Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

6205867921

BIOLOGY **9700/21**

Paper 2 Structured Questions AS **October/November 2014**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name in the spaces provided at the top of this page.
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.
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.

This document consists of **14** printed pages and **2** blank pages.

© UCLES 2014

CAMBRIDGE International Examinations

PAPA CAMBRIDGE

Answer **all** the questions

1 Fig. 1.1 is an electron micrograph of cells from the lining of the small intestine.

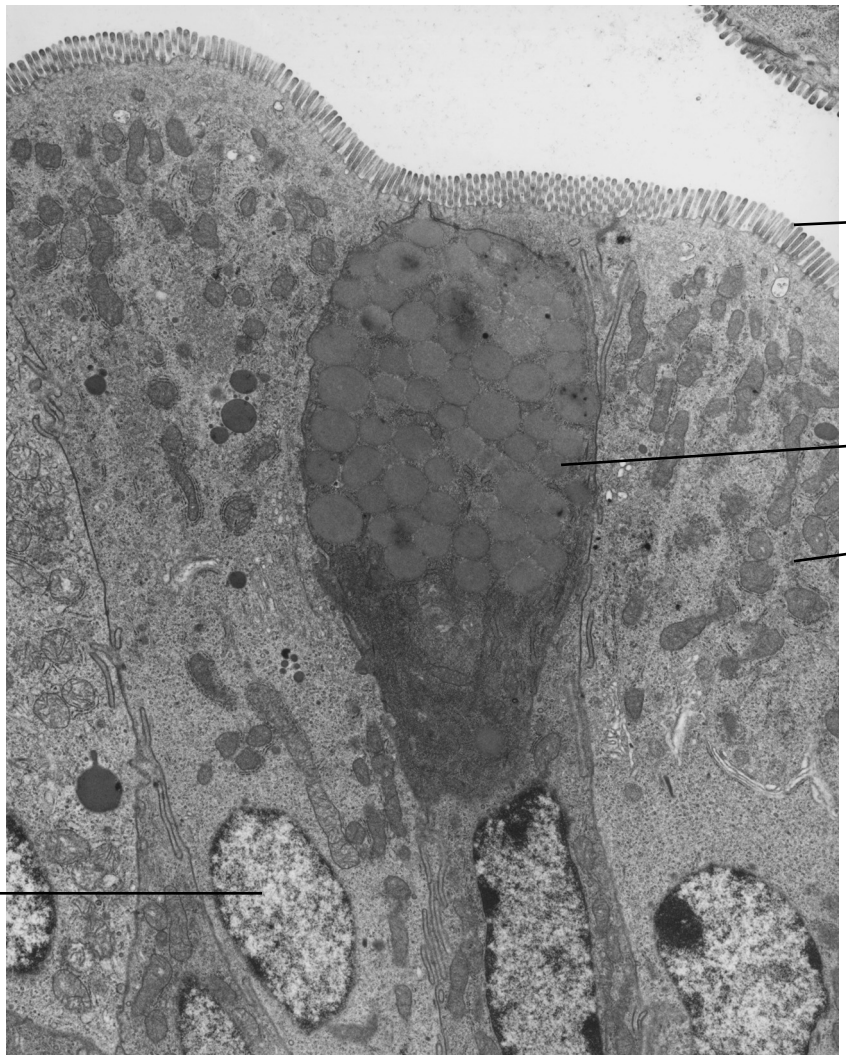


Fig. 1.1

(a) Identify the structures labelled **A** and state their role for the cell.

.....

.....

.....

.....

..... [2]

PAPA CAMBRIDGE

(b) There are many mitochondria in cell **B**.

Suggest why cell **B** contains a large number of mitochondria.

.....

.....

.....

.....

..... [2]

(c) Calculate the actual length of the nucleus **C**.

Show your working and express your answer to the nearest 0.1 micrometre.

answer ..... μm [2]

(d) There are many goblet cells within the epithelium lining the trachea and the bronchi in the gas exchange system.

Describe the role of goblet cells in the gas exchange system.

.....

.....

.....

.....

.....

.....

..... [3]

(e) State two ways in which the cells lining the alveoli in the lungs differ from cell **B** shown in Fig. 1.1.

1. .....

2. .....

[2]

[Total: 11]

PAPA CAMBRIDGE

BLANK PAGE

© UCLES 2014

PAPA CAMBRIDGE

2 **(a)** Define the term *disease*.

.....

.....

..... [1]

Fig. 2.1 is a flow chart that shows the four different ways that a person can become immune to an infectious disease.

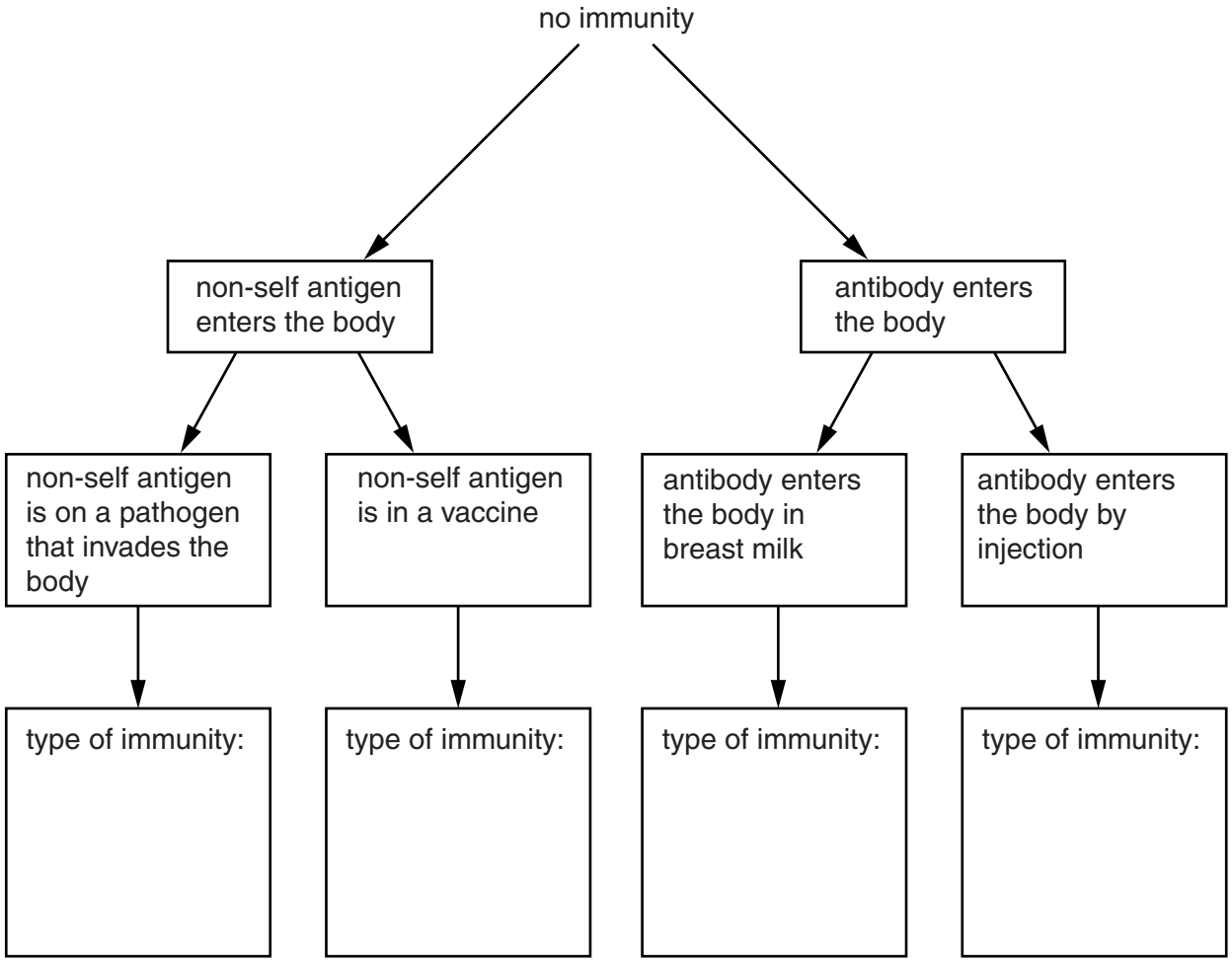


Fig. 2.1

(b) Complete Fig. 2.1 by writing in the boxes provided the four types of immunity described. [4]

PAPA CAMBRIDGE

Fig. 2.2 shows the number of cases of smallpox from 1950 to 1980:

- in all the countries of the world
- in India.

