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Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education
Advanced Level

BIOLOGY **9700/06**

Paper 6 Options

October/November 2004

1 hour

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 at the top of this page.
Write in dark blue or black pen in the spaces provided on the Question Paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** the questions set on **one** of the options.
At the end of the examination, **enter the number of the option you have answered in the grid below**.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets [ ] at the end of each question or part question.
The options are:
1 – Mammalian Physiology (page 2)
2 – Microbiology and Biotechnology (page 11)
3 – Growth, Development and Reproduction (page 20)
4 – Applications of Genetics (page 28)

If you have been given a label, look at the details. If any details are incorrect or missing, please fill in your correct details in the space given at the top of this page.

Stick your personal label here, if provided.

OPTION ANSWERED	
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1	
2	
3	
4	
TOTAL	

This document consists of **35** printed pages and **1** blank page.

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OPTION 1 – MAMMALIAN PHYSIOLOGY

1 **(a)** Fig. 1.1 shows part of the retina in a mammalian eye.

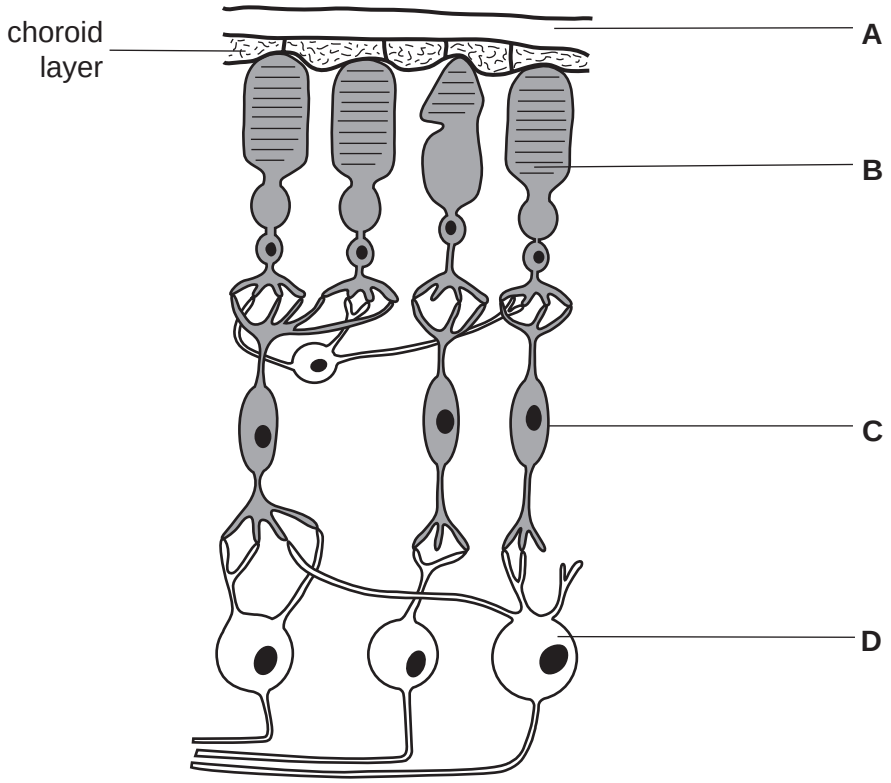

Fig. 1.1

(i) Name **A** to **D**.

A .....

B .....

C .....

D ..... [2]

(ii) Describe the function of the choroid layer.

.....

.....

.....[2]

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(iii) With reference to Fig. 1.1, explain why visual acuity is greater when light is detected by cone cells than when it is detected by rod cells.

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.....[3]

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(b) Rod cells contain the light-sensitive pigment rhodopsin. There are three different types of cone cells each containing a different pigment, known as **B** (blue), **R** (red) and **G** (green).

Fig. 1.2 shows the absorption spectra of these four pigments.

