Centre Number	Candidate Number	Name

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
General Certificate of Education Advanced Level

BIOLOGY **9700/06**

Paper 6 Options

May/June 2006

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 on all the work you hand in.
Write in dark blue or black pen.
You may use a pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer the questions set on **one** of the options only.
Answer **all** four questions from your chosen option only.

Within your chosen option, write your answers to the Questions in the spaces provided on the Question Paper. **Enter the number of the option you have answered in the grid below**.

The number of marks is given in brackets [ ] at the end of each question or part question.
The options are:
1 – Mammalian Physiology (page 3)
2 – Microbiology and Biotechnology (page 12)
3 – Growth, Development and Reproduction (page 20)
4 – Applications of Genetics (page 28)

At the end of the examination, fasten all your work securely together.

OPTION ANSWERED	
FOR EXAMINER'S USE	
1	
2	
3	
4	
TOTAL	

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

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OPTION 1 – MAMMALIAN PHYSIOLOGY

1 A reflex action involving the iris can be used by medical staff to assess a person's level of consciousness. A light is shone into one eye, and the speed with which the pupils of both eyes reduce in diameter, and the extent to which this happens, can be measured. This test, known as the pupil response test, is also used in some countries to determine whether a driver has a blood alcohol concentration above the legal limit.

(a) Describe how the reduction in diameter of the pupil in bright light is brought about.

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.....[4]

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[Turn over

(b) In one country, the legal limit of blood alcohol concentration for a driver is 0.08%. An investigation was carried out to find out how accurately the pupil response test could determine whether a person's blood alcohol concentration was over this limit.

A number of volunteers each consumed quantities of alcohol expected to produce blood alcohol concentrations between 0.08% and 0.15%. The pupil response test was then performed on each volunteer at hourly intervals. The results were classified as shown in the table.

correct positive	correct identification of a person over the legal limit
correct negative	correct identification of a person not over the legal limit
false positive	a person **not** over the legal limit identified incorrectly
false negative	a person over the legal limit **not** identified correctly

The results of this investigation are shown in Fig. 1.1.

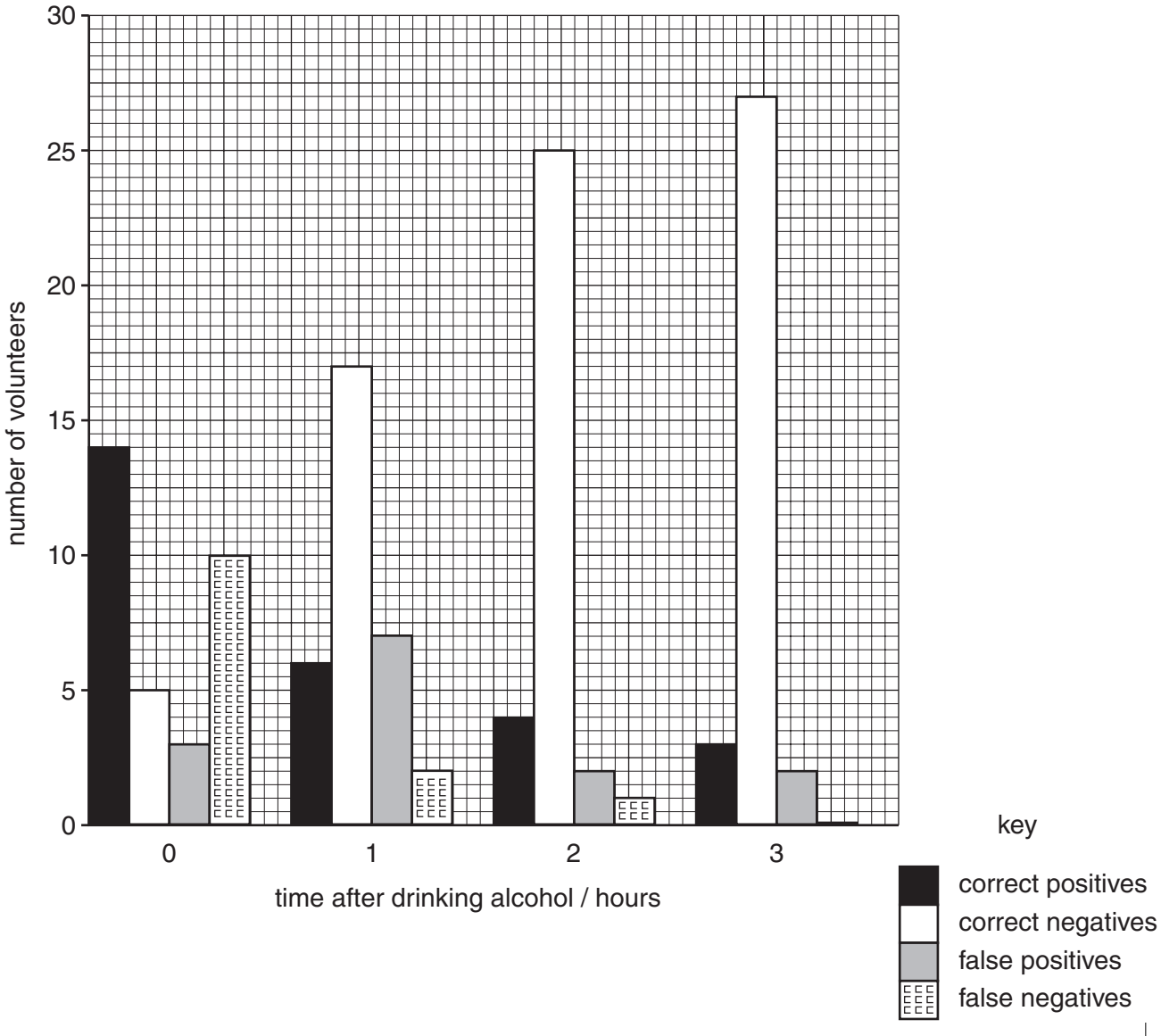


Fig. 1.1

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(i) With reference to Fig. 1.1, describe the relationship between the number of correct positives, determined by the pupil response test, and the time after drinking alcohol.

.....

.....

.....[2]

(ii) Suggest an explanation for this relationship.

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.....[2]

(iii) With reference to Fig. 1.1, explain why the pupil response test should not be the only method used to determine whether a driver has a blood alcohol concentration over the legal limit.

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.....[2]

(c) (i) Describe how the liver metabolises alcohol.

.....

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.....[3]

(ii) Explain **one** way in which the long-term excessive consumption of alcohol can damage the liver.

.....

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.....

.....

.....[2]

[Total: 15]

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2 Fig. 2.1 is a micrograph of a section through the wall of the colon. The structure of the wall of the colon is similar to that of the ileum.

