OCR

Friday 20 June 2014 – Morning

A2 GCE BIOLOGY

F215/01 Control, Genomes and Environment

Candidates answer on the Question Paper.

OCR supplied materials:
Insert (inserted)

Other materials required:
- Electronic calculator
- Ruler (cm/mm)

Duration: 2 hours

F215 01

Candidate forename		Candidate surname	

Centre number						Candidate number				

INSTRUCTIONS TO CANDIDATES

- The Insert will be found inside this document.
- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answer to each question in the space provided. If additional space is required, you should use the lined pages at the end of this booklet. The question number(s) must be clearly shown.
- Do **not** write in the bar codes.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **100**.
- Where you see this icon you will be awarded marks for the quality of written communication in your answer.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.
- This document consists of **32** pages. Any blank pages are indicated.

Answer **all** the questions.

1 In 1958, scientists made a breakthrough in artificial reproductive cloning by successfully cloning a vertebrate species. The species cloned was the African clawed frog, *Xenopus laevis*.

Fig. 1.1, **on page 2 of the insert**, shows the cloned offspring produced, labelled **D**, as well as the three adult frogs (**A**, **B** and **C**) that were used to create them.

- frog **A**, a brown-coloured female frog, laid eggs, which then had their nuclei removed.
- frog **B**, an albino (white-coloured) female, laid eggs that were fertilised by sperm from **C**.
- frog **C**, an albino male, produced sperm that fertilised the eggs of **B**.

One of the fertilised eggs from **B** was allowed to divide. Nuclei were extracted from the resulting cells and placed into the eggs from frog **A**. These eggs developed into the frogs labelled **D** in Fig. 1.1.

(a) (i) The frogs in Fig. 1.1 show discontinuous variation in colour.

Using your knowledge of discontinuous and continuous variation, and the information given, suggest:

one other phenotypic characteristic in which the frogs show a discontinuous pattern of variation

.....

one phenotypic characteristic in which they show a continuous pattern of variation.

..... **[2]**

(ii) State the extent to which the environment is likely to affect each of the phenotypic characteristics that you have suggested in **(i)**.

.....

.....

.....

.....

.....

..... **[2]**

(iii) Suggest why albino frogs were used to produce the nuclei for transfer.

.....

.....

.....

.....

.....

..... **[2]**

Question 1(b) begins on page 4

(b) Samples of DNA were taken from frogs **A**, **B**, **C** and **D**.

Electrophoresis was used to separate the different lengths of DNA after cutting.

Fig. 1.2 shows the results.

These results are known as genetic profiles. Only the genetic profile of frog **C** is identified. The remaining profiles are labelled **1** to **3**.

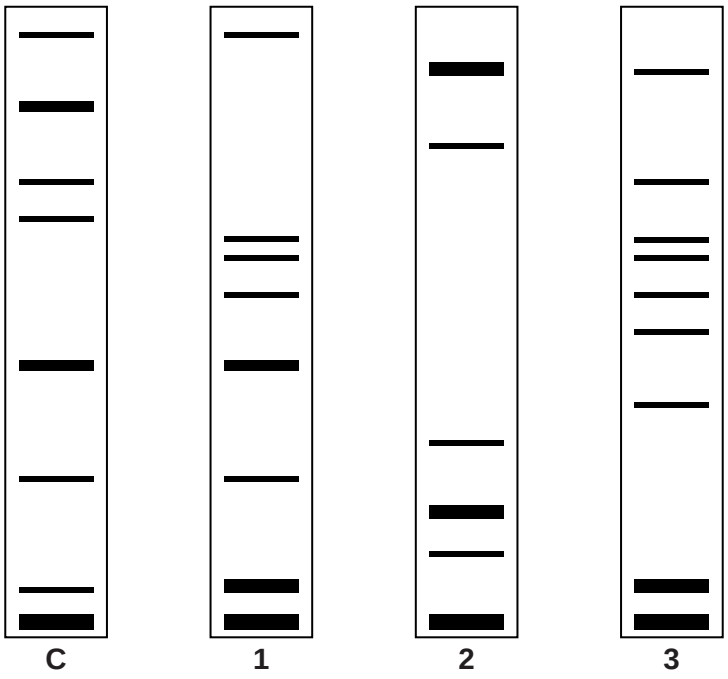

Fig. 1.2

(i) Identify which of the frogs in Fig. 1.1 gave genetic profiles corresponding to **1**, **2** and **3** in Fig. 1.2.