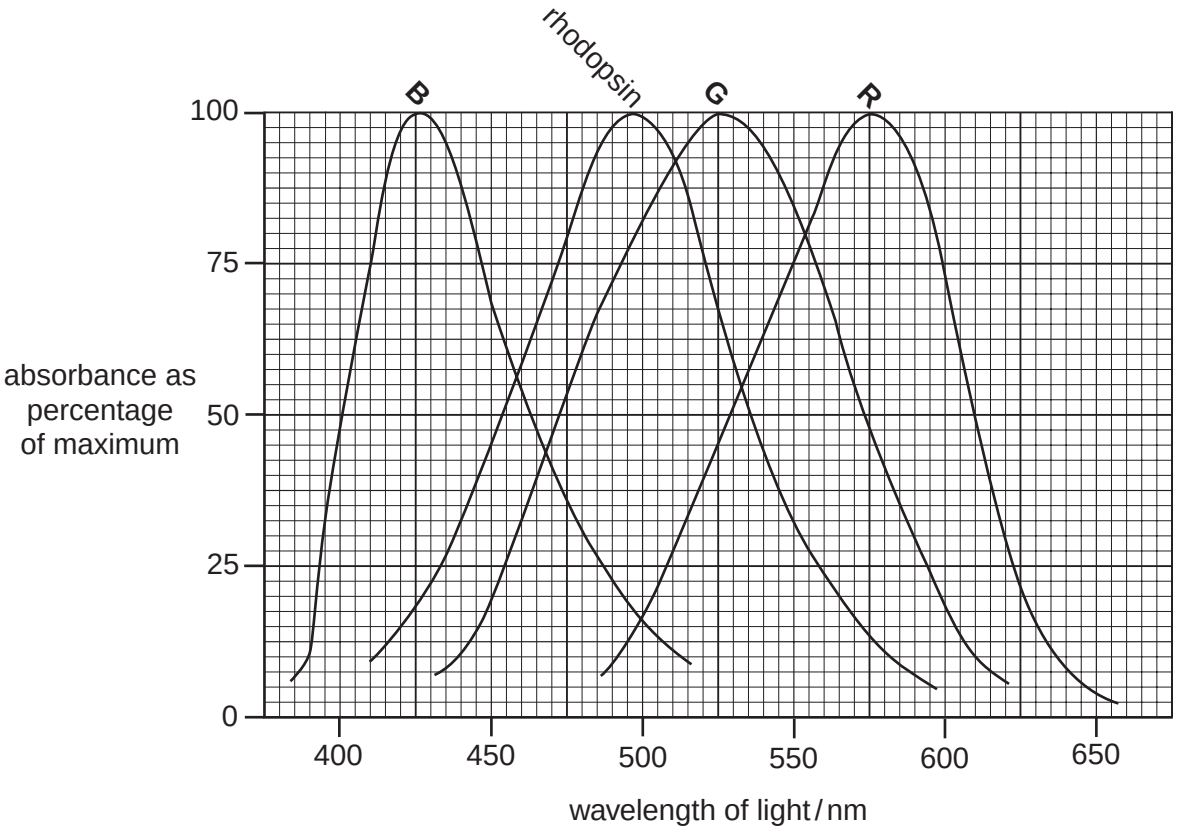

Fig. 1.2

With reference to Fig. 1.2,

(i) explain how the brain distinguishes red light from blue light;

.....

.....

.....[2]

(ii) explain why colours cannot be seen when only rod cells are in use.

.....

.....

.....[2]

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(c) All four pigment molecules of the rod and cone cells are composed of a protein called opsin and the light-sensitive compound retinal. The genes for the pigment molecules in **R** cones and in **G** cones are on the X chromosome. They are very close to each other and very similar to each other. Mutations affecting these genes are relatively common.

One such mutation, resulting from loss of part of the chromosome, results in the two genes becoming one 'hybrid' gene, which codes for the production of a single type of pigment. This results in red-green colour blindness.

(i) Explain why red-green colour blindness is more common in men than in women.

.....

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.....[3]

(ii) Suggest which part of the **R** and **G** pigment molecules is coded for by the genes on the X chromosome, giving a reason for your answer.

.....

.....[1]

[Total : 15]

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2 Fig. 2.1 shows the arrangement of two of the muscles in the upper arm. Fig. 2.2 is a diagrammatic representation of part of a myofibril from the biceps muscle when this muscle is relaxed.

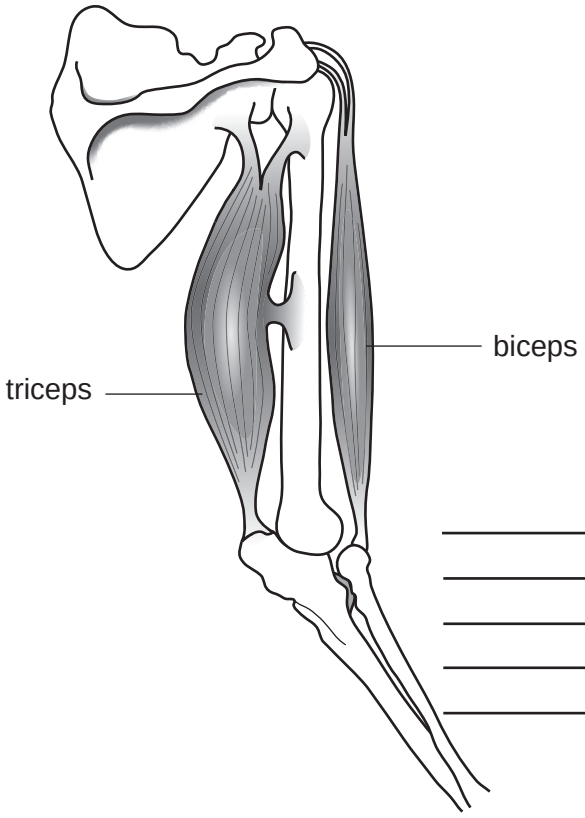

Fig. 2.1

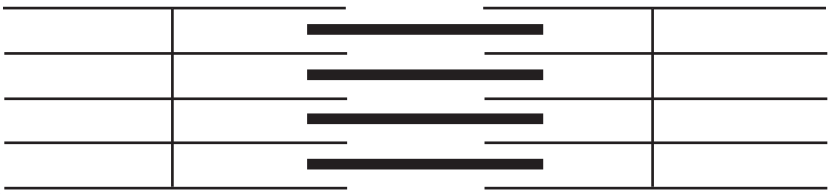

Fig. 2.2

(a) In the space below, draw the part of the myofibril shown in Fig. 2.2 as it would appear when it is fully contracted.

[3]

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(b) Describe the role of myosin in producing the changes between the relaxed myofibril in Fig. 2.2 and the contracted myofibril in your diagram.

.....

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.....[4]

(c) With reference to Fig. 2.1, explain how the contracted myofibril of the biceps could be returned to the relaxed state shown in Fig. 2.2.

.....

.....

.....[2]

[Total : 9]

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3 Bile salts (bile acids) are produced in the liver and secreted in bile. They pass along the bile duct and into the duodenum, and are mostly reabsorbed as they pass through the ileum. Some, however, are converted by bacteria in the small intestine into substances which cannot be absorbed. These are lost in the faeces.

Fig. 3.1 shows the quantities of bile salts passing along these routes each day.