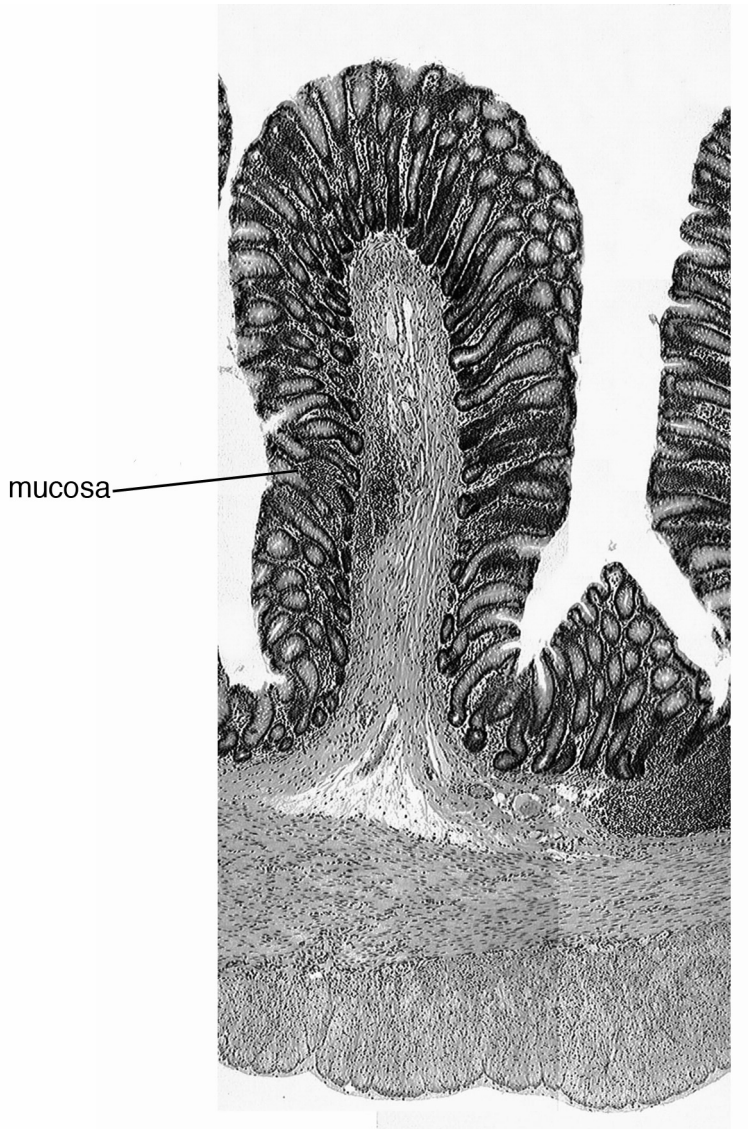


Fig. 2.1

(a) On Fig. 2.1, use a label line and the appropriate letter to identify each of these structures.

M muscles

S submucosa [2]

(b) Explain how the folding of the mucosa helps the colon to carry out its functions.

.....

.....

.....

.....[2]

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(c) Cholera is an infectious disease caused by the bacterium *Vibrio cholerae*. This bacterium binds to the epithelium of the cells in the walls of the small intestine, and causes these cells to secrete large amounts of ions, including sodium, chloride and hydrogencarbonate, into the lumen. This causes large volumes of water to move from the cells into the lumen. The resulting fluid is then passed through the colon so rapidly that most of the water is not reabsorbed. If not treated, the person may die from dehydration.

(i) Explain why the secretion of ions results in the movement of water into the lumen of the small intestine.

.....

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.....[3]

The normal concentration of plasma proteins in the blood is 7.5 g dm^{-3}. In a person with cholera, this rises to 14.2 g dm^{-3}.

(ii) Calculate the percentage difference in plasma protein concentration between a healthy person and someone who is suffering from cholera. Show your working.

.....% [2]

(iii) Using the information provided, suggest why patients with cholera have abnormally high blood concentrations of plasma proteins.

.....

.....

.....[1]

[Total: 10]

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3 The lens in the eye is made of layers of normally transparent cells which contain proteins. As a person ages, these proteins tend to denature so that the lens loses its elasticity. The proteins may also begin to clump together to form a cloudy area known as a cataract.

(a) Explain how each of these changes will affect vision.

(i) loss of elasticity of the lens

.....

.....

.....

.....[3]

(ii) formation of a cloudy area

.....

.....

.....[2]

(b) Describe how cataracts are treated.

.....

.....

.....[2]

[Total: 7]

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4 Fig. 4.1 is an enhanced computer assisted tomography (CAT) scan of part of a human vertebral column. Some of the lower thoracic vertebrae and the upper lumbar vertebrae are shown.

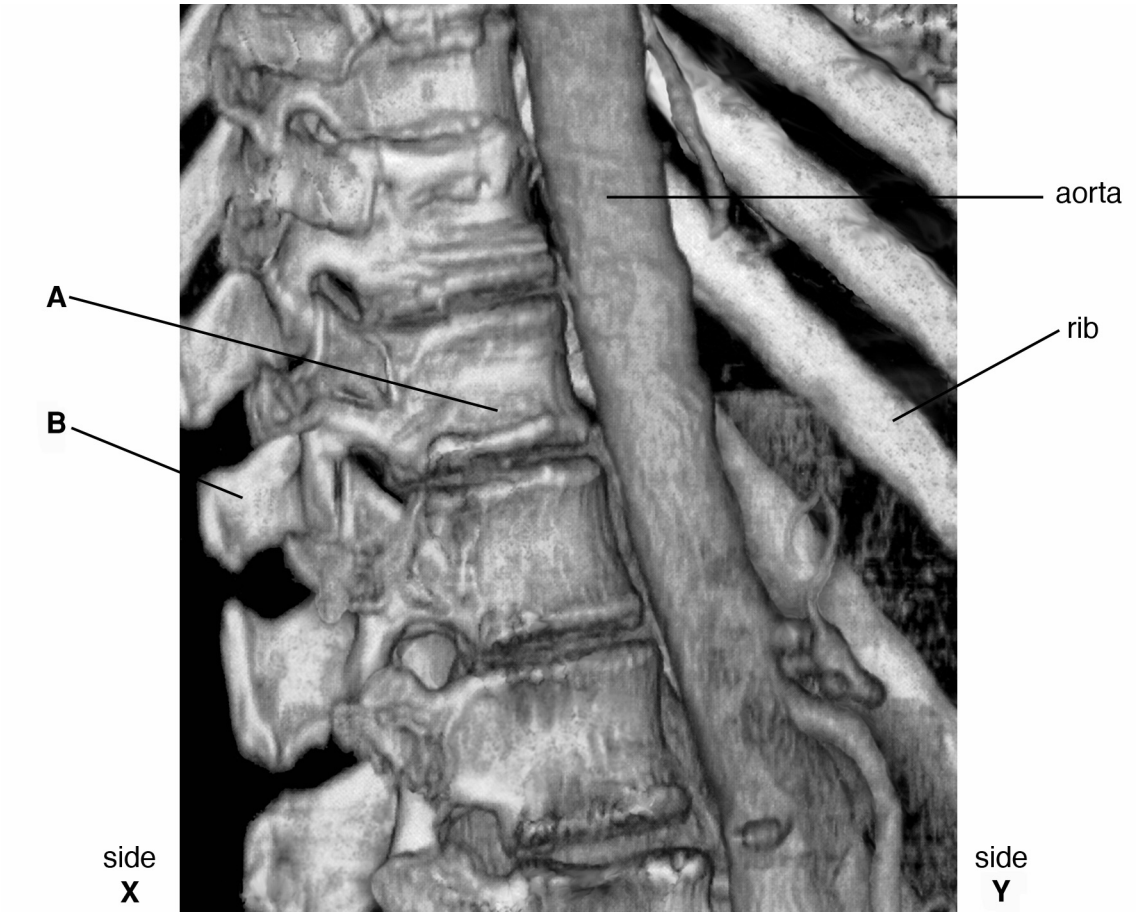


Fig. 4.1

(a) (i) Name the parts **A** and **B** of the vertebra.