Write the letters **A**, **B** and **D**, as appropriate, in the table below.

Genetic profile number	Letter of frog
1	
2	
3	

[3]

(ii) Mitochondrial DNA from the frogs was sequenced.

State, giving a reason, which of the frogs **A, B** and **C** would have a mitochondrial DNA sequence identical to **D**.

.....

..... **[1]**

(c) In the 1970s, the technique used to clone the frogs was successfully adapted to clone mice from embryos. Cloned mice are used to investigate factors affecting the development and treatment of disease.

(i) State **one advantage** and **one disadvantage** of using clones to test a treatment for a disease.

advantage

.....

.....

disadvantage

.....

..... **[2]**

(ii) In the 1990s, there were further developments in cloning technology when it became possible to make a clone of an adult mammal. The first clone produced from an adult cell nucleus was Dolly the sheep.

Adult cell cloning can be used to investigate the development and treatment of disease.

Outline **two other** potential applications of adult cell cloning.

1 .....

.....

.....

2 .....

.....

.....

[2]

Question 1(d) begins on page 6

(d) Identical twins in humans are natural clones. They form when a fertilised egg cell divides by mitosis into two entirely separate groups of cells. Each group of cells develops into a baby.

Two brothers, who were identical twins, married two sisters, who were also identical twins. Each couple had one child.

Fig. 1.3 shows the relationships between these six people.

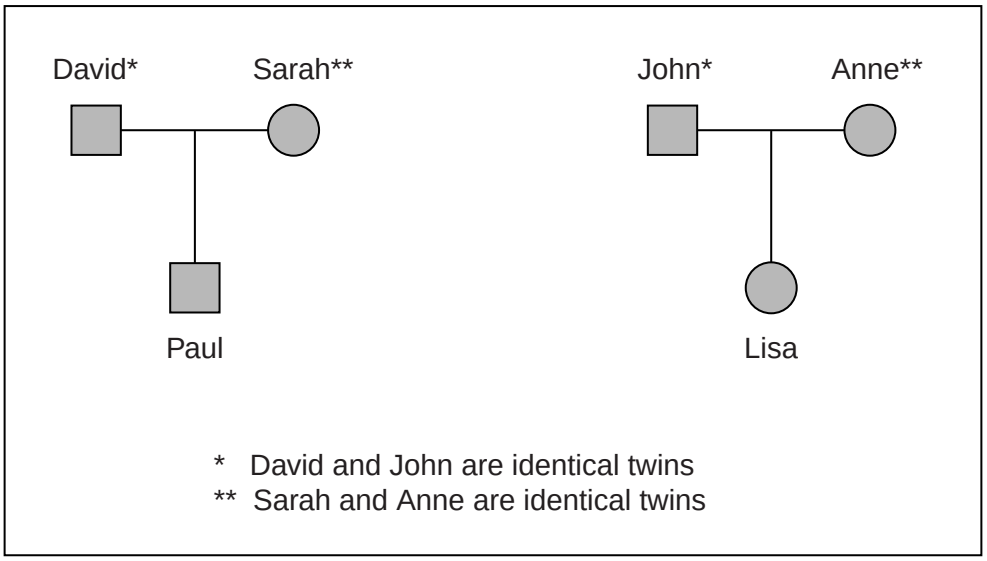

Fig. 1.3

Using your knowledge of mitosis and meiosis, estimate the percentage of alleles shared by the individuals listed in the table below.

Individuals	% of alleles shared
David and John	
Anne and Lisa	
Sarah and Lisa	

[3]

[Total: 17]

2 **(a)** *Bombus pratorum* and *Bombus terrestris* are two British species of bumble bee.

These bumble bees are social insects. They live in colonies founded by a female queen bee who lays eggs. The eggs develop into female worker bees, who collect food (nectar and pollen) and look after the young and the nest.