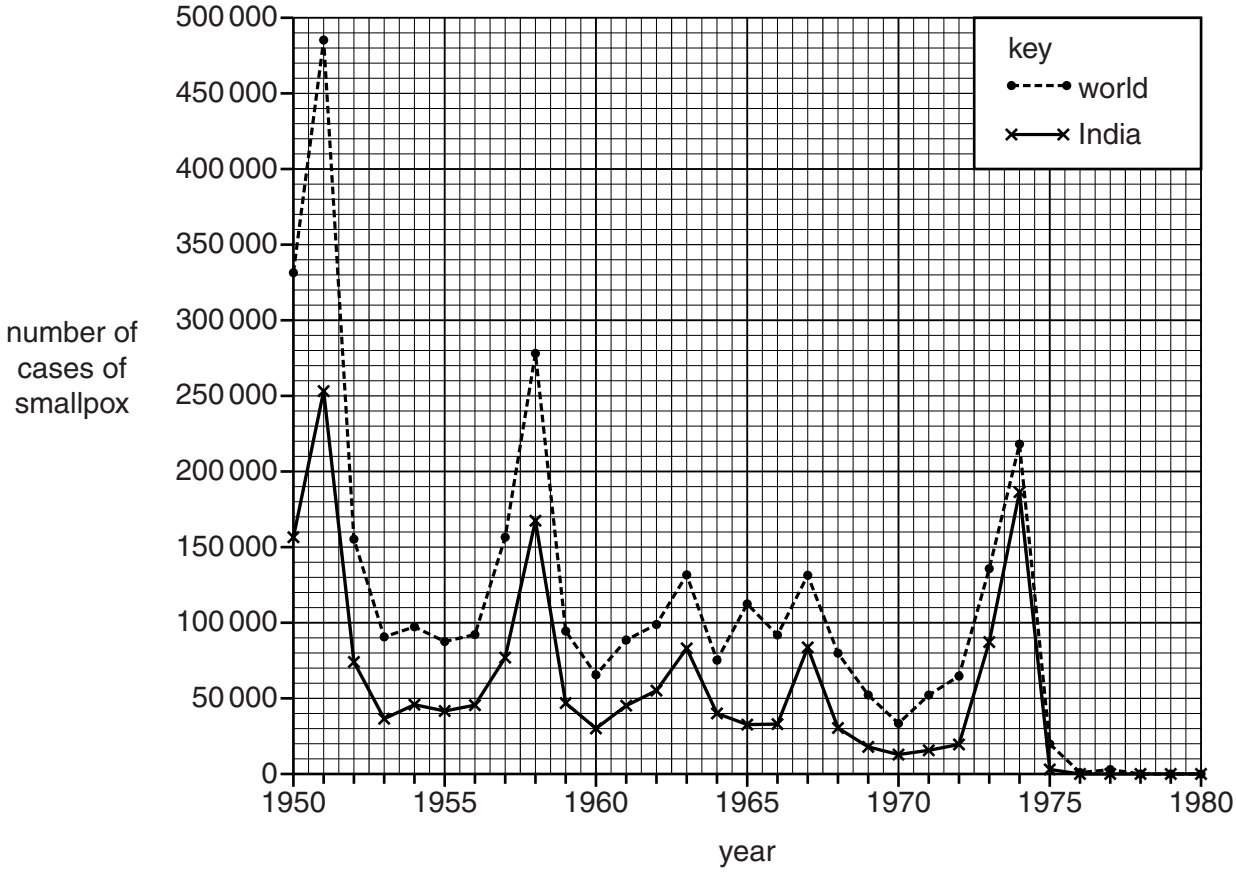


Fig. 2.2

(c) Describe the changes in number of cases of smallpox as shown in Fig. 2.2.

.....

.....

.....

.....

.....

.....

.....

..... [3]

PAPA CAMBRIDGE

The World Health Organization (WHO) declared the world to be free of smallpox in 1980.

(d) Outline some of the factors that led to the successful eradication of smallpox from the world population.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 12]

PAPA CAMBRIDGE

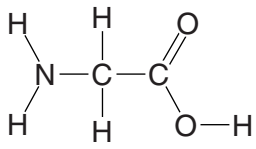
3 There are many types of amino acids, but only twenty that are polymerised to make polypeptides and proteins in animals.

(a) Name the type of chemical reaction that occurs when two amino acids form a dipeptide.

..... [1]

(b) Fig. 3.1 shows two amino acids, glycine and valine. Use the space below to make a drawing to show what happens when these two molecules join together to form a dipeptide.

glycine



valine

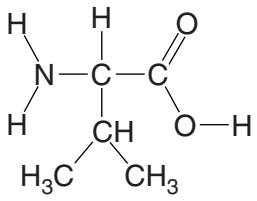


Fig. 3.1

[4]

PAPA CAMBRIDGE

(c) Angiotensinogen is an inactive protein molecule. When blood pressure decreases, part of angiotensinogen is removed to form a short polypeptide, angiotensin that stimulates an increase in blood pressure.

Fig. 3.2 shows the base sequence within the gene for angiotensinogen that codes for this short polypeptide, the RNA codons and the primary structure of angiotensin.

DNA base sequence	CTA	GCA	CAA	ATG	TAG	GTG	GGG	.....
RNA codons	.....	CGU	.....	UAC	AUC	CAC	CCC	UUC
polypeptide primary structure	Asp	Arg	Val	Tyr	Ile	His	Pro	Phe

Fig. 3.2

(i) Complete Fig. 3.2 to show the missing DNA triplet and the RNA codons. [1]

(ii) State the full name of the type of RNA shown in Fig. 3.2.

..... [1]

Table 3.1 shows the blood pressure in the right ventricle and in the pulmonary artery of a person who is in good health.

Table 3.1

phase of cardiac cycle	blood pressure / kPa	
	right ventricle	pulmonary artery
Ventricular systole	3.33	3.33
Ventricular diastole	0.67	1.33

(d) Use the information in Table 3.1 to explain why the blood pressure in the pulmonary artery is the same as the pressure in the right ventricle during systole, but higher during diastole.

.....

.....

.....

.....

.....

.....

..... [3]

PAPA CAMBRIDGE

(e) People with long-term chronic obstructive pulmonary disease (COPD) usually have blood which is poorly oxygenated during its passage through the lungs. This leads to a constriction of blood vessels in the lungs.

Suggest the likely effect of this on the heart.

.....

.....

.....

.....

..... [2]

(f) Describe the signs and symptoms of COPD that help doctors make an early diagnosis of this condition.

.....

.....

.....

.....

..... [2]

[Total: 14]

© UCLES 2014

PAPA CAMBRIDGE

4 **(a)** A student cut thin sections of a root tip of *Allium cepa* and stained them to show chromosomes. A photomicrograph of part of one of these sections is shown in Fig. 4.1.