A .....

B .....[1]

(ii) State which is the dorsal side of the image, side **X** or **Y**.

.....

State the reason for your decision.

.....

.....[1]

(b) Describe two differences between a thoracic vertebra and a lumbar vertebra, and explain how each of these differences relates to their functions.

1.....

explanation .....

.....

.....

2.....

explanation .....

.....

.....[4]

(c) As a person ages, osteoporosis of the spine may occur. Explain how this can lead to an elderly person losing height.

.....

.....

.....

.....[2]

[Total: 8]

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OPTION 2 – MICROBIOLOGY AND BIOTECHNOLOGY

1 The effluent from sewage treatment is routinely tested for the number of bacteria present. A serial dilution of the effluent is made and 0.1 cm^3 of each dilution plated onto a nutrient agar plate. After 24 hours, the numbers of colonies of bacteria are counted. Table 1.1 shows the results of one test on sewage effluent.

Table 1.1

dilution	undiluted	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}
number of colonies	too many colonies to count			302	55	15

(a) (i) Explain how a serial dilution is made.

.....

.....

.....

.....

.....[3]

(ii) State which of the dilutions might be used to find the number of bacteria in the effluent. Explain the reasons for your choice.

.....

.....

.....

.....[3]

(iii) Using the dilution you have chosen in **(ii)**, calculate the number of bacterial cells per cm^3 in the **undiluted** effluent from the sewage treatment. Show your working.

..... cells per cm^3 [2]

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(b) Outline how microorganisms are involved in the aerobic treatment of sewage.

.....

.....

.....

.....

.....[3]

(c) Dried solid sediment left from sewage treatment is suitable for use as fertiliser because it contains high levels of nitrate formed by microbial action during sewage treatment.

Describe how this nitrate is formed from the organic molecules present in sewage.

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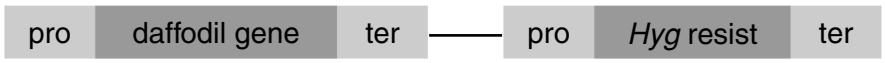
.....[4]

[Total: 15]

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2 Rice is the staple diet in many parts of the world. It lacks a number of important nutrients, including β carotene, from which vitamin A is synthesised. Adequate concentrations of vitamin A give protection from night blindness. Higher concentrations act as an antioxidant that may give some protection from cancer and heart disease.
Golden rice, which contains β carotene, was developed in Switzerland by genetically modifying rice using genes from a daffodil (a flowering plant) and a bacterium.

Fig. 2.1 shows an artificial DNA sequence used.



Key
pro – start site for polymerase enzymes
ter – end signal for polymerase enzymes
Hyg resist – antibiotic resistance gene from a bacterium

Fig. 2.1

Fig. 2.2 shows the main events in obtaining a transgenic plant.

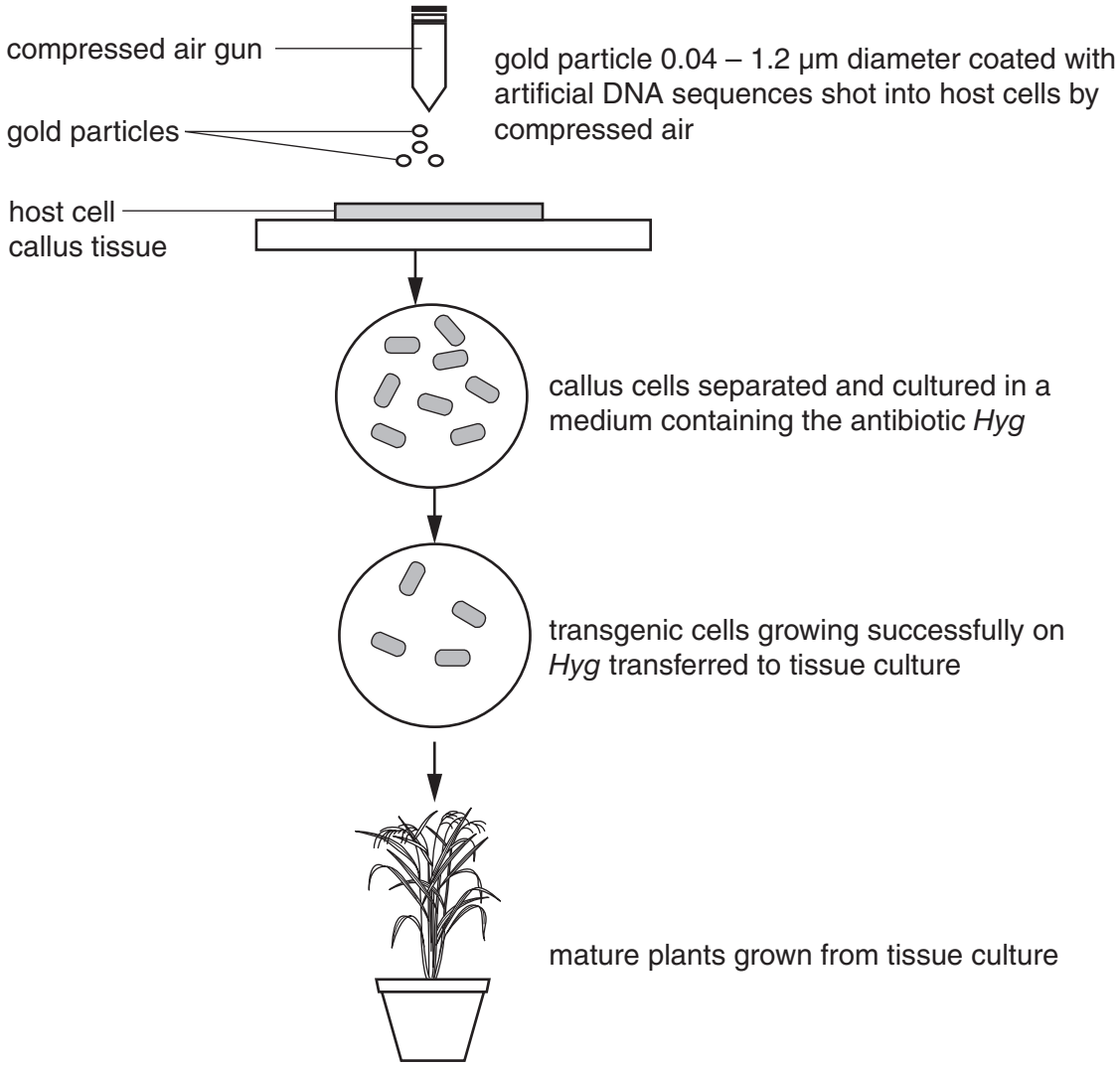


Fig. 2.2

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(a) With references to Figs. 2.1 and 2.2

(i) outline how the genes might have been isolated from the donor organisms,

.....