When the number of worker bees starts to decrease, young queens and males are produced. These mate and the mated queens survive winter underground and start a new colony the following spring.

Why do the two bee species share the first name *Bombus*?

.....

..... **[1]**

Question 2(b) begins on page 8

(b) Fig. 2.1 shows the number of worker bees of *B. pratorum* and *B. terrestris* observed at one location over a year.

Table 2.1 shows some differences in the food collecting behaviour of worker bees of these species.

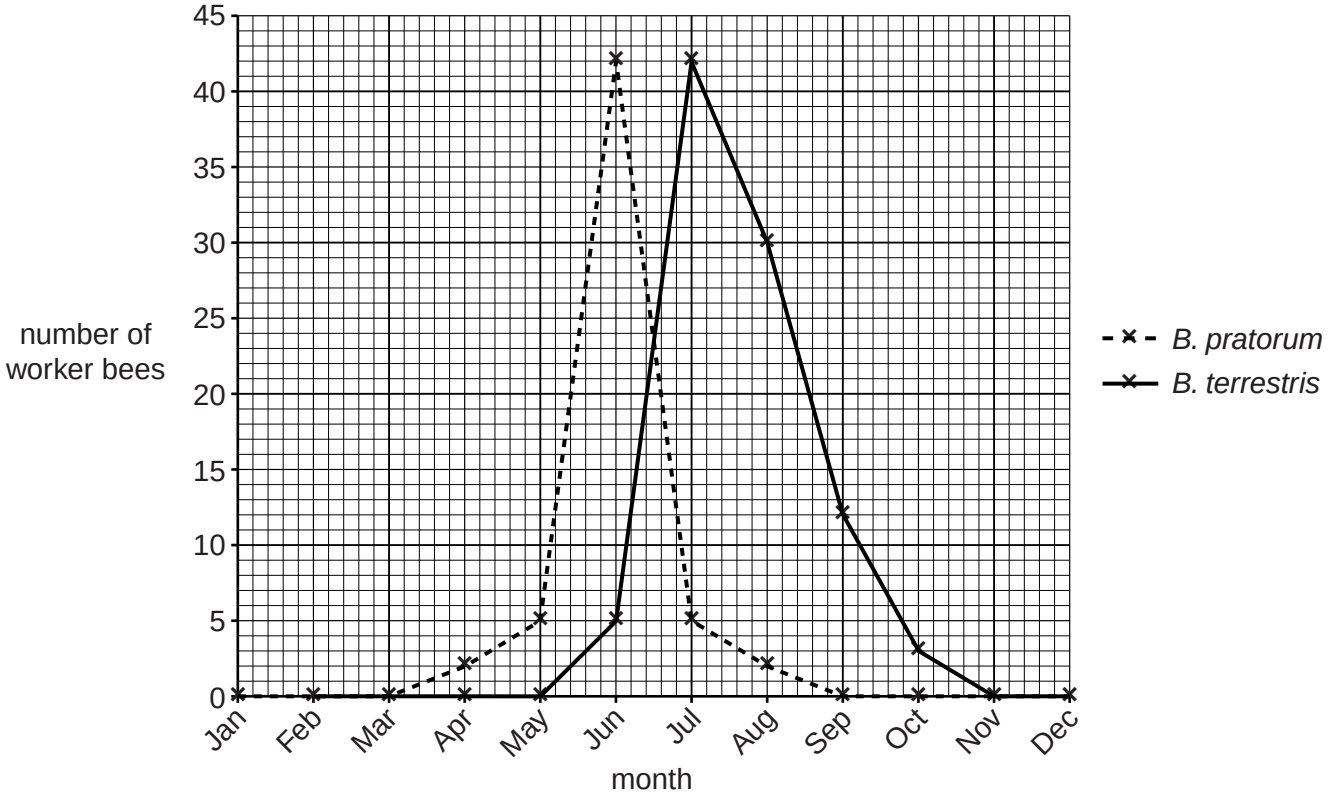

Fig. 2.1

Species of bumble bee	Mean depth of flower visited (mm)	Visits to flowers when nectar only collected (%)	Visits to flowers when pollen only collected (%)	Visits to flowers when both nectar and pollen collected (%)
Bombus pratorum	7.4	23	10	67
Bombus terrestris	6.3	80	11	9

Table 2.1

(i) *B. pratorum* and *B. terrestris* both live in Britain. They can often be found in the same location, as their geographical distributions overlap.