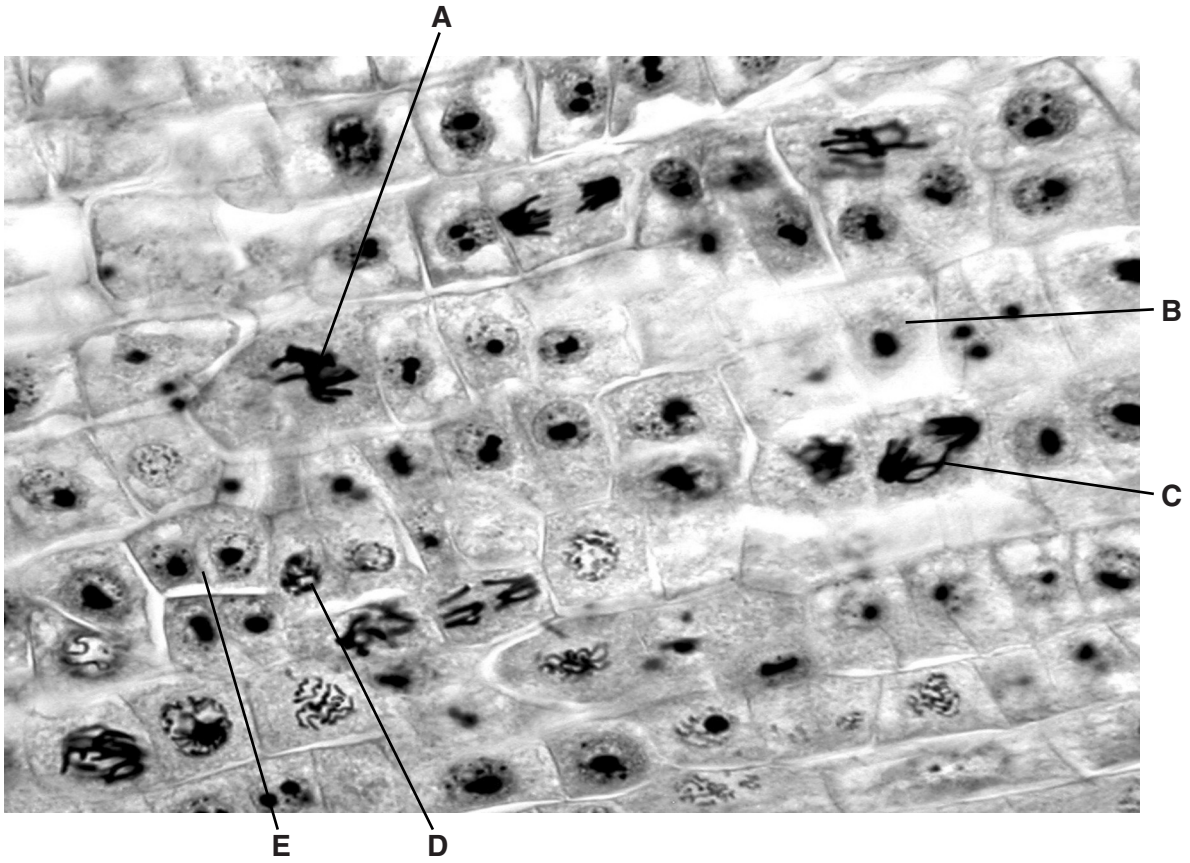


Fig. 4.1

Table 4.1 shows the behaviour of chromosomes and the changes that occur to the nuclear envelope during a mitotic cell cycle in the root tip of *A. cepa*.

Complete Table 4.1.

Table 4.1

name of stage	cell in Fig. 4.1	behaviour of chromosomes	nuclear envelope
	B	chromosomes uncoiled, may be replicating	intact
prophase			intact, but then breaks down
metaphase			not present
anaphase		chromosomes / chromatids, moving to opposite poles	
telophase		chromosomes uncoiling	

[5]

PAPA CAMBRIDGE

(b) Explain why the growth of roots, such as those of *A. cepa*, involves mitosis and **not** meiosis.

.....

.....

.....

.....

.....

.....

.....[3]

(c) State two processes, **other than growth**, in which mitosis is involved.

1. .....

2. .....
[2]

[Total: 10]

5 In some ecosystems there are very low concentrations of nitrate ions in the soil. Some species of flowering plants are able to obtain the nitrogen that they need from other sources. Carnivorous plants have modified leaves that trap animals.

Leaves of *Drosera rotundifolia* have hairs around each leaf that secrete a sticky solution. Insects, such as the one shown in Fig. 5.1, stick to this solution. The leaves curl around the insect and secrete enzymes to digest its body.

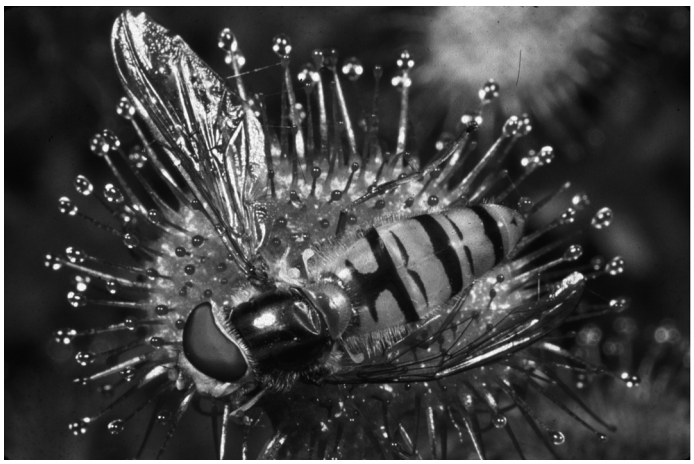


Fig. 5.1

PAPA CAMBRIDGE

(a) Explain why *D. rotundifolia* can be considered to be both an autotroph and a heterotroph.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) In 1999, Dutch scientists discovered a new reaction, the anammox reaction, to add to the nitrogen cycle. They discovered the bacterium *Brocadia anammoxidans* that converts ammonia, nitrite ions and nitrate ions to nitrogen gas (N_2) in anaerobic environments.

The reaction carried out by these bacteria is thought to be responsible for the loss of a large quantity of nitrogen-containing compounds from marine ecosystems, such as the oceans.

Suggest and explain the effect that this reaction has on marine ecosystems.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 7]