.....

.....

.....[2]

(ii) explain what is meant by

callus tissue .....

.....

transgenic .....

.....[2]

(iii) explain the role of the *Hyg* resistance gene in this procedure.

.....

.....

.....

.....[2]

(b) An agreement has been made between the commercial company that owns the production rights of golden rice and its developers. This allows the developers to give the rice to government-run breeding centres in rice-dependent countries. Local farmers will be able to grow the rice without paying a high fee. The commercial company will market the rice in developed countries as a 'functional food' that can improve health.

Suggest **one** reason why

(i) governments in rice-dependent countries are in favour of golden rice,

.....

.....[1]

(ii) a commercial company may be able to market golden rice as a 'functional food' in developed countries.

.....

.....[1]

[Total: 8]

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3 Fig. 3.1 shows the hybridoma technique for growing monoclonal antibodies.

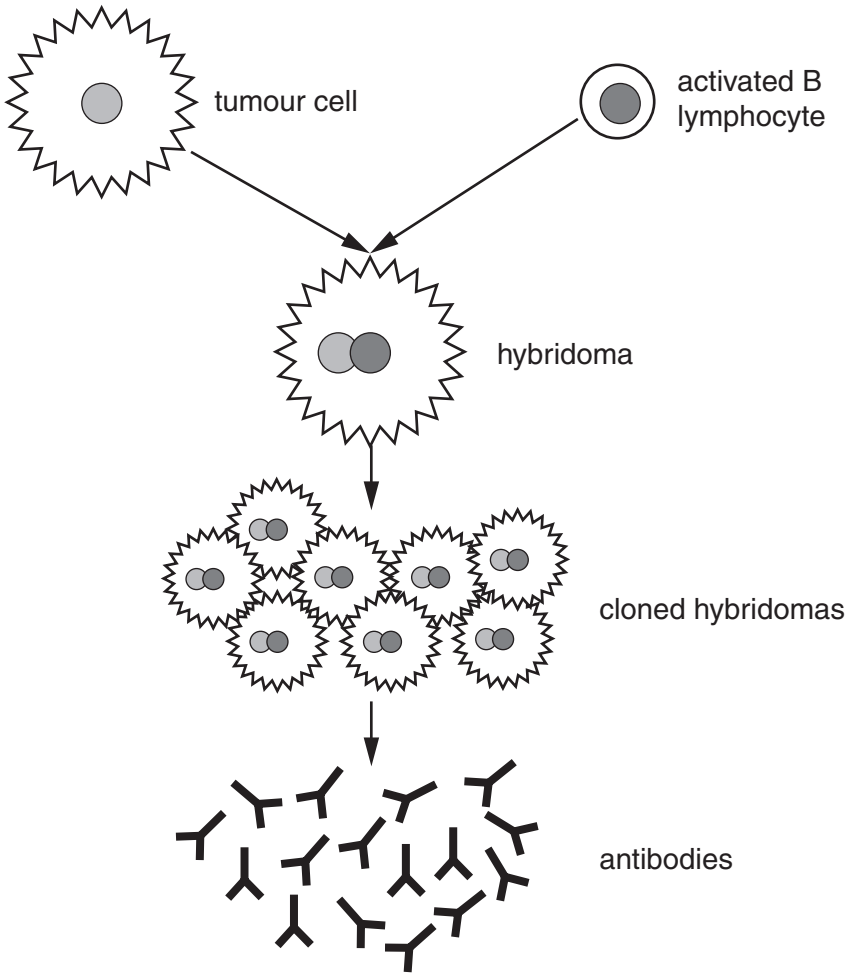


Fig. 3.1

(a) With reference to Fig. 3.1

(i) explain how activated B lymphocytes are obtained,

.....

.....

.....

.....[2]

(ii) state **one** reason why a cancer cell is used to form a hybridoma.

.....

.....[1]

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(b) 'Magic bullets' are monoclonal antibodies linked to drugs. They are used to treat some types of cancer and diseased organs.

(i) Magic bullets used to treat cancer have a cytotoxic (cell killing) drug attached. Explain why these can be used to treat cancer without harming normal body cells.

.....

.....

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.....[2]

(ii) Suggest why magic bullets carrying antibiotics are effective at lower dosage than antibiotics taken by mouth.

.....

.....[1]

(c) A random sample of individuals from an 'at risk' population was tested for HIV using indirect ELISA techniques. Serum from each test subject was added to HIV antigens bound to the surface of a glass well. A human anti-HIV antibody with an enzyme attached was then added, followed by the substrate of the enzyme. A coloured product was produced if the individual tested had HIV antibodies.
The results of the survey are shown in Fig. 3.2.

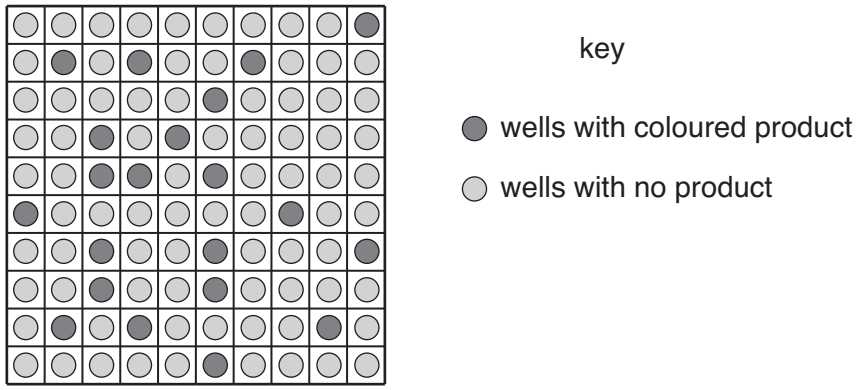


Fig. 3.2

Explain why the serum of HIV positive individuals gave a coloured product.

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.....[3]

[Total: 9]

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4 Fig. 4.1 is an electronmicrograph of a bacterium.