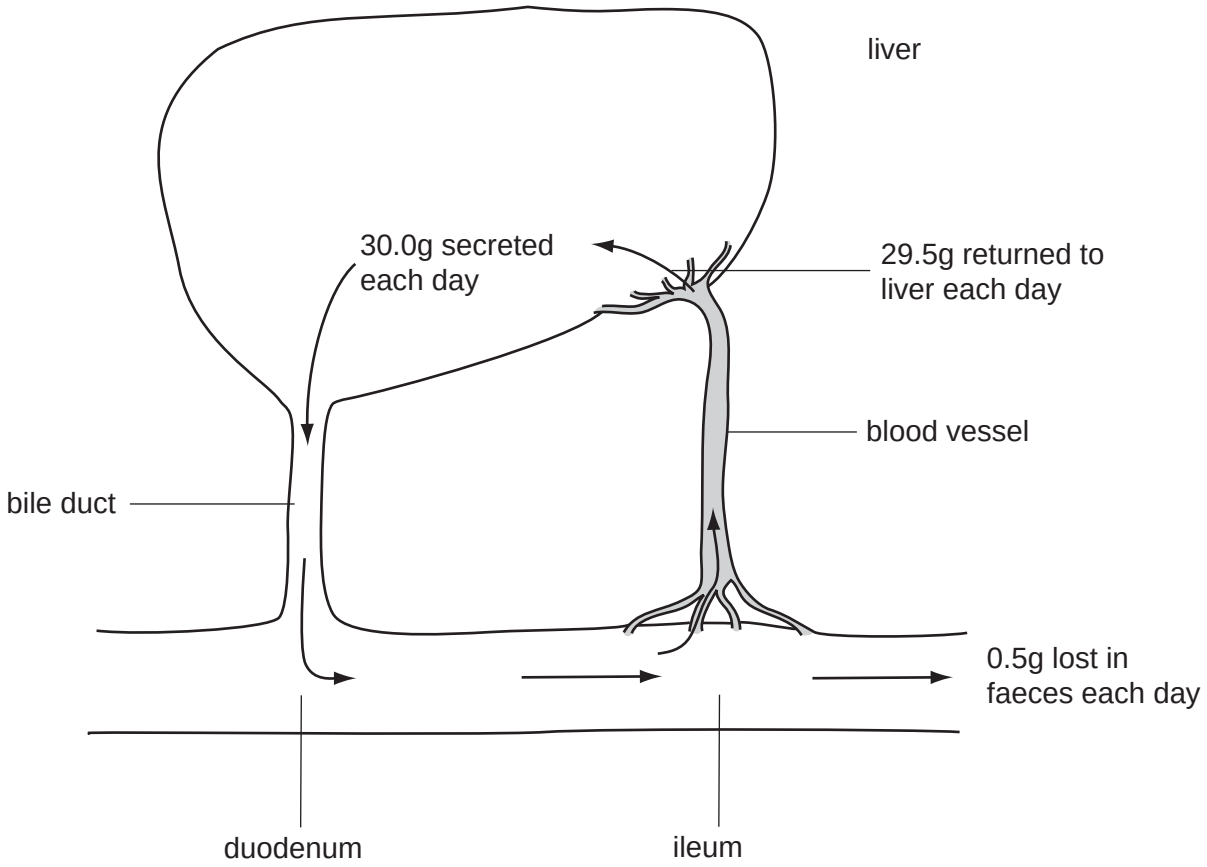

Fig. 3.1

(a) Calculate the percentage of the bile salts that are lost from the body each day. Show your working.

…… [2]

(b) Name the blood vessel in which the reabsorbed bile salts are returned to the liver.

.....[1]

(c) Describe how and where bile salts are produced in the liver.

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.....[2]

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(d) Describe the role of bile salts in fat digestion.

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4 **(a)** Fig. 4.1 shows a gymnast performing on the pommel horse.

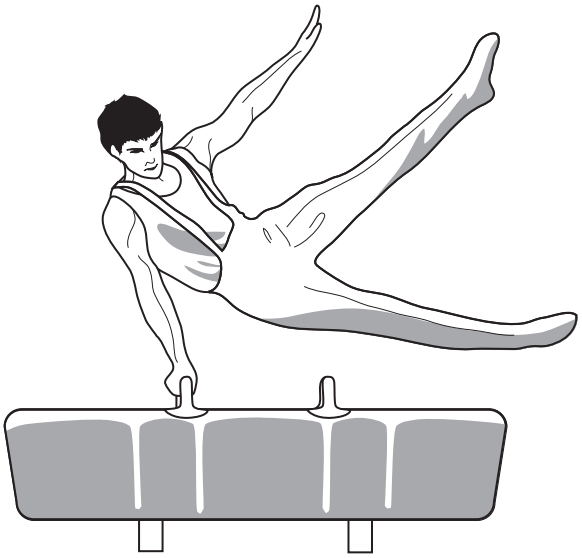

Fig. 4.1

Outline the roles of the gymnast's cerebellum and medulla oblongata in enabling him to carry out this activity.

cerebellum .....

.....

.....

medulla oblongata .....

.....

.....[4]

(b) Alzheimer's disease is a type of dementia characterised by changes in the appearance of the tissue in part of the brain.

(i) Name the part of the brain that is affected in Alzheimer's disease.

.....[1]

(ii) Describe the possible causes of Alzheimer's disease.

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.....

.....

.....[3]

[Total : 8]

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OPTION 2 – MICROBIOLOGY AND BIOTECHNOLOGY

1 **(a)** The number of bacteriophages in a liquid medium can be determined by serial dilution of the medium. A small volume of each dilution, 5 mm^3, is plated on to agar plates that have a lawn of bacteria growing on them. When the agar plates are incubated at 25°C there are clear areas, known as plaques, in the bacterial lawn. When one or more bacteriophages infect a bacterium, each infected bacterial cell lyses, releasing many bacteriophages. The released bacteriophages then infect the surrounding bacteria, which also lyse to leave plaques.

Explain why the agar plates are incubated at 25°C rather than 37°C.

.....

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.....[2]

(b) To determine the number of bacterophages in a medium, three serial dilutions were made. Nine plates were set up with bacteria lawns. These were used to make three replicate plates, **A**, **B** and **C**, for each of the serial dilutions. After incubation, the number of plaques in each plate is shown in Table 1.1.