PAPA CAMBRIDGE

6 Fig. 6.1 shows the pathway taken by water as it enters the root of a flowering plant.

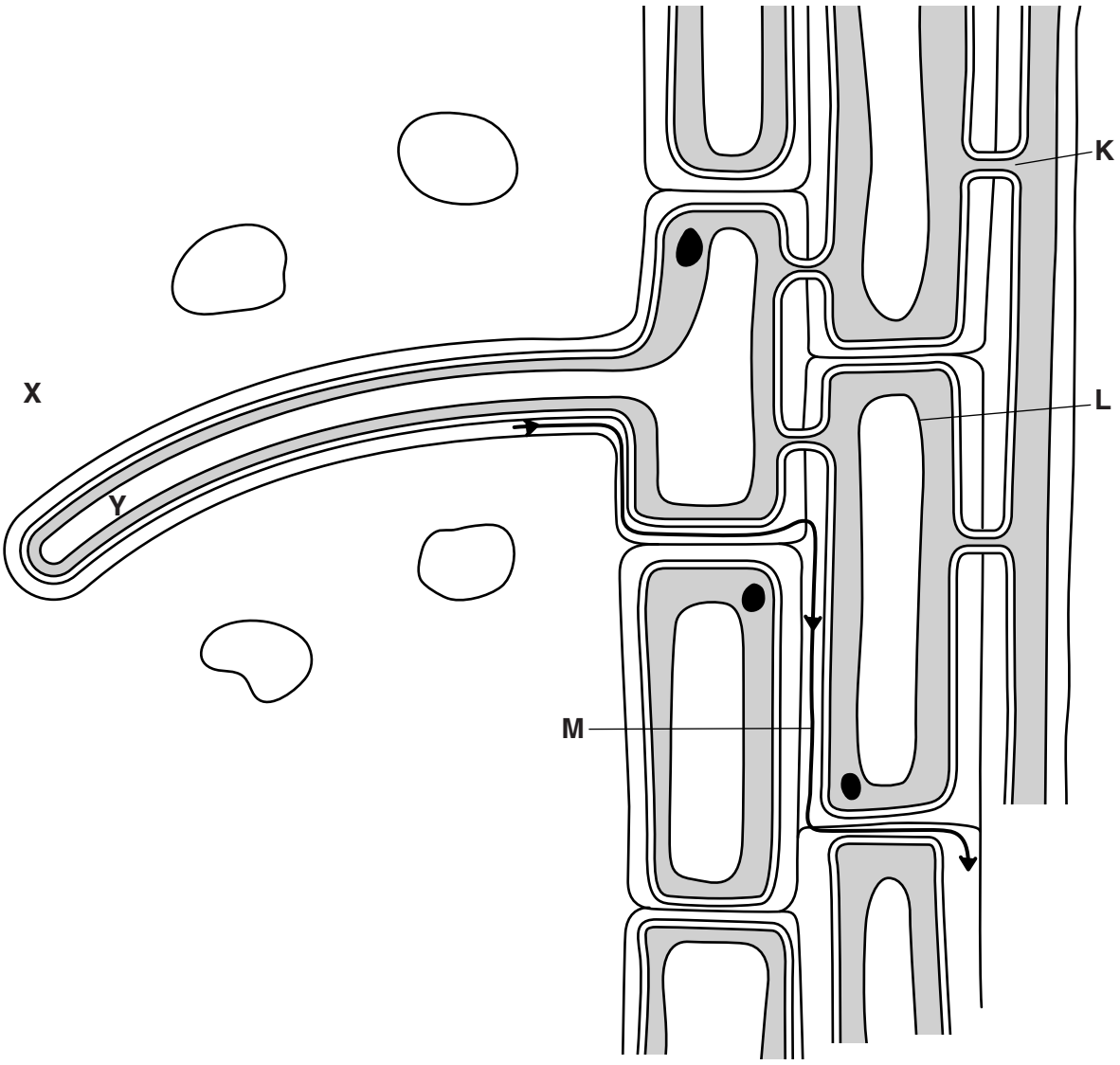


Fig. 6.1

(a) Explain how water passes from **X** to **Y**.

.....

.....

.....

.....

.....

.....

..... [3]

PAPA CAMBRIDGE

(b) Name:

(i) the structures **K** and **L**

K .....

L .....
[2]

(ii) the pathway indicated by **M**.

.....[1]

[Total: 6]

PAPA CAMBRIDGE

BLANK PAGE

Copyright Acknowledgements:

Fig 1.1 © STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY.
Fig 5.1 © CLAUDE NURIDSANY & MARIE PERENNOU/SCIENCE PHOTO LIBRARY.

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

PAPA CAMBRIDGE

Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

8793885303

BIOLOGY **9700/22**

Paper 2 Structured Questions AS **October/November 2014**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name in the spaces provided at the top of this page.
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.
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.

DC (LK/SW) 79830/4
© UCLES 2014

Answer **all** the questions

1 Fig. 1.1 is a light micrograph of a section through part of the gas exchange system.

A, **B** and **C** are three different types of tissue.



Fig. 1.1

(a) The cell types in tissue **A** have different functions.

Describe how the cell types work together to maintain the health of the gas exchange system.

.....

.....

.....

.....

.....

.....

.....

.....[3]

(b) Suggest why the cells in tissue **B** have many mitochondria.

.....

.....

.....

.....[1]

(c) Name the parts of the gas exchange system where tissue **C** is distributed.

.....

.....[1]

[Total: 5]

2 Fig. 2.1 shows one section of the nitrogen (N) cycle. Some details of the water cycle are also included.

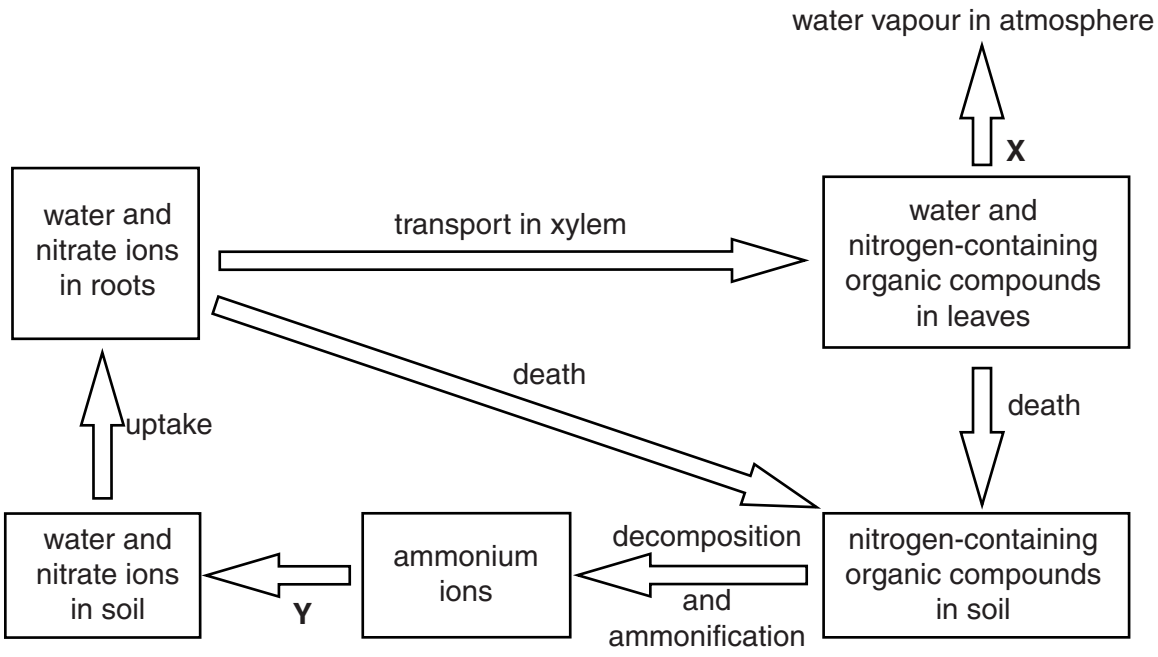


Fig. 2.1

(a) Name processes **X** and **Y**.

X .....

Y .....[2]

(b) Name **one** organism involved in process **Y**.

.....[1]

(c) Explain why process **X** occurs, even if it is a disadvantage to a plant.

.....

.....

.....[1]

(d) State two examples of how the leaves of xerophytic plants are adapted to reduce the loss of water vapour to the atmosphere.

1. .....

.....

2. .....

.....[2]

© UCLES 2014

(e) Nitrate ions are taken up by root hair cells.

Outline the role of the cell surface membrane of root hair cells in the uptake of nitrate ions.

.....

.....

.....

.....

.....

.....[2]

(f) Describe **and** explain how water and nitrate ions are transported in the xylem from roots to leaves.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

(g) One use of the nitrogen in the nitrate ions is for the synthesis of organic molecules such as RNA.

State where nitrogen is found within an RNA molecule.

.....

.....[1]

[Total: 13]

3 In mammals, oxygen is transported by red blood cells in a system that is described as a closed double circulation. The majority of oxygen molecules are transported as oxyhaemoglobin. At the respiring tissues, oxygen dissociates from haemoglobin and diffuses to the surrounding cells.

(a) Explain what is meant by a *closed double circulation*.

.....

.....

.....