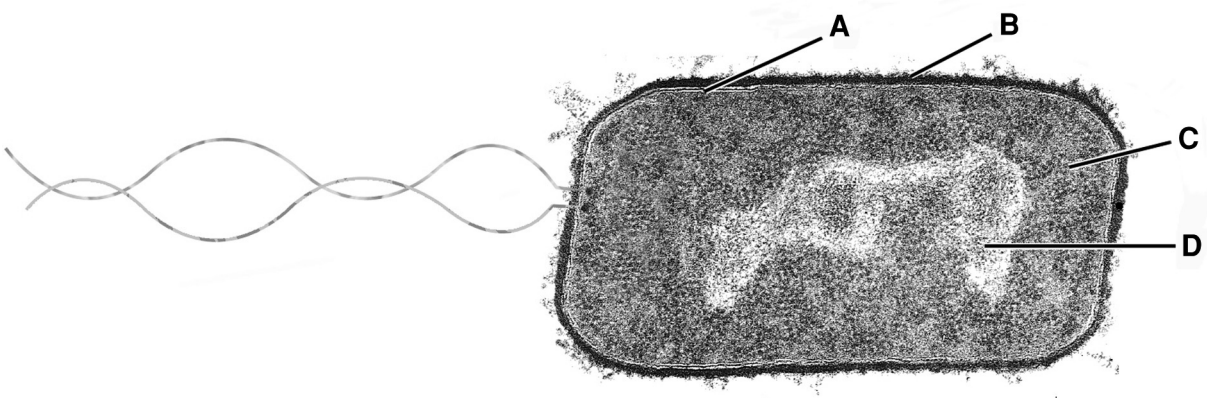


Fig. 4.1

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

A .....

B .....

C .....

D .....[2]

(b) The bacterium in Fig. 4.1 is Gram positive. Describe the differences between the wall of this bacterium and that of a Gram negative bacterium.

.....

.....

.....

.....

.....[3]

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(c) To investigate the effect of the amount of oxygen on microbial growth, 2.5×10^6 cells of the bacterium *Aerobacter aerogenes* were grown in a fermenter without oxygen. After 220 minutes air was passed through the fermenter.
Table 4.1 shows the population size at intervals during the investigation.

Table 4.1

time / min	100	130	160	190	220	250	280	310	340	370
population size / 10^6 per cm^3	14	23	40	66	78	224	436	812	1122	1148

With reference to Table 4.1, explain how the data shows that the bacterium prefers aerobic conditions.

.....[1]

(d) Fig. 4.2 is a diagram of one method by which air is supplied to an industrial fermenter.

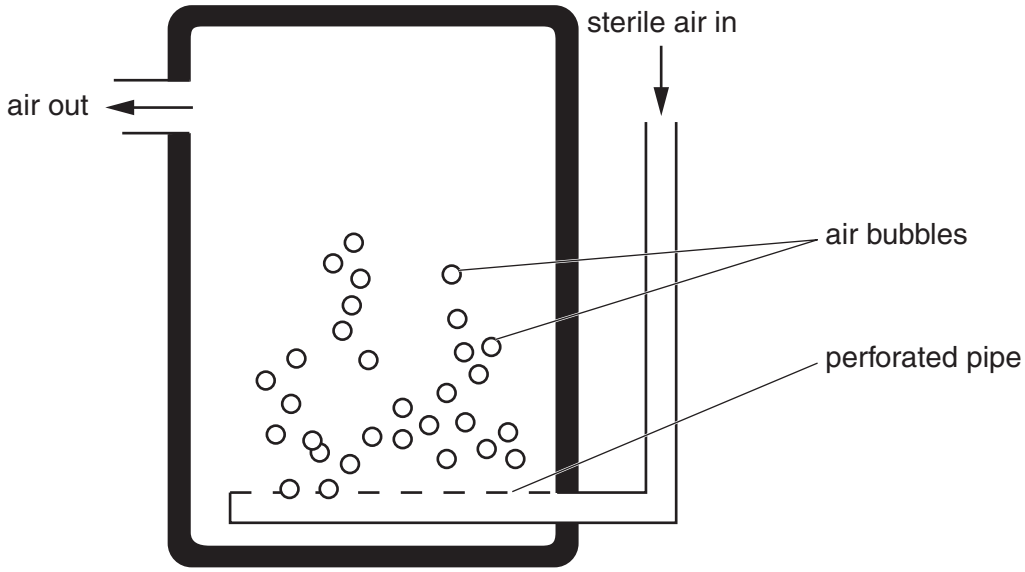


Fig. 4.2

(i) Explain why the air supply must be sterile.

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.....[1]

(ii) Explain why this fermenter does not need a stirrer.

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.....[1]

[Total: 8]

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OPTION 3 – GROWTH, DEVELOPMENT AND REPRODUCTION

1 **(a)** A single specimen of a new species of flowering plant was found living in a rainforest. Of 100 seeds collected, 40 were used to investigate the conditions required for the seeds to germinate. After three days, 90% of the seeds germinated.

These 36 newly germinated seedlings were grown in nutrient solution. All conditions were kept constant.

The fresh mass of each seedling or plant was measured at intervals and the mean fresh mass calculated. The results are shown in Table 1.1.

Table 1.1

time / days	mean fresh mass / g
0	15.0
4	13.5
8	14.7
16	17.9
22	22.7
26	25.6
30	27.5
35	27.5
40	27.3
50	23.0
60	19.0

With reference to Table 1.1

(i) describe the pattern shown,

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.....[3]

(ii) explain the change in fresh mass,

between 0 and 4 days .....

.....

.....

after 35 days .....

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.....[3]

(iii) explain why 36 seeds were used to measure the fresh mass.

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.....

.....[2]

(b) (i) State **one** disadvantage of measuring fresh mass rather than dry mass.

disadvantage .....

.....[1]

(ii) Suggest why it was decided not to measure dry mass in this case.

.....

.....

.....[2]

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(c) A different species of plant was used to investigate the effect of daylength on flowering. The plants were exposed to a series of days of different lengths. They were then grown under uniform conditions and the percentage of plants flowering was recorded. Table 1.2 shows the results.

Table 1.2

length of dark period / hours, in 24 hours	percentage of plants flowering
8	0
10	0
14	95
16	100

With reference to Table 1.2, explain how flowering is controlled in this plant.

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.....[4]

[Total: 15]

2 **(a)** Outline the roles of the hypothalamus and pituitary gland in human growth and development.

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.....[3]

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(b) Fig. 2.1 shows the growth patterns for two girls with the same height at birth living in two different countries.

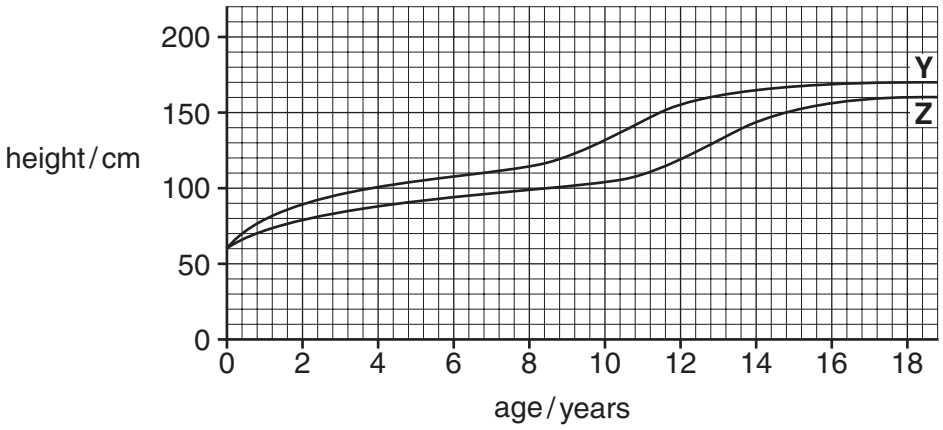


Fig. 2.1

With reference to Fig. 2.1

(i) describe the differences in the growth patterns shown for girls **Y** and **Z**,

.....