Table 1.1.

dilution	number of plaques in each plate		
	replicate **A**	replicate **B**	replicate **C**
1.0×10^{-6}	657	616	620
1.0×10^{-7}	68	64	66
1.0×10^{-8}	4	8	7

(i) With reference to Table 1.1, suggest why the number of plaques counted at the dilutions of $1.0x10^{-6}$ and $1.0x10^{-8}$ may be inaccurate or unreliable and should not be used to estimate bacteriophage numbers.

.....

.....

.....

.....[3]

(ii) Calculate the number of bacteriophage particles **per mm^3** in the original liquid medium. Show your working.

.....[2]

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(c) Legionnaires' disease is caused by the bacterium *Legionella pneumophila*. Outbreaks of legionnaires' disease have occurred after people have breathed mists that come from a water source. The disease is not passed from person to person. It affects the lungs.

An outbreak of legionnaires' disease occurred in Cumbria, UK, in the summer of 2002. The cumulative total number of deaths is shown in Fig. 1.1.

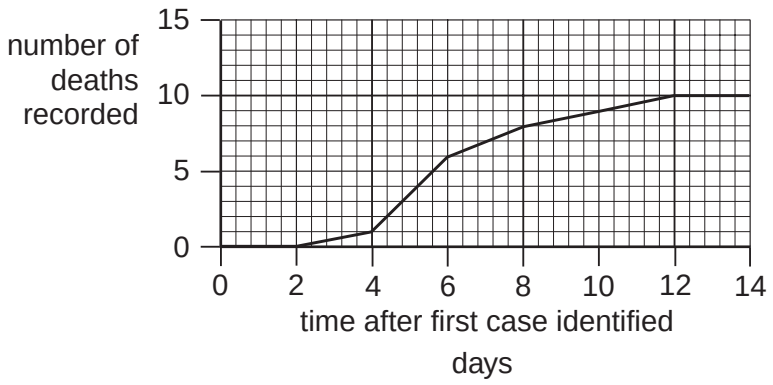

Fig. 1.1

Describe the pattern in the number of deaths during the outbreak of legionnaires' disease shown in Fig. 1.1.

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.....

.....

.....[2]

(d) **(i)** Legionnaires' disease is not an infectious disease.

Explain what is meant by an *infectious disease.*

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.....[2]

(ii) Describe the specialist **structural** features of laboratories working with pathogenic microorganisms that prevent the spread of infectious diseases.

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.....[4]

[Total : 15]

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Question 2 begins on the next page.

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2 **(a)** Table 2.1 shows the distinguishing characteristics of the three groups of organisms collectively known as microorganisms. Complete the table by filling in the empty boxes.

Table 2.1

group of organisms	type of genetic material	presence or absence of nucleus	type of cell wall material
Fungi		present	
	DNA or RNA		no cell wall
	DNA		peptidoglycan

[3]

(b) List two ways in which the life cycle of a bacteriophage differs from that of a bacterium.

1. .....

2. .....[2]

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(c) Fig. 2.1 shows the cell wall and associated structures of a **Gram positive** bacterium.

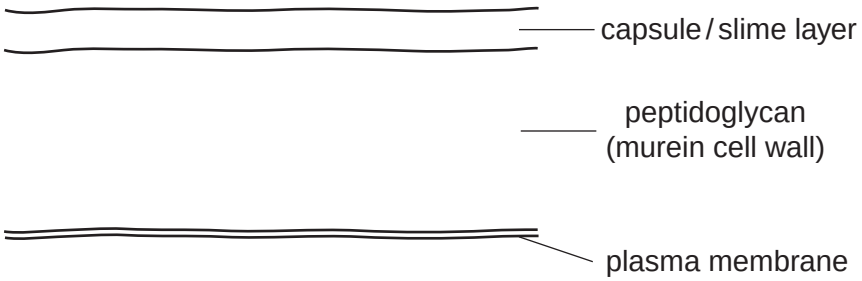

Fig. 2.1

Draw and label the cell wall of a **Gram negative** bacterium in the space below.

[2]

[Total : 7]

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3 **(a)** Outline **one** method for the production of monoclonal antibodies.

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.....[4]

(b) Monoclonal antibodies are used as diagnostic and therapeutic reagents. In some cases the monoclonal antibody is coupled to another molecule.

Suggest the advantage of coupling the monoclonal antibody to a

fluorescent molecule for diagnosis,

.....

.....

radioactive molecule for treatment.

.....

.....[3]

(c) During pregnancy a hormone called human gonadotrophin (HCG) is released from the placenta. It accumulates in the blood stream and is released in the urine. Detection of this hormone is the basis of some home pregnancy kits in which HCG binds to specific monoclonal antibodies. The monoclonal antibodies are incorporated into the surface of a plastic dipstick.

Complete the correct sequence of the stages shown in Fig. 3.1 opposite, by writing the letter of each stage in the boxes provided below. The first two have been completed for you.

sequence	1	2	3	4	5	6	7	8
letter of stage			**A**		**B**			

[3]

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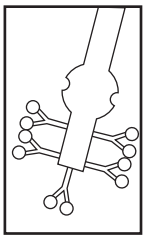
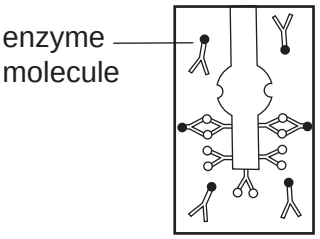
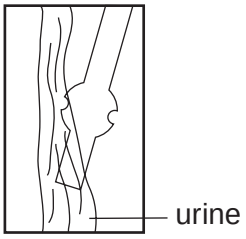


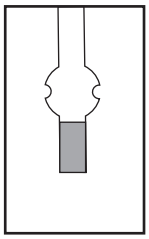
A HCG has bound to antibody on stick. All other antigens washed away.