.....

..... [2]

(b) Fig. 3.1 is a diagram that highlights the tertiary and quaternary structure of a haemoglobin molecule.

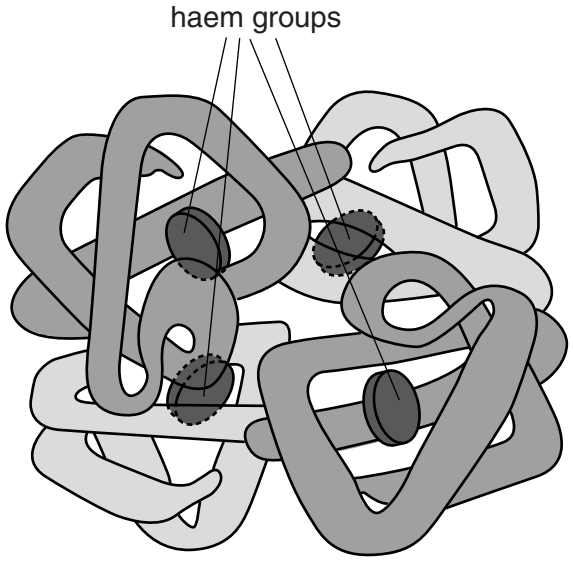


Fig. 3.1

Explain how the tertiary and quaternary levels of protein structure of the haemoglobin molecule contribute to its role in the transport of oxygen.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(c) At high altitudes, the partial pressure of inspired oxygen is considerably lower than at sea level. This means that the partial pressure of oxygen in the blood is also much lower at high altitudes than at sea level.

Fig. 3.2 is an oxygen dissociation curve of adult oxyhaemoglobin.

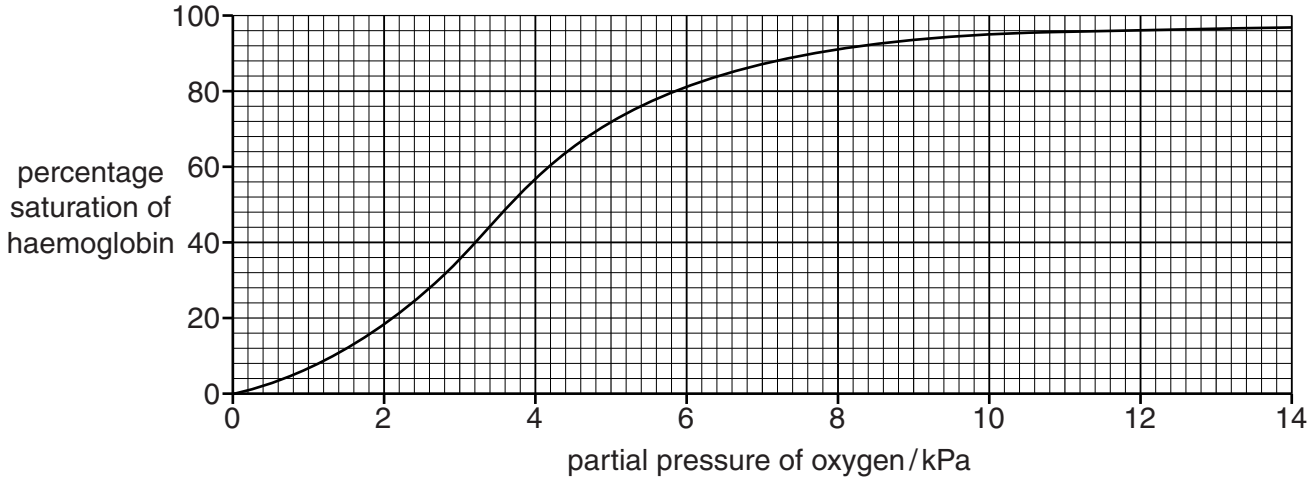


Fig. 3.2

With reference to Fig. 3.2, calculate the difference in percentage saturation of haemoglobin at sea level, where the partial pressure of oxygen is 13.0 kPa, and at a higher altitude, where the partial pressure of oxygen is 6.2 kPa.

Show your working.

answer ..... % [2]

(d) After spending time at altitude, a person can become acclimatised. One feature of acclimatisation is an increase in the red blood cell count.

Explain the importance of the increase in the red blood cell count.

.....

.....

.....

.....

..... [2]

© UCLES 2014

(e) Before acclimatisation can occur, some people develop a condition known as acute mountain sickness when they travel to high altitude areas.
Acetazolamide is a non-competitive enzyme inhibitor that is used as a drug to prevent and treat acute mountain sickness.

Explain the effects of a non-competitive inhibitor on the rate of enzyme activity.

.....

.....

.....

.....

.....

.....

..... [3]

(f) Tobacco smoking can have an effect on the transport of oxygen by haemoglobin.
Fig. 3.3 shows oxygen dissociation curves with and without the presence of carbon monoxide (CO).

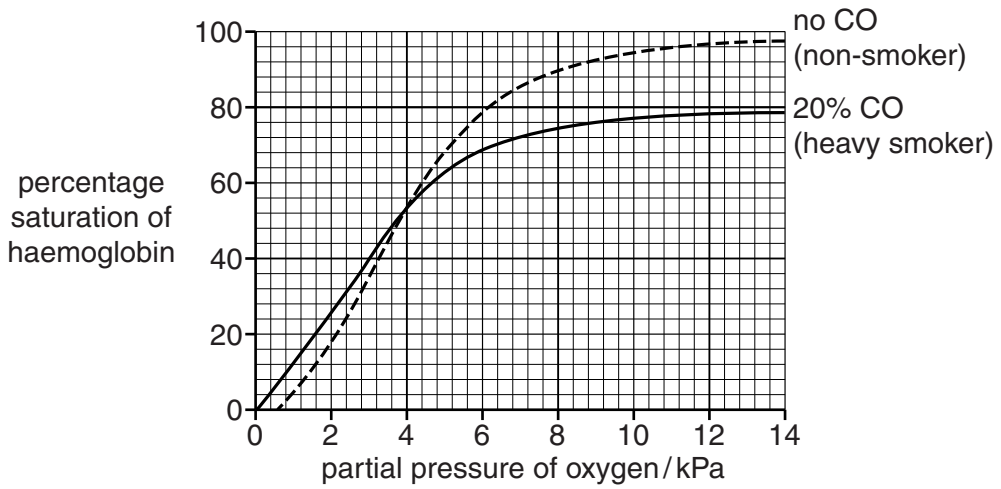


Fig. 3.3

With reference to Fig. 3.3, describe the effect of carbon monoxide on the cardiovascular system.

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 16]

4 Cholera is an infectious disease that can affect children and adults. Symptoms of the disease can occur very quickly, from a few hours to a few days.

Table 4.1 shows:

- the economic status of each of five countries
- the number of cases of cholera reported to the World Health Organization (WHO) over a five year period for each country
- the population in 2006 and in 2010 of each country.

Table 4.1

country	economic status	number of cholera cases reported			population / millions	
		2006	2008	2010	2006	2010
Zimbabwe	low	789	60055	951	12.5297	12.5715
Uganda	low	5194	3726	2341	29.3703	33.4247
Angola	middle	67257	10511	1484	17.0104	19.0819
Cameroon	middle	922	0	10759	17.9484	19.5989
Canada	high	2	1	2	32.6490	34.1088

© UCLES 2014

(a) (i) Table 4.1 shows that there are differences in the number of cholera cases reported between the high economic status country and the low economic status countries.

Suggest three reasons to explain these differences.

1. .....

.....

.....

2. .....

.....

.....

3. .....

.....

..... [3]

(ii) With reference to Table 4.1, suggest reasons for the differences in the number of cases of cholera reported over the five year period for Angola and Cameroon.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) Vaccination helps to prevent the spread of infectious diseases by stimulating an immune response in individuals against specific pathogens, such as Morbillivirus, the virus that causes measles.