.....

.....

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.....[3]

(ii) explain the differences in the growth patterns.

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.....[3]

[Total: 9]

3 **(a)** Fig. 3.1 shows a diagram of the male urinogenital system.

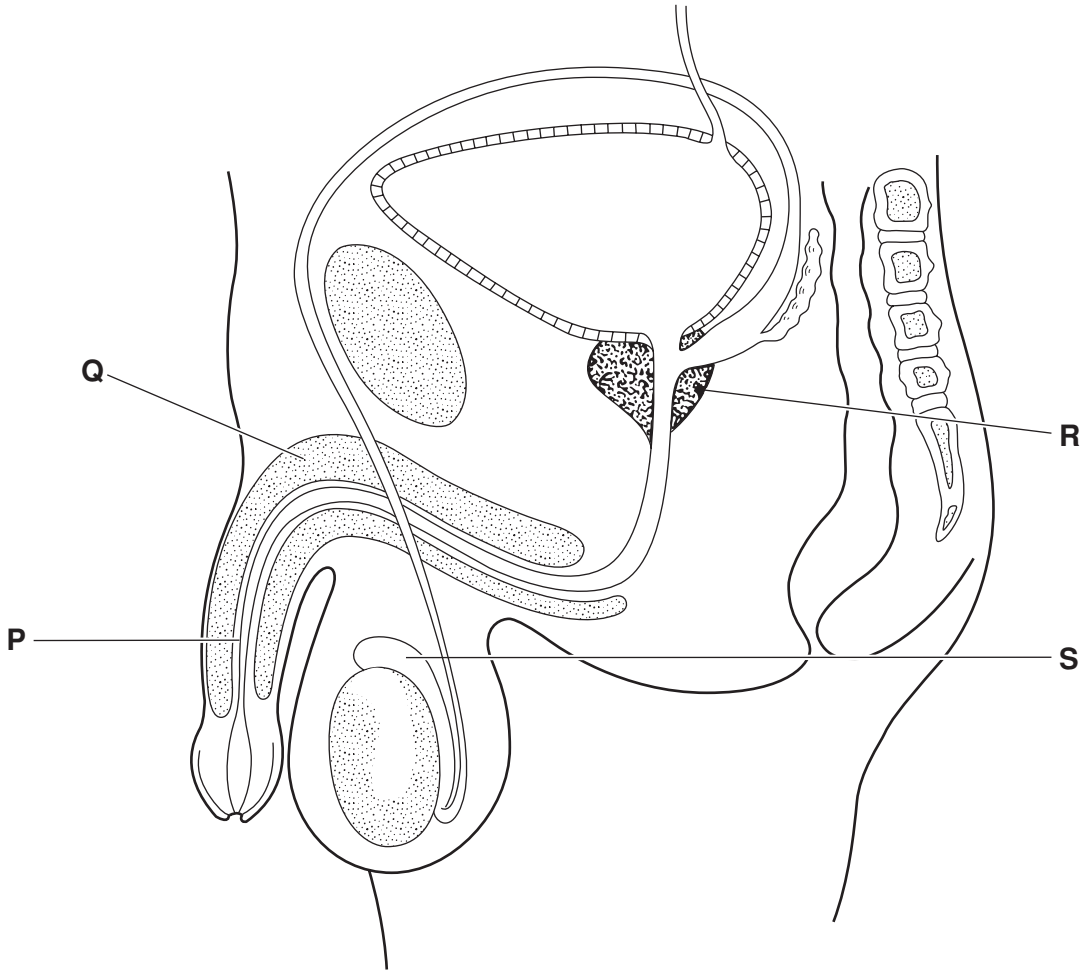


Fig. 3.1

Name **P** to **S**.

P .....

Q .....

R .....

S ..... [2]

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(b) Concern is being expressed world wide about the fall in sperm production.
Fig. 3.2 shows the number of sperm produced per cm^3 in humans from 1973 to 1993.

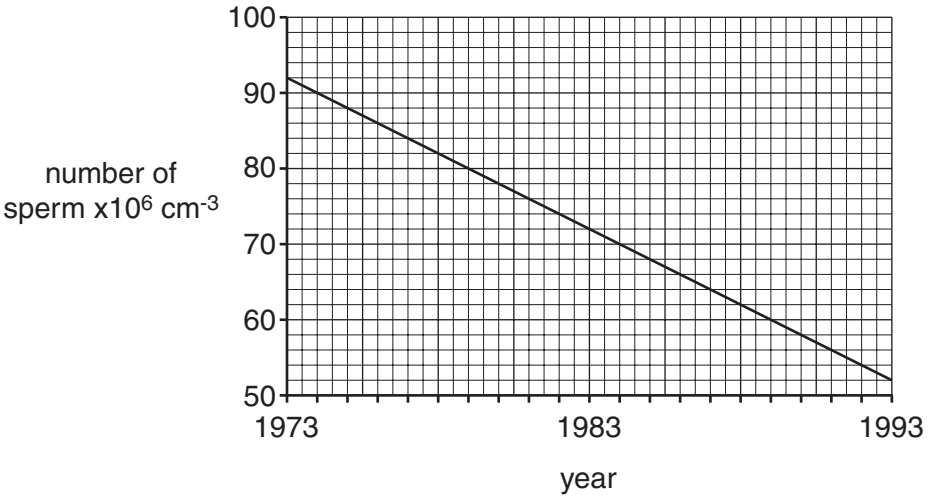


Fig. 3.2

(i) Calculate the percentage decrease in sperm production over the 20 years.
Show your working.

.....% [2]

(ii) Suggest how the changes in oestrogen concentration in drinking water may explain the fall in sperm production.

.....

.....

.....[1]

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[Turn over

(c) Describe four differences between spermatogenesis and oogenesis in humans.

spermatogenesis	oogenesis

[4]

[Total: 9]

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4 **(a)** Fig. 4.1 is a photograph of a leaf of a plant, commonly grown as an ornamental plant.