Use Fig. 2.1 and Table 2.1 to evaluate the extent to which the two species may compete.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[4]**

(ii) Use Fig. 2.1 and Table 2.1, and the information given on page 7, to suggest how an ancestral species might have evolved into the two species, *B. pratorum* and *B. terrestris*.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[3]**

(c) Bees show a variety of interesting behaviour patterns.

(i) Consider the following observations about bee behaviour and suggest what type of behaviour is being shown in each observation.

Observation	Type of behaviour
The time taken for a worker bee to collect food from a flower decreases with practice.	
All bumble bees start at the bottom of a vertical spike of flowers and work upwards.	

[2]

(ii) On returning to the colony, worker bees perform ‘dances’ to tell other bees the direction and distance of a food source.

How might this social behaviour benefit the colony?

.....

..... **[1]**

(d) In a colony of bees, about 5% of the workers are more adventurous than other workers. These bees are known as scout bees. They actively seek out new food sources and, if necessary, new nest sites.

Researchers investigated how gene expression differed in the brains of the scout bees compared to the normal worker bees.

- The researchers extracted mRNA from the brain cells of **normal worker** bees.
- This mRNA was used to produce lengths of single-stranded DNA, which were then attached to a fluorescent dye.
- These lengths of single-stranded DNA were used as gene probes fixed onto a device known as a 'microarray DNA chip'.
- mRNA extracted from the brain cells of **scout** bees would only bind to the gene probes that matched it, causing these probes to fluoresce.
- The locations of the brightest fluorescent spots on the DNA chip revealed which genes were most active.

(i) Name the enzyme that can be used to convert mRNA to single-stranded DNA.

..... **[1]**

(ii) Explain how the locations of the fluorescent spots on the DNA chip reveal which genes are most active.

.....

.....

.....

.....

.....

.....

.....

..... **[3]**

Question 2(d)(iii) begins on page 12

(iii) The researchers found many differences in gene activity in the scout bees compared to the normal worker bees. One of these differences in activity was in a gene used to make the neurotransmitter, dopamine.

In a follow-up experiment, scout bees became less adventurous if dopamine signalling was prevented.

Use your knowledge of the DRD4 dopamine receptor in humans to comment on the findings of this research into scout bee behaviour.

.....

.....

.....

.....

.....

.....

.....

..... **[3]**

[Total: 18]

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

Question 3 begins on page 14

3 Animals and plants respond to changes in their environment.

(a) Plants respond to changes in their environment using chemicals known as plant hormones or plant growth regulators.

A student carried out a two-part experiment to identify the contents of two unlabelled bottles, **J** and **K**. One bottle contained auxin and the other contained gibberellin.

In Part 1 of the experiment, 30 seedlings had their shoot tips removed. The 30 seedlings were then divided into three groups of 10 and treated as shown in Table 3.1 and Fig. 3.1.

Group	Treatment
1	no treatment applied
2	solution of **J** applied to cut stem at apex of seedling
3	solution of **K** applied to cut stem at apex of seedling