(i) Suggest two reasons why measles vaccination programmes may fail to prevent epidemics.

1. .....

.....

2. .....

..... [2]

(ii) Outline the response produced by **B-lymphocytes** on exposure to Morbillivirus in an individual **who already has immunity** to measles.

.....

.....

.....

.....

.....

.....

.....

..... [3]

[Total: 12]

5 **(a)** Complete Table 5.1 by numbering each event to show the sequence occurring in the initiation and control of one heart beat.

Use **1** as the first event in the sequence.

Table 5.1

event	sequence
impulses pass down septum through conducting fibres known as the bundle of His	
atrioventricular node sends out impulses	
impulses travel across atrial walls	
impulses reach base of ventricles (apex of heart)	
impulses pass up through Purkyne fibres in ventricle walls	
sinoatrial node sends out impulses	

[3]

(b) Explain the circumstances that cause the closing of the semi-lunar valves during the cardiac cycle.

.....

.....

.....

.....[2]

(c) At the arterial end of a capillary bed in muscle tissue, the hydrostatic pressure is high enough to cause the formation of tissue fluid.

Explain the differences between the composition of blood and the composition of tissue fluid at the arterial end of a capillary bed.

.....

.....

.....

.....

.....

.....[2]

[Total: 7]

© UCLES 2014

[Turn over

6 *Agrobacterium tumefaciens* is a bacterium that can enter plants through wounds and cause a disease known as crown gall disease.

The bacterium attaches to the surface of cells and inserts a small circular DNA molecule, known as a plasmid, into the cell. Some of the genes on the plasmid code for proteins that cause changes in the plant cell and result in the formation of a plant tumour, or gall.

(a) Outline the changes that occur during tumour formation.

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) Bacteria that enter the stem through a wound can reach the root of the plant to cause damage.

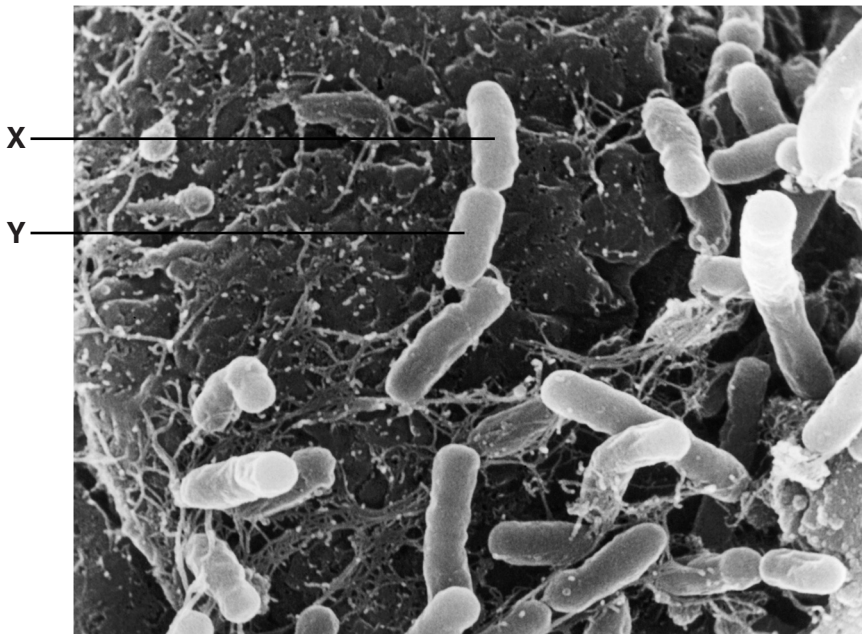
Suggest how the bacteria are able to reach the root of the plant.

.....

..... [1]

(c) Fig. 6.1 shows *A. tumefaciens* on the surface of cells of a tobacco plant, *Nicotiana plumbaginifolia*.

The cells **X** and **Y** are newly formed cells.



magnification ×11500

Fig. 6.1

Calculate the actual length of cell **X** in micrometres.

Show your working.

answer ..... μm [2]

[Total: 7]

© UCLES 2014

BLANK PAGE

Copyright Acknowledgements:

Fig. 1.1 © ASTRID & HANNS-FRIEDER MICHLER/SCIENCE PHOTO LIBRARY.
Fig. 6.1 © DR. JEREMY BURGESS/SCIENCE PHOTO LIBRARY.

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER			

4322934003

BIOLOGY **9700/23**

Paper 2 Structured Questions AS **October/November 2014**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name in the spaces provided at the top of this page.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.
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.

This document consists of **14** printed pages and **2** blank pages.

© UCLES 2014

CAMBRIDGE International Examinations

Answer **all** the questions

1 Fig. 1.1 is a photomicrograph of plant root cells near the growing tip. Some of the cells are undergoing mitosis.

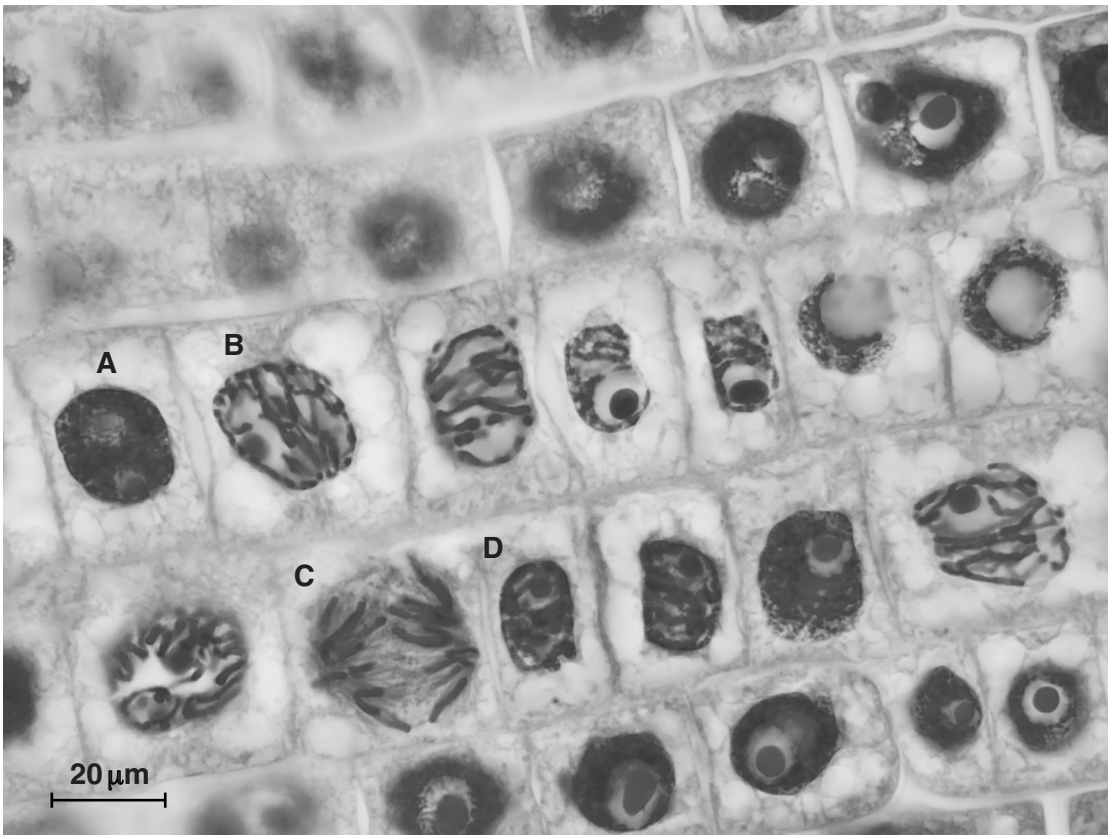


Fig. 1.1

(a) State **one** feature, visible in Fig. 1.1, which indicates that the section is taken from plant tissue and not animal tissue.