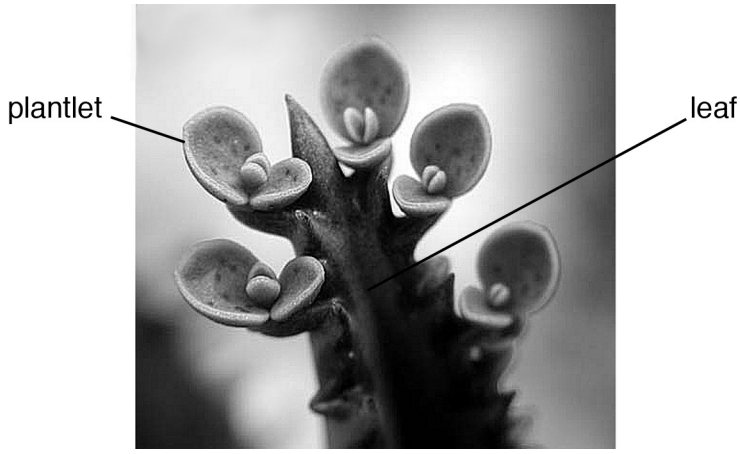


Fig. 4.1

(i) Name the type of reproduction shown in Fig. 4.1.

.....[1]

(ii) Explain why this type of reproduction is of commercial importance.

.....

.....

.....

.....[2]

(b) One plantlet had purple and green colouring on the leaves. This change was found to be caused by a single gene mutation, resulting in a changed enzyme.

(i) Outline how a gene mutation may result in the production of a new enzyme.

.....

.....

.....

.....

.....[3]

(ii) Suggest how this mutation could affect the growth of the plant.

.....

.....[1]

[Total: 7]

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OPTION 4 – APPLICATIONS OF GENETICS

1 **(a)** Describe briefly the inheritance of cystic fibrosis.

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.....[4]

(b) In Europe, the commonest mutation of the cystic fibrosis transmembrane conductance regulator (CFTR) gene is ΔF508. Deletion of three base pairs results in the loss of one amino acid, phenylalanine, in the CFTR protein.

In genetic screening for this mutation, a fragment of DNA including the site of the deletion is cut out of the gene.

The fragment is 100 base pairs (bp) long when cut out of the normal allele and 97 bp long when cut from the mutant allele. The different fragments are separated by gel electrophoresis.

The results of genetic screening for ΔF508 of three individuals, **A**, **B** and **C**, are shown in Fig. 1.1.

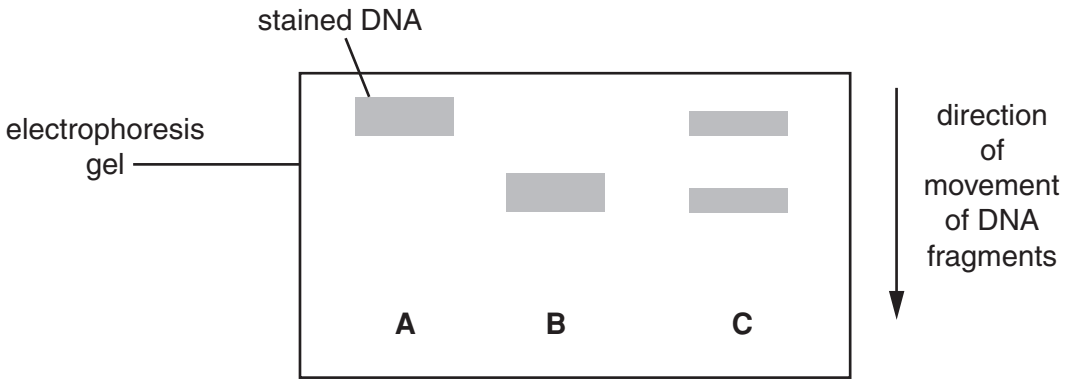


Fig. 1.1

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(i) Describe how DNA fragments are separated in gel electrophoresis.

.....

.....

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.....

.....[3]

(ii) Identify the position of a 97 bp fragment on Fig. 1.1 by means of a labelled arrow. [1]

(iii) Explain the result obtained from individual **C**.

.....

.....

.....[2]

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[Turn over

(c) CFTR with the ΔF508 mutation **does not** become part of plasma (cell surface) membranes.

A second mutation of CFTR, called R117H, results in the replacement of an arginine amino acid by histidine. CFTR with this mutation **does** become part of plasma membranes.

Sweat gland cells were taken from three sets of volunteers:

- homozygous for the normal CFTR allele;
- heterozygous ΔF508 and R117H;
- homozygous for the ΔF508 mutation.

The conductance of hydrogencarbonate ions (HCO_3^-) and chloride ions (Cl^-) across the plasma membranes was measured. The results are shown in Fig. 1.2.

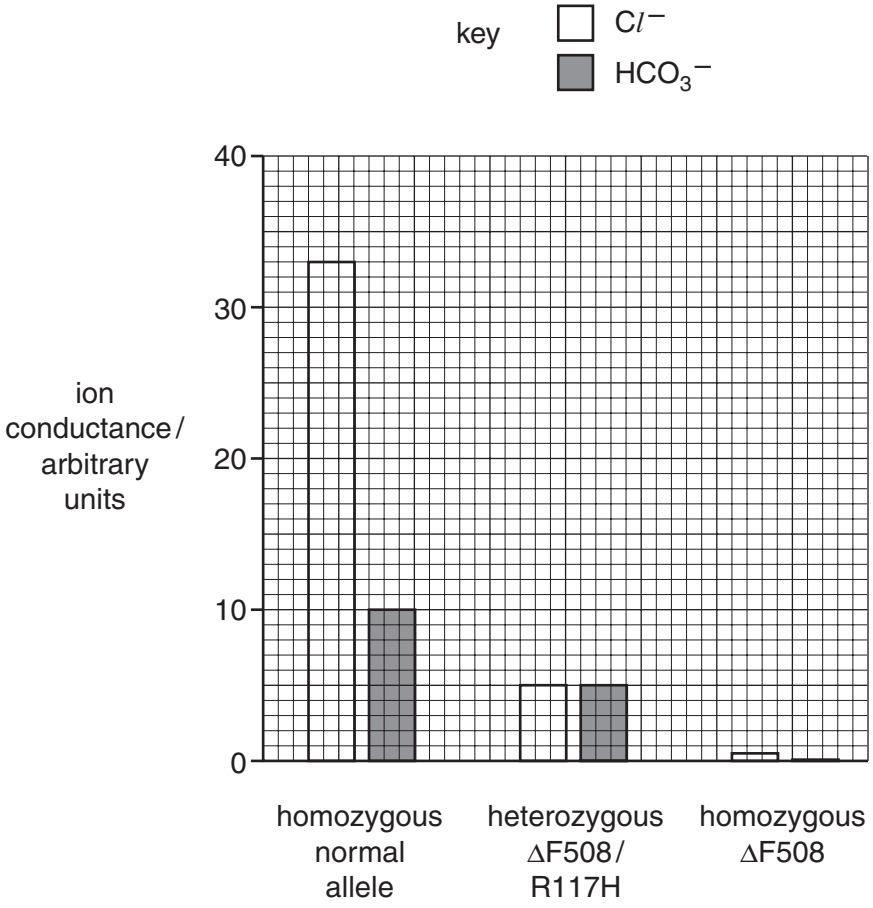


Fig. 1.2

(i) With reference to Fig. 1.2 and the information given in the question, explain the different effects of the two CFTR mutations on ion conductance.