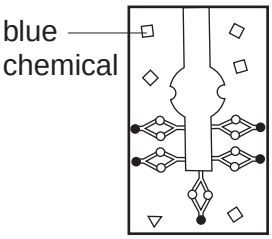
B Second antibody binds to first.



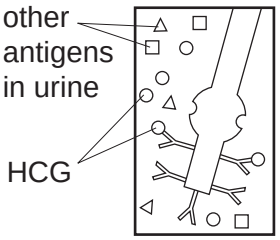
C Stick held in flowing urine.



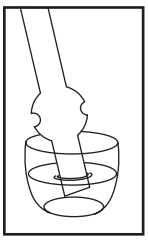
D Stick appears blue - a positive pregnancy test.



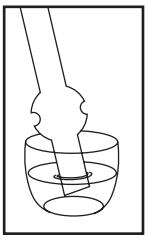
E Chemical turns blue with specific enzyme.



F HCG in urine of pregnant female binds to antibody on surface of stick.



G Stick dipped into second antibody with enzyme attached.



H Stick dipped into chemical.

Fig. 3.1

[Total : 10]

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4 **(a)** Penicillin is produced in batch fermenters. Explain how a batch fermenter differs from a continuous fermenter.

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(b) Fig. 4.1 shows the number of reported cases, between the years 1982 and 1992, of a sexually-transmitted disease caused by a bacterium resistant to penicillin.

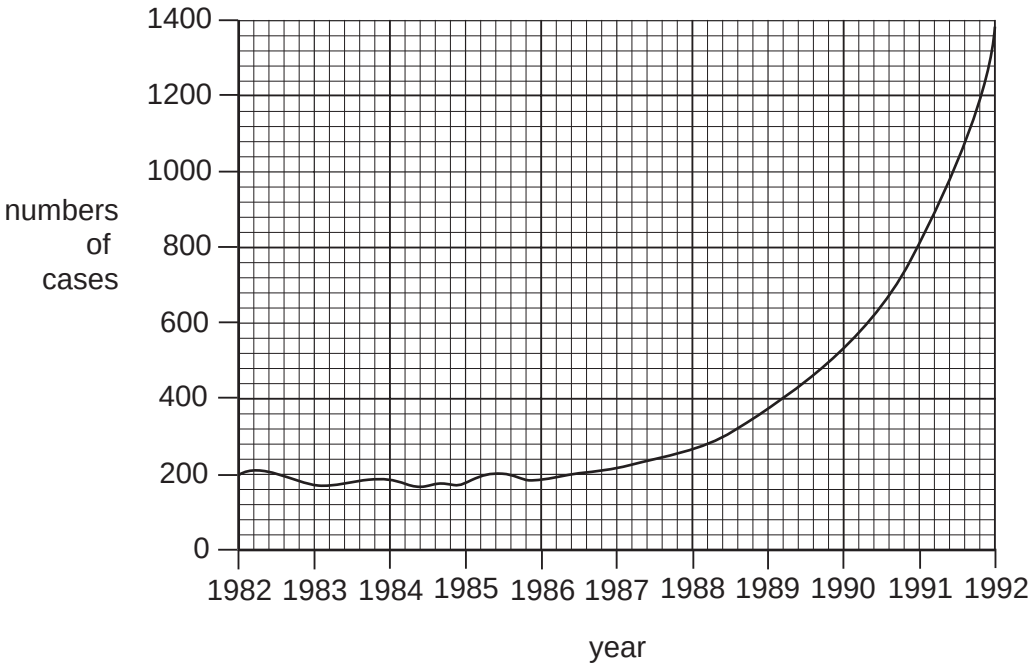

Fig. 4.1

Suggest why the steep rise in the incidence of this disease occurred between 1987 and 1992.

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.....[2]

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(c) Penicillin is produced as a secondary metabolite in batch fermenters. Fig. 4.2. shows the rate of penicillin production when grown in various glucose concentrations.

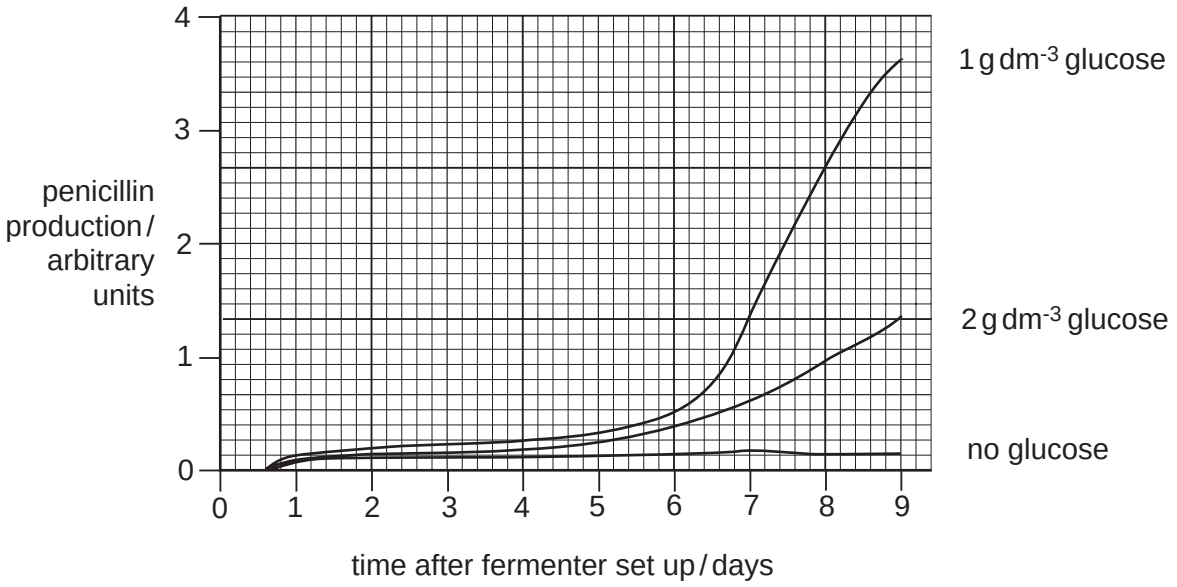

Fig. 4.2

Describe how the glucose concentration affects penicillin production.