.....

.....[1]

(b) State the letter, **A** to **D**, of the cell in Fig. 1.1 which is in:

(i) prophase .....

(ii) anaphase. ..... [2]

(c) Describe two events occurring in cell **B**.

1. .....

.....

2. .....

.....
[2]

© UCLES 2014

(d) (i) Describe the role of mitosis in a growing plant root tip.

.....

.....

.....

.....

..... [2]

(ii) Mutations can sometimes occur in cells which are rapidly dividing.

Outline how a mutation can cause an altered polypeptide to be produced.

.....

.....

.....

.....

.....

.....

..... [2]

(e) Calculate the magnification of Fig. 1.1.

Show your working and give your answer to the nearest whole number.

magnification × .....
[2]

[Total: 11]

2 Fig. 2.1 shows a food chain in a freshwater ecosystem.

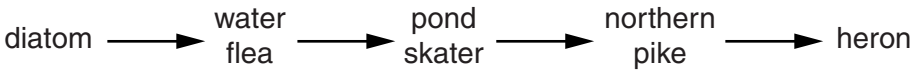


Fig. 2.1

(a) The diatom is an autotroph.

Explain what is meant by the term *autotroph*.

.....

.....

..... [2]

(b) Describe the role of the water flea in the food chain shown in Fig. 2.1.

.....

.....

..... [2]

(c) Suggest why the heron population is much smaller than the population of the water flea.

.....

.....

.....

.....

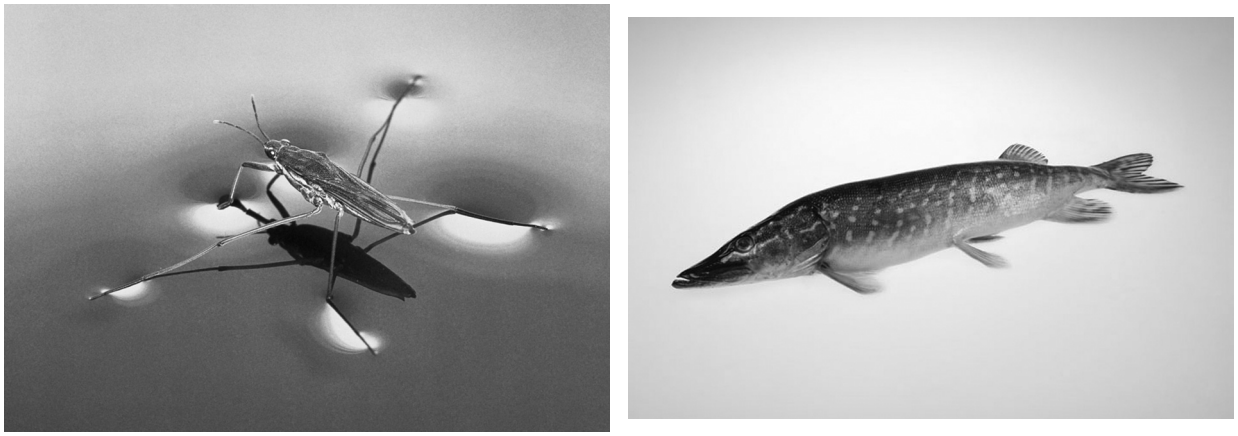
..... [2]

© UCLES 2014

Fig. 2.2a shows a pond skater walking on the surface of the water.

Fig. 2.2b shows a northern pike.

These are not shown to the same scale.



a **b**

Fig. 2.2

Both animals live in northern countries of the world, where temperatures often drop below 0 °C.

(d) Describe the importance of water as an environment for the pond skater **and** the northern pike.

.....

.....

.....

.....

.....

.....

.....

.....

..... [4]

(e) The mud at the bottom of the freshwater ecosystem contains dead organic material and also supports the growth of water plants.

Outline how nitrogen from the dead organic material is made available to the growing plants.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[4]

[Total: 14]

© UCLES 2014

3 Measles is an infectious disease for which vaccines have been developed.

The commonly used vaccine consists of an attenuated (weakened) form of the virus.

The measles vaccine is normally given to children when they are about one year old, followed by a booster dose when they are about four years old.

(a) Explain how this vaccine can provide long-term immunity against measles.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

Fig. 3.1 shows the number of reported cases of measles and the percentage of the population vaccinated worldwide between 1980 and 2002.

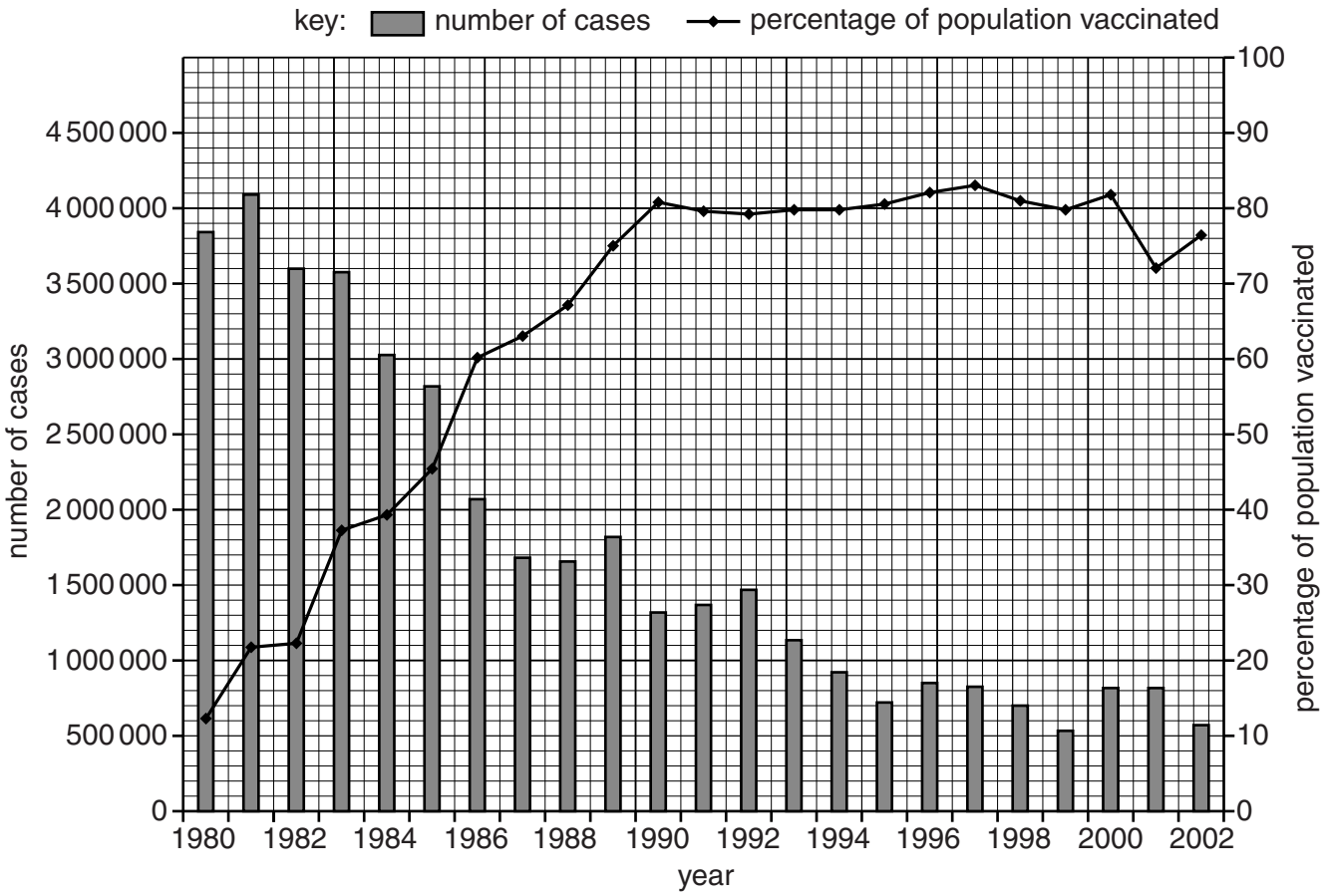


Fig. 3.1

(b) Describe the trends shown in Fig. 3.1:

between 1980 and 1990

.....