Table 3.1

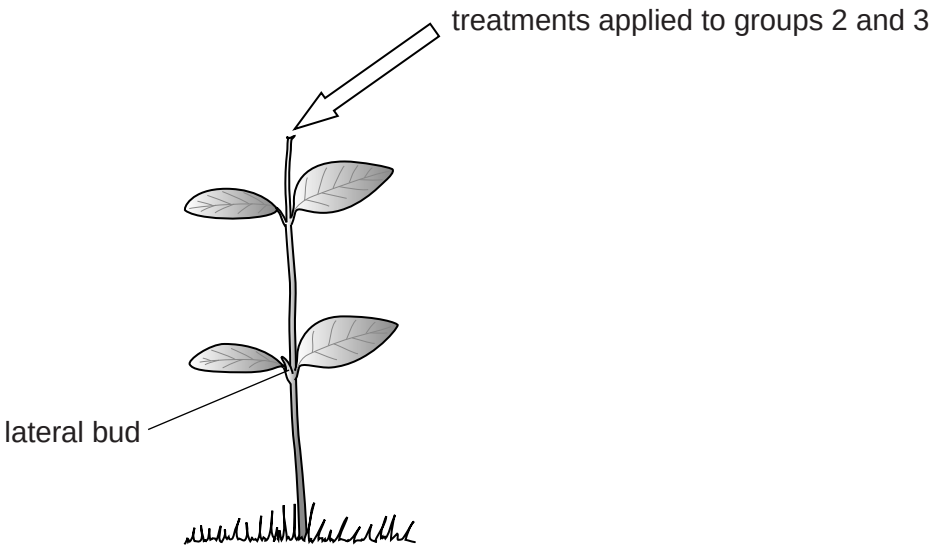

Fig. 3.1

All the seedlings were then exposed to light from **all** directions and left for seven days.

In Part 2 of the experiment, 30 coleoptiles had their tips removed. They were then divided into three groups of 10 coleoptiles and treated as shown in Table 3.2 and Fig. 3.2.

Group	Treatment
4	no treatment applied
5	solution of **J** applied to cut tip of coleoptile
6	solution of **K** applied to cut tip of coleoptile

Table 3.2

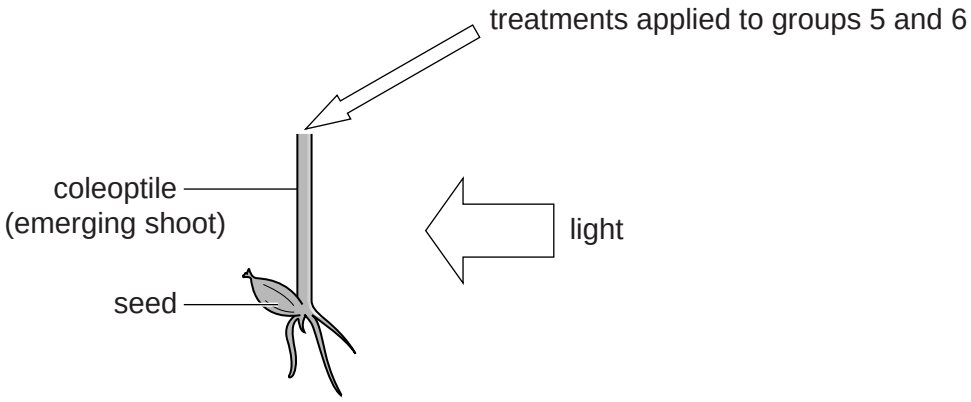

Fig. 3.2

The coleoptiles in groups **4**, **5** and **6** were then exposed to light from **one direction**, as shown in Fig. 3.2, and left to grow for two days.

(i) Identify **three** variables that must be controlled in this experiment to produce valid results.

1 .....

2 .....

3 .....

[3]

(ii) Groups **1** and **4** were controls in this experiment.

Explain why these controls were necessary.

.....

.....

.....

..... **[1]**

The observations at the end of each part of the experiment are shown in Table 3.3.

Group	Treatment	Observations
1	none	increase in stem length of 10 mm and growth of lateral buds
2	**J** on cut stem apex	no growth of lateral buds
3	**K** on cut stem apex	increase in stem length of 40 mm and growth of lateral buds
4	none	vertical growth of the coleoptiles
5	**J** on cut coleoptile tip	growth of the coleoptiles towards the light source
6	**K** on cut coleoptile tip	vertical growth of the coleoptiles

Table 3.3

(iii) Using the information from Table 3.3, identify the contents of bottles **J** and **K and** give reasons for your answer.

J .....

K .....

reasons .....

.....

.....

.....

.....

.....

.....

.....

..... **[3]**

(b) Fig. 3.3 is a diagram representing the neuromuscular junction in mammals.