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.....[3]

[Total : 8]

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OPTION 3 – GROWTH, DEVELOPMENT AND REPRODUCTION

1 **(a)** Describe briefly the process of fertilisation in humans.

.....

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.....[4]

(b) Mice and humans share a gene for a protein ion channel that is found only in the plasma membrane (cell surface membrane) of the tails of spermatozoa. Mice homozygous for a mutation which results in an inactive ion channel are sterile.

Explain how a mutation can result in an inactive ion channel.

.....

.....

.....

.....[3]

(c) Sperm from mice homozygous for the mutation giving an inactive ion channel and from homozygous normal mice were examined. Their rate of movement was measured and their ability to fertilise eggs was tested by *in vitro* fertilisation (IVF) of intact eggs and eggs without their outer zona pellucida. The results are shown in Table 1.1.

Table 1.1

	sperm from homozygous normal mice	sperm from homozygous mutant mice
rate of movement / μm s^{-1}	180	60
successful fertilisation of intact eggs / %	81	0
successful fertilisation of eggs with zona pellucida removed / %	76	62

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(i) Explain what is meant by *in vitro* fertilisation.

.....

.....

.....[2]

(ii) With reference to Table 1.1, compare the abilities of sperm from normal and mutant mice to fertilise eggs successfully *in vitro*.

.....

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.....[4]

(iii) With reference to Table 1.1, suggest an explanation for the **differences** you have described in **(ii)**.

.....

.....

.....[2]

[Total : 15]

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2 **(a)** Explain briefly what is meant by *growth* of an organism.

.....

.....

.....[2]

(b) Two thousand Sitka spruce trees were planted 2.0 m apart and their growth in volume measured at five year intervals from ages 20 to 75 years.

Table 2.1 shows the mean volume of the trees per hectare from 20 to 75 years, their mean increase in volume per 5 year period and also their relative growth calculated as:

$$\frac{\text{mean change in volume over 5 year period}}{\text{mean volume at start of 5 year period}}$$

Table 2.1

age of trees / years	mean volume of trees / $m^3\ ha^{-1}$	mean increase in volume per 5 year period / $m^3\ ha^{-1}$	relative growth of trees $\frac{\text{mean increase in volume over 5 year period}}{\text{mean volume at start of 5 year period}}$
20	66	–	–
25	133	67	1.02
30	214	81	0.61
35	301	87	0.41
40	386	85	0.28
45	465	79	0.20
50	534	69	0.15
55	593	59	0.11
60	642	49	0.08
65	683	41	0.06
70	718	35	0.05
75	751	33	

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With reference to Table 2.1,

(i) calculate, showing your working, the **relative growth** of the trees for the period 70 to 75 years; and put your answer in the space provided in Table 2.1.

[2]

(ii) describe the change in relative growth with age;

.....

.....

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.....[3]

(iii) describe how the data could be used to plot a curve of **absolute growth rate**.

.....

.....

.....[2]

[Total : 9]

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3 **(a)** Fig. 3.1 shows the female gametophyte of a typical flowering plant.

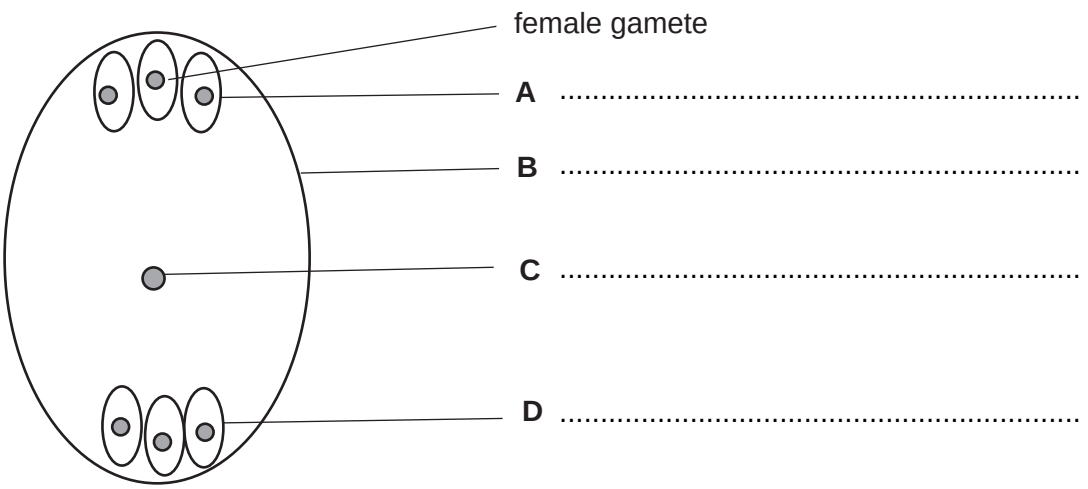

Fig. 3.1

(i) Name **A** to **D**. [2]

(ii) Describe what happens at fertilisation to the female gamete and to structure **C**.

female gamete .....

.....

.....

*structure **C*** .....

.....

.....[4]

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(b) The water lily, *Nuphar*, appears to have a female gametophyte containing only four haploid nuclei, as shown in Fig. 3.2.