.....

.....

.....

.....

between 1990 and 2002.

.....

.....

.....

.....

.....

.....

.....

.....[4]

(c) The measles virus has a unique protein on its surface called MV-H which can bind to a protein called CD-46 on the surface of human cells. This allows the measles virus to infect these cells.

Suggest how the two proteins, MV-H and CD-46, can bind to each other.

.....

.....

.....

.....[2]

[Total: 11]

4 Fig. 4.1 is a computer-generated image of the enzyme hexokinase binding with its substrate, glucose. The product of the enzyme-catalysed reaction is glucose-6-phosphate.

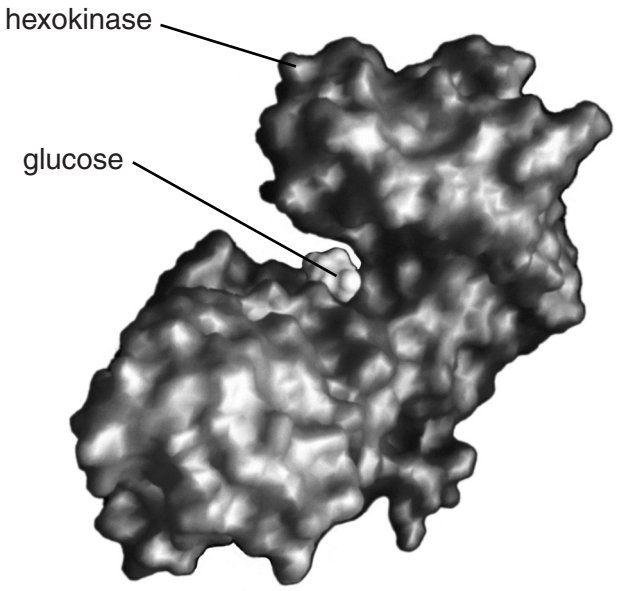


Fig. 4.1

(a) Hexokinase binds with glucose using the induced fit mechanism.
Describe how an enzyme-substrate complex forms by this mechanism.

.....

.....

.....

.....

.....

.....

.....

..... [3]

(b) Suggest how enzymes which use the induced fit mechanism can be less affected by competitive inhibitors than those which use the lock and key mechanism.

.....

.....

.....

.....

..... [2]

© UCLES 2014

(c) When a solution of the enzyme hexokinase is heated to 45 °C for 10 minutes, the quantity of product formed decreases by 50% compared to a sample kept between 30 °C and 40 °C.

Explain this result.

.....

.....

.....

.....

.....

..... [3]

Glucose can enter cells by active transport or facilitated diffusion.

Glucose-6-phosphate is a charged, polar molecule and cannot move out of cells.

(d) (i) State two **differences** between active transport and facilitated diffusion.

1. .....

.....

2. .....

.....

[2]

(ii) Suggest why glucose-6-phosphate cannot move out of cells.

.....

.....

.....

.....

.....

..... [2]

[Total: 12]

5 Fig. 5.1 shows a section of lung tissue from a smoker. The image magnification is ×10.

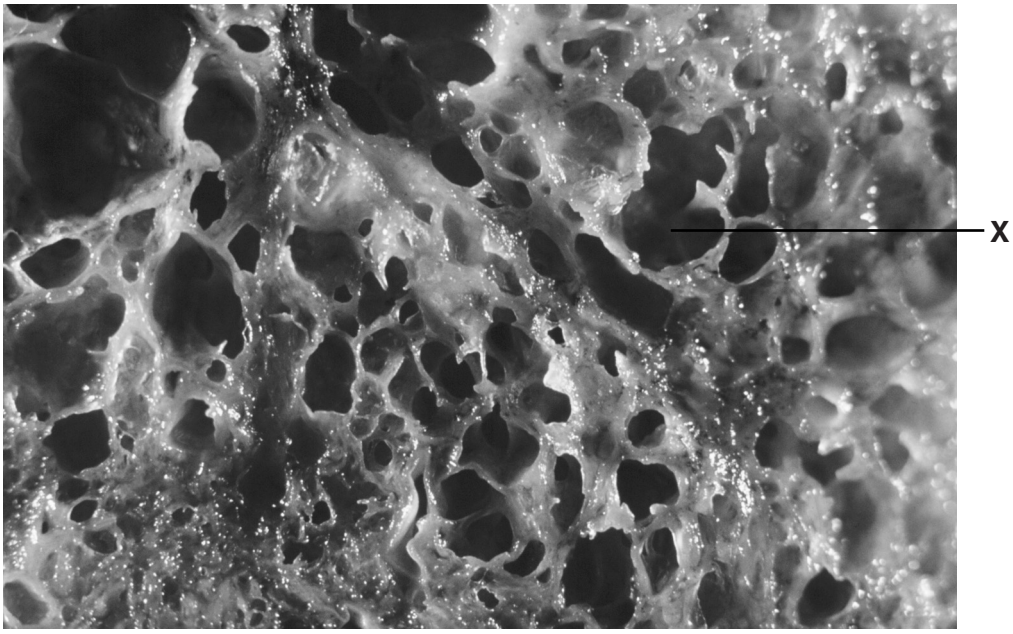


Fig. 5.1

In a smoker, the walls between the gas exchange structures in the lungs can break down, resulting in the damaged features visible in Fig. 5.1. One of these damaged features is labelled **X**.

(a) (i) Name the gas exchange structures which are damaged in Fig. 5.1.

.....[1]

(ii) Name the smoking-related disease resulting in the damaged feature labelled **X** in Fig. 5.1.

.....[1]

(b) Smoking-related diseases may increase the risk of infectious diseases of the gas exchange system.

Describe **and** explain how smoking can increase the risk of these infections.

.....

.....

.....

.....

.....

.....

.....[3]

(c) From one cigarette, a smoker will inhale between 14 and 20 mg of carbon monoxide.

Describe the effects of carbon monoxide on haemoglobin.

.....

.....

.....

.....

.....

.....[2]

[Total: 7]

6 Table 6.1 contains some information about xylem vessels and phloem sieve tube elements in plants.

Table 6.1

features	**xylem vessels**	**phloem sieve tube elements**
living cells		yes
substances transported		dissolved sugars and amino acids
direction of flow of substances	one direction, roots to leaves	
permeability of cell walls to water	not permeable	
cell wall material		

(a) Complete Table 6.1. [4]

(b) State **one** use for magnesium ions in plants.

.....[1]

[Total: 5]

© UCLES 2014

BLANK PAGE

© UCLES 2014

BLANK PAGE

Copyright Acknowledgements:

Fig. 1.1 © GERD GUENTHER/SCIENCE PHOTO LIBRARY.
Fig. 2.1 a © HERMANN EISENBEISS/SCIENCE PHOTO LIBRARY.
Fig. 2.1 b © Francisco Martinez / Alamy.
Fig. 4.1 © KENNETH EWARD/BIOGRAFX/SCIENCE PHOTO LIBRARY.
Fig. 5.1 © CNRI/SCIENCE PHOTO LIBRARY.

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

© UCLES 2014