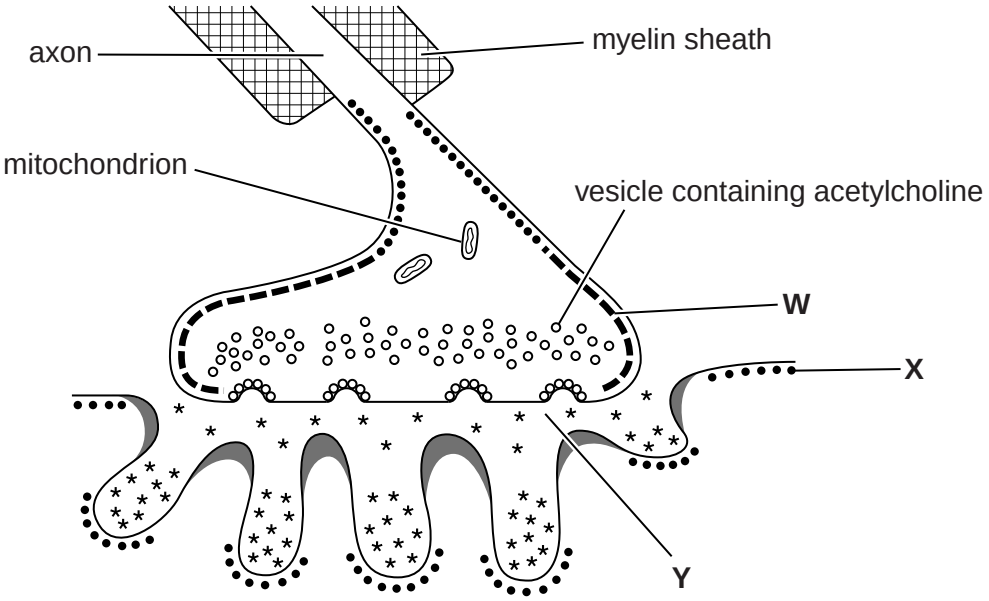

Fig. 3.3

(i) What type of molecule forms ion channels **W** and **X**?

..... **[1]**

(ii) Identify region **Y**.

..... **[1]**

(iii) Name the enzyme found in region **Y**.

..... **[1]**

Question 3(c) begins on page 18

(c) As mammalian muscle uses energy to contract, it needs an energy supply.

Complete the following passage by choosing the best term to fill each gap.

Most ATP for muscle contraction is generated by aerobic respiration in organelles called ..... . Most of this ATP is produced by the stage of aerobic respiration called ..... .

If the oxygen supply is insufficient, ATP can also be obtained from anaerobic respiration, in which pyruvate is converted to the toxic product ..... .

A third source of ATP in muscle involves the transfer of a phosphate group to ADP from a substance called ..... .

During the contraction of skeletal muscle, energy from ATP is used to break the ..... that hold the actin and ..... together. **[6]**

[Total: 16]

4 The genetic code carries instructions for the synthesis of polypeptides.

(a) (i) State the number of DNA nucleotide bases that code for a single amino acid.

..... **[1]**

(ii) There is a maximum of 64 different base combinations in DNA that could each code for an amino acid.

How is this number of combinations calculated?

.....

..... **[1]**

(iii) Twenty different amino acids are commonly used for protein synthesis. In theory, this would need only 20 different base combinations.

Explain the uses of the remaining 44 combinations.

.....

.....

.....

.....

..... **[2]**

(iv) Which nucleotide bases are common to DNA and RNA?

.....

..... **[1]**

Question 4(b) begins on page 20

(b) Describe how a nucleotide base sequence in a gene is used to synthesise a polypeptide.

In your answer you should describe the steps of the process in the correct order.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[7]**

[Total: 12]

5 A batch fermenter is used during the production of beer.

Fig. 5.1(a) and Fig. 5.1(b), **on page 3 of the insert**, show some changes that take place in the fermenter over the first 6 days.

(a) (i) Describe the pattern of growth of the yeast population in this fermenter.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[4]**

(ii) Fig. 5.1(a) shows that as the sugar concentration decreases the ethanol concentration increases.

Explain this relationship.

.....

.....

.....

.....

.....

.....

.....

..... **[3]**

(iii) Using the information from Fig. 5.1(a), explain why ethanol is considered to be a primary metabolite of yeast.

.....

.....