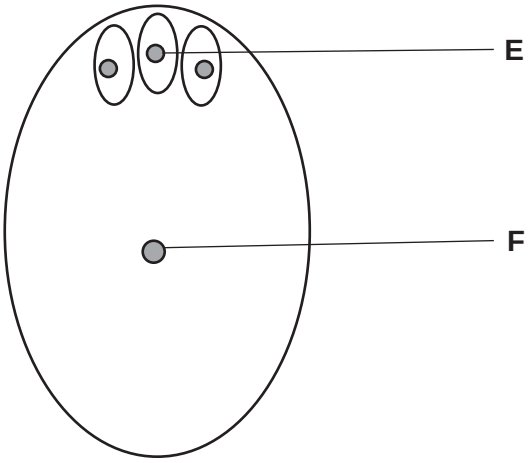

Fig. 3.2

The DNA content of nuclei **E** and **F** can be measured by their fluorescence. This was measured in a number of ovules before and after fertilisation. The results are shown in Table 3.1.

Table 3.1

	mean relative fluorescence / arbitrary units	
nucleus	before fertilisation	after fertilisation
E	10.19	20.55
F	10.31	20.33

Explain whether the data in Table 3.1 support the suggestion that the water lily gametophyte contains four haploid nuclei.

.....

.....

.....[2]

[Total : 8]

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4 **(a)** Fig. 4.1 shows the procedure that is followed when a sample of seeds arrives at a seed bank.

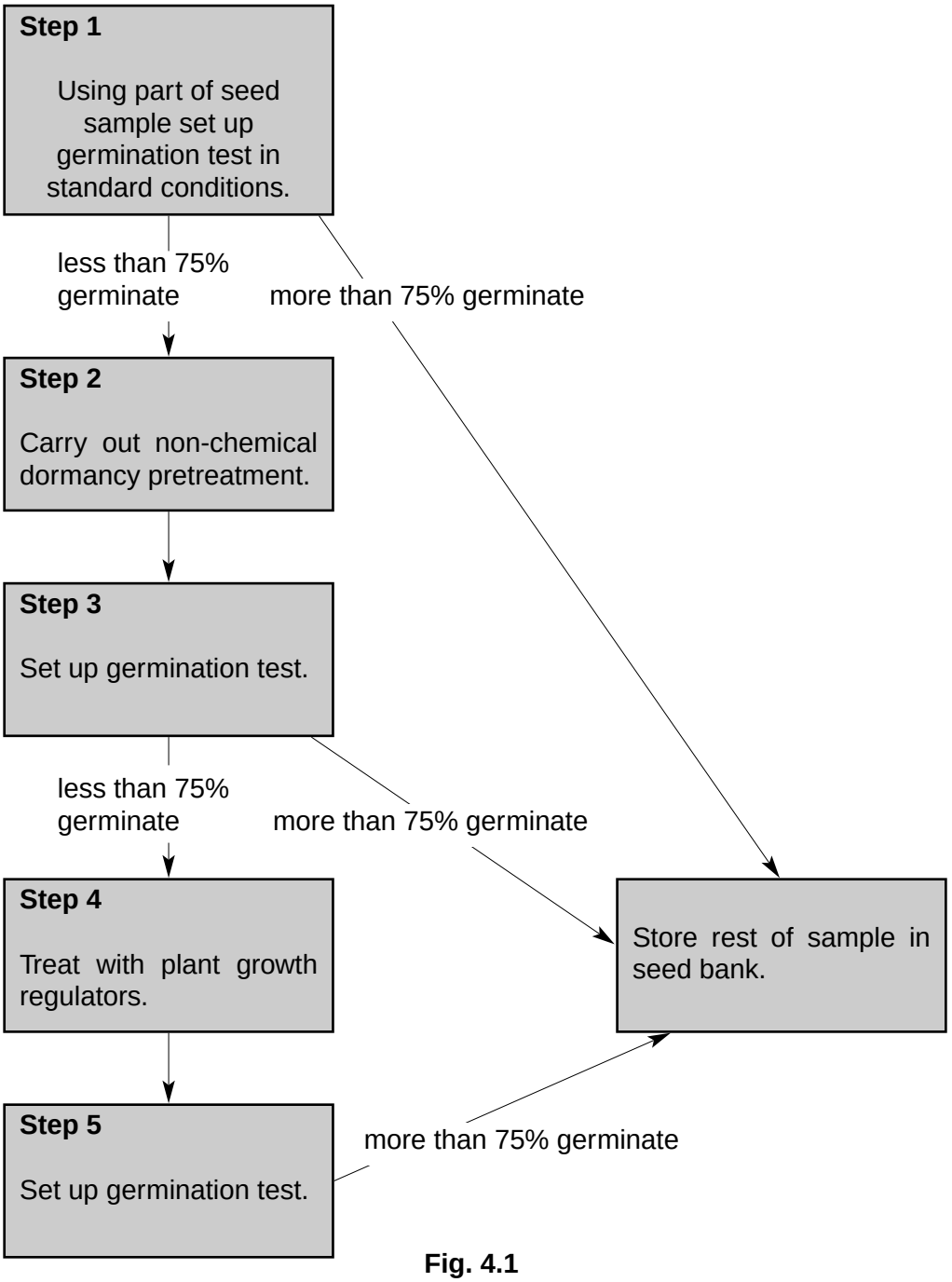

Fig. 4.1

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With reference to Fig. 4.1,

(i) describe the conditions that might be used for germinating seeds in steps **1**, **3** and **5**;

.....

.....

.....

.....[3]

(ii) describe briefly **two** different treatments that might be used to break seed dormancy in step **2**;

treatment 1 .....

.....

treatment 2 .....

.....[2]

(iii) name **one** plant growth regulator that might be used to break seed dormancy in step **4** and explain how it does so.

plant growth regulator .....

explanation .....

.....

.....[3]

[Total : 8]

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OPTION 4 – APPLICATIONS OF GENETICS

1 **(a)** Mice and humans share a gene for a protein ion channel that is found only in the plasma membrane (cell surface membrane) of the tails of spermatozoa. Mice homozygous for a mutation which results in an inactive ion channel are sterile.

