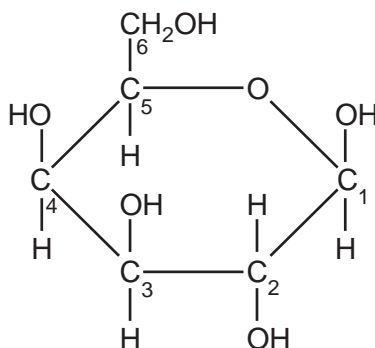


Fig. 24.3

Describe one difference between the ring structure of β -galactose and the ring structure of α -glucose.

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- (c) Collagen is widely used in biomedical applications, including tissue engineering, such as the production of artificial blood vessels and valves, and cosmetic surgery.

Although not always cost effective, production of recombinant collagen has become increasingly favoured over extraction of collagen from cows and other animal sources.

- (i) Apart from ethical considerations, suggest **one** advantage of producing recombinant collagen.

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..... [1]

- (ii) At present, bacteria have limited use as recombinant hosts to produce collagen because they cannot carry out hydroxylation or glycosylation.

Suggest **one** reason why they cannot carry out these reactions.

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- (i) Explain how the investigation using the rat cDNA probe supports the idea that *GULOP* was once an active gene, rather than a meaningless length of DNA.

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- (ii) Explain the possible effects of a single base-pair insertion on the production of an enzyme, such as GULO.

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- (f) Scurvy can be fatal.

Suggest why the loss of expression of the *GULO* gene has not proved to be an evolutionary disadvantage to humans.

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[Total: 20]

25 (a) Explain the roles of ovarian hormones and anterior pituitary hormones in controlling the menstrual cycle.

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(b) Fig. 25.1 is a diagram of a cell in a stage of meiosis.

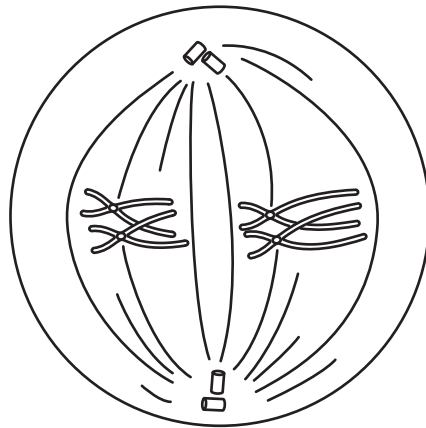


Fig. 25.1

(i) Name precisely the stage of meiosis that is shown in Fig. 25.1.

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- (ii) Describe chromosome behaviour occurring in meiosis **before** the stage shown in Fig. 25.1.

You may use the space below for annotated diagrams.

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- (c) In the human female the formation of mature oocytes, from cells known as oogonia, is a prolonged process.

Meiosis in an oogonium begins before a female's birth, but only reaches late prophase 1. Once the cell enters meiosis it is known as a primary oocyte. After the onset of puberty, hormones associated with the menstrual cycle stimulate the primary oocyte to resume meiosis to become a secondary oocyte. At ovulation, the secondary oocyte has only reached the metaphase 2 stage of meiosis and does not proceed to complete the process until binding of a sperm, when the actual mature ovum is formed.

A newly-formed human oogonium contains 46 chromosomes, each consisting of one DNA molecule, complexed with proteins.

Complete Table 25.1 to show the number of chromosomal DNA molecules per cell for each of the cell types listed.

Table 25.1

cell type	timing	number of chromosomal DNA molecules per cell
oogonium	newly-formed	46
oogonium	late interphase immediately prior to onset of meiosis	
primary oocyte	shortly before puberty begins	
secondary oocyte	at ovulation	
ovum	after binding of a sperm, but before the sperm nucleus enters the cell	

[4]

[Total: 14]

26 Fig. 26.1 is a diagram of the digestive system of a carnivore.

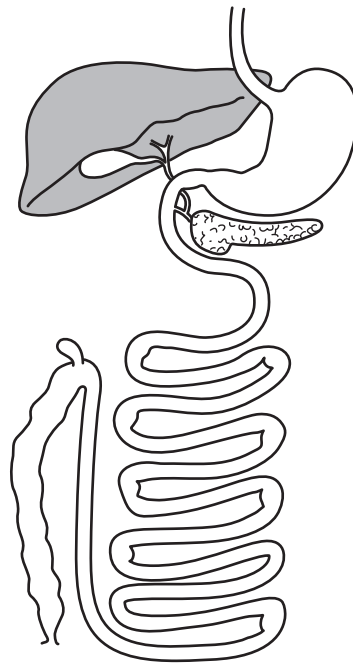


Fig. 26.1

Describe and explain how the structure and function of the small intestine and large intestine of a herbivore differ from that of a similar-sized carnivore.

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