..... **[1]**

(iv) Using only the information from Fig. 5.1(a) and Fig. 5.1(b), outline how **two** factors may limit the maximum size of the yeast population.

1 .....

.....

.....

2 .....

.....

.....

[2]

(b) A mixture of three sugars is added to the batch fermenter at the beginning of the process:

- the monosaccharide glucose, which the yeast uses up first, during days 0 to 2
- the disaccharide maltose, which is used during days 1 to 5
- the trisaccharide maltotriose, which is used during days 4 to 6.

Suggest why the yeast uses the sugars in this order.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[3]**

Question 5(c) begins on page 24

(c) Ethanol is an important chemical that is manufactured on a large scale.

One large-scale process to produce ethanol uses biotechnology, with yeast acting on sugar in a fermenter.

Another large-scale process uses a chemical method instead of microorganisms. This method needs:

- ethene (obtained from oil)
- a high temperature of 300 °C
- high pressure steam.

Discuss the advantages and disadvantages of **using yeast** to make ethanol rather than using the chemical method.

In your answer you should give a balanced account of both the advantages and disadvantages.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[6]**

[Total: 19]

6 **(a)** Fig. 6.1 shows a number of examples of inheritance.

A	An *Antirrhinum* plant with red flowers is crossed with one that has white flowers. All the offspring have pink flowers.
B	A haemophiliac man has children with a woman who is not a haemophiliac. Their daughters all carry the allele for the disease, but their sons do not have the disease.
C	Two *Salvia* plants with purple flowers are crossed. The offspring are produced in the ratio 9 purple-flowered : 3 pink-flowered : 4 white-flowered.
D	A short-haired black mouse crossed with a long-haired brown mouse produces all short-haired black offspring. Mating one of these offspring with the long-haired parent produces mice in the ratio of 1 short-haired black : 1 long-haired black : 1 short-haired brown : 1 long-haired brown.
E	Two snails with plain shells produce 34 offspring with plain shells and 12 with striped shells.

Fig. 6.1

Complete the table below, by matching each of the examples **A** to **E** to the correct explanation of their pattern of inheritance.

Explanation	Letter of example
One gene with two alleles. The alleles show codominance.	
One gene with two alleles located on an autosome (gene not sex linked). One allele is dominant and the other is recessive.	
Two genes for two different characteristics on two different chromosomes.	
A sex linked gene with a dominant and a recessive allele.	
Epistasis, where two genes interact to affect one phenotypic character.	

[5]

(b) The Hardy-Weinberg principle, represented by the equations below, can be used to estimate the frequency of alleles in a population.

$$p^2 + 2pq + q^2 = 1$$

$$p + q = 1$$

Albino rabbits have white fur as these individuals are unable to produce the pigment melanin. The ability to produce melanin is controlled by a gene with a dominant allele (B), resulting in brown fur, and a recessive allele (b), resulting in an albino.

Of the 60 rabbits in a pet shop, 45 are brown.

(i) A student decided to use the Hardy-Weinberg principle to estimate the frequencies of the alleles in this group of rabbits.

Using the Hardy-Weinberg equations, calculate the frequency of the dominant allele in this group.

Show your working.

Frequency of the dominant allele = ... **[3]**

(ii) Give **two** reasons why it was not appropriate to use the Hardy-Weinberg principle to estimate the frequencies of alleles in this group of rabbits in the pet shop.

1 .....

.....

.....

2 .....

.....

.....

[2]

[Total: 10]

7 Describe the differences between the following biological terms:

(a) a pioneer community and a climax community

.....

.....

.....

.....

..... **[2]**

(b) decomposition and denitrification

.....

.....

.....

.....

..... **[2]**

(c) conservation and preservation

.....

.....

.....

.....

..... **[2]**

(d) nitrogen fixation and nitrification.

.....

.....

.....

.....

..... **[2]**

[Total: 8]

END OF QUESTION PAPER

ADDITIONAL ANSWER SPACE

If additional answer space is required, you should use the following lined page(s). The question number(s) must be clearly shown in the margins.

BLANK PAGE

PLEASE DO NOT WRITE ON THIS PAGE

PLEASE DO NOT WRITE ON THIS PAGE