.....

.....

.....

.....[3]

(ii) Calculate the percentage reduction in chloride ion (Cl^-) transport by cells from heterozygous volunteers, in comparison with cells from volunteers homozygous for the normal CFTR allele. Show your working.

.....% [2]

[Total: 15]

2 **(a)** Warfarin is an anticoagulant. It is widely prescribed to prevent blood clots in humans and is also used as a rat poison. Both humans and rats may be resistant to the action of warfarin.

Susceptible and resistant individuals have different alleles of a gene coding for an enzyme involved in the production of vitamin K. This enzyme, VKOR, is found in the membranes of the rough endoplasmic reticulum.

Cell contents from a susceptible individual were centrifuged. Samples of the layer containing fragments of the rough endoplasmic reticulum were incubated with equal concentrations of substrate and different concentrations of warfarin. The amount of vitamin K produced in the presence of different concentrations of warfarin is shown in Fig. 2.1.

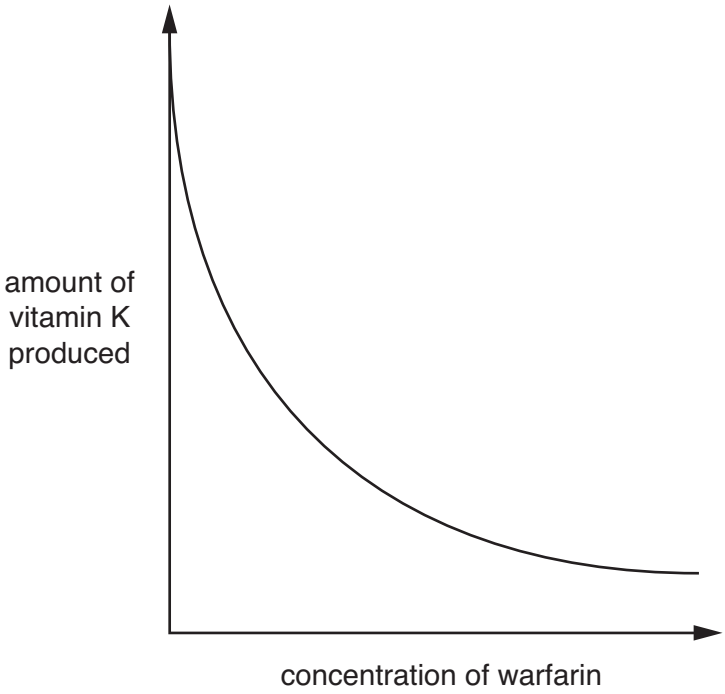


Fig. 2.1

(i) Draw onto Fig. 2.1 a line showing the activity of VKOR from an individual **resistant** to warfarin. Label the line **R**. [1]

(ii) Suggest how warfarin acts as an anticoagulant in susceptible individuals.

.....

.....

.....[2]

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(b) The differences between VKOR from susceptible and resistant individuals involve **one** of its 163 amino acids.

Explain

(i) how such differences in enzyme structure occur,

.....

.....

.....

.....[3]

(ii) how a change of a single amino acid of VKOR can result in resistance to warfarin.

.....

.....

.....

.....

.....

.....

.....[4]

[Total: 10]

3 **(a)** Some alleles are lethal when homozygous causing the organism to die.

In the plant, *Antirrhinum*, two genes, **A**/**a** and **B**/**b** affect leaf colour.

- The dominant allele, **A**, codes for yellow leaves and is **lethal** when homozygous.
- The recessive allele, **a**, codes for green leaves.
- The dominant allele, **B**, codes for chlorophyll production, giving green leaves.
- The recessive allele, **b**, results in white leaves and is **lethal** when homozygous.

- When **both** alleles **A** and **B** are present, the leaves are yellow.

(i) Suggest why plants with the homozygous genotypes **AA--** and **--bb** die.

.....

.....

.....[2]

(ii) A plant with the genotype **AaBb** was self-pollinated.

List the genotypes and phenotypes of the **viable** offspring.

genotypes of viable offspring	phenotypes of viable offspring

[2]

(b) Genes **A**/**a** and **B**/**b** are linked on the same pair of homologous chromosomes, as shown in Fig. 3.1.

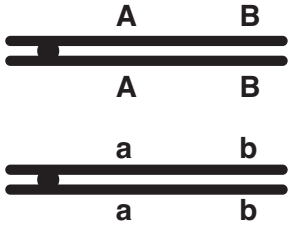


Fig. 3.1

With reference to Fig. 3.1

(i) draw a diagram to show the effect of crossing-over between the homologous chromosomes,

[2]

(ii) state the effect of linkage and crossing-over on the proportions of gametes with different genotypes that are produced.

.....

.....

.....[2]

[Total: 8]

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4 The wild tomato, *Lycopersicon cheesmanii*, of the Galapagos Islands has black fruit.

This colour has been selectively bred into a commercial variety of tomato, *L. esculentum*, to produce a large, sweet, black tomato, known as a kumato.

Two steps of the selective breeding programme are shown in Fig. 4.1.

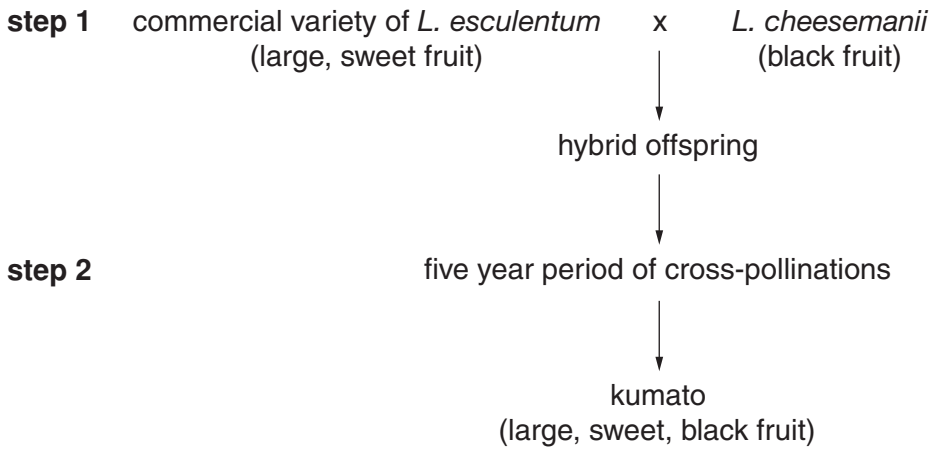


Fig. 4.1

With reference to Fig. 4.1

(a) describe the precautions the plant breeder would have taken to make sure that the hybrid offspring in **step 1** resulted from the cross shown,

.....

.....

.....

.....

.....[3]

(b) explain why, in **step 2**, cross-pollinations need to be carried out for a period as long as five years.

.....

.....

.....

.....

.....

.....[4]

[Total: 7]

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Option 3 Question 4 Fig. 4.1 © www.TopTropicals.com

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