Explain how a mutation can result in an inactive ion channel.

.....

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.....[3]

(b) Sperm from mice homozygous for the mutation giving an inactive ion channel and from homozygous normal mice were examined. Their rate of movement was measured and their ability to fertilise eggs was tested by *in vitro* fertilisation (IVF) of intact eggs and eggs without their outer zona pellucida. The results are shown in Table 1.1.

Table 1.1

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(i) Explain what is meant by *in vitro* fertilisation.

.....

.....

.....[2]

(ii) With reference to Table 1.1, compare the abilities of sperm from normal and mutant mice to fertilise eggs successfully *in vitro*.

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.....[4]

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(iii) With reference to Table 1.1, suggest an explanation for the **differences** you have described in **(ii)**.

.....

.....

.....[2]

(c) The DNA coding for the ion channel was analysed by a process similar to genetic fingerprinting. DNA from three different mice was used:

A – a mouse homozygous for the normal ion channel;
B – a heterozygous mouse;
C – a mouse homozygous for the mutation giving an inactive ion channel.

The resulting genetic fingerprint is shown in Fig. 1.1.

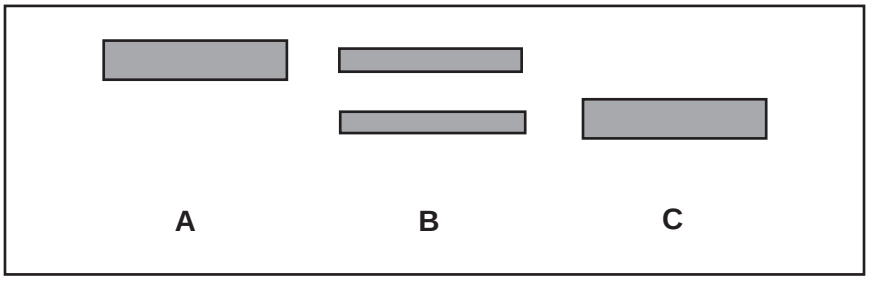

Fig. 1.1

With reference to Fig. 1.1, explain

(i) the difference in the position of the bands from mouse **A** and mouse **C** in the genetic fingerprint;

.....

.....

.....

.....[3]

(ii) the presence of two bands in the genetic fingerprint of mouse **B**.

.....

.....[1]

[Total : 15]

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For Examiner's Use

2 **(a)** 'Sticky' rice has a high market value in China, but is susceptible to a major fungal disease of rice called rice blast. Non-sticky, hybrid rices are more resistant to rice blast.

Explain briefly how sticky rice might be selectively bred to show resistance to rice blast.

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.....[4]

(b) In 1998 and 1999 a large number of farmers in Yunnan Province planted both sticky rice and hybrid rice alone (in monoculture) and in mixed planting. In the mixed plantings, single rows of sticky rice (**S**) were planted between rows of hybrid rice (**R**) in the pattern shown in Fig. 2.1.

R R S R R R R S R R
R R S R R R R S R R
R R S R R R R S R R
R R S R R R R S R R
R R S R R R R S R R

Fig. 2.1

The severity of infection by rice blast in mixed planting was then compared with that in monoculture. The genetic diversity of the rice blast fungus populations was also found. The results are shown in Table 2.1.

Table 2.1

	rice grown in monoculture	rice grown in mixed planting
mean percentage of stems of sticky rice dying from rice blast	20.0	1.2
mean percentage of stems of hybrid rice dying from rice blast	2.3	1.0
genetic diversity of rice blast fungus populations	one or a few strains	many strains with no single predominant strain

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With reference to Table 2.1, explain

(i) the difference in infection by rice blast between monoculture and mixed planting;

.....

.....

.....[2]

(ii) the difference in the genetic diversity of rice blast fungus populations.

.....

.....

.....[2]

[Total : 8]

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3 Drylands are among the most threatened environments in the world. Seeds from dryland plants are being collected and stored. At intervals, samples of seeds from storage are germinated, plants grown and a new generation of seeds collected for storage.

Seeds from plants that only grow in one place in the world, from endangered species and from plants used by local people may be stored in the country of origin or in the Millennium Seed Bank in the UK.

(a) Explain why dryland seeds are being collected and stored.

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.....[3]

(b) Describe the conditions in which seeds are stored in a seed bank.

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.....

.....[2]

(c) Explain why, at intervals, samples of seeds are germinated, plants grown and a new generation of seeds collected for storage.

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.....

.....[2]

[Total : 7]

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Question 4 begins on the next page.

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For Examiner's Use

4 **(a)** Explain the genetic basis of Down's syndrome in humans.

.....

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.....

.....[3]

(b) State what is meant by *genetic screening*.

.....

.....[1]

(c) In a study into diagnosis of Down's syndrome, the way in which 323 people with Down's syndrome were initially diagnosed was recorded. **All** had been screened before 24 weeks of pregnancy by **one** of four different tests, **A**, **B**, **C** or **D**, in approximately equal numbers.

The number of cases detected by each test, as well as the total number of cases missed by the tests, and so detected only at or after birth, is shown in Table 4.1.

Table 4.1

Screening test	**A**	**B**	**C**	**D**
number of cases of Down's syndrome detected before 24 weeks of pregnancy	32	36	42	61
number of cases of Down's syndrome detected at or after birth	152			
total number of cases of Down's syndrome	323			

With reference to Table 4.1.

(i) calculate the percentage of cases of Down's syndrome that were detected before 24 weeks of pregnancy. Show your working;

…… [2]

(ii) describe the differences in the success of the different screening tests in diagnosing Down's syndrome before birth;

.....

.....

.....

.....[3]

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(iii) suggest **one** way of making use of tests **A**, **B**, **C** and **D** that would increase the percentage of cases of Down's syndrome detected before birth.

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.....[1]

[Total : 10]

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