Gold Paper

Question Paper 6

Level	A Level
Subject	Biology
Exam Board	OCR
Paper	Gold Paper
Booklet	Question Paper 6

Time allowed: **84 minutes**

Score: **/62**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>69%	56%	50%	42%	34%	26%

This question is about genetic control and selective breeding.

(a) Fill the gaps in the following passage using the most appropriate term: **[3]**

Much of the ..... in cells contains sequences called genes. Many genes code for ..... that fold to make enzymes. Often, enzymes are kept in an inactive form until needed. These enzymes may then be activated by cAMP, which involves changes in their ..... .

(b) Control is also achieved by genes switching on and off. There is a highly conserved set of genes called homeobox genes that control the development of body plans.

(i) Name **all** the **kingdoms** of living organisms that use homeobox genes to control the development of body plans.

[1]

Fig. 2.1 shows a human embryo during the second month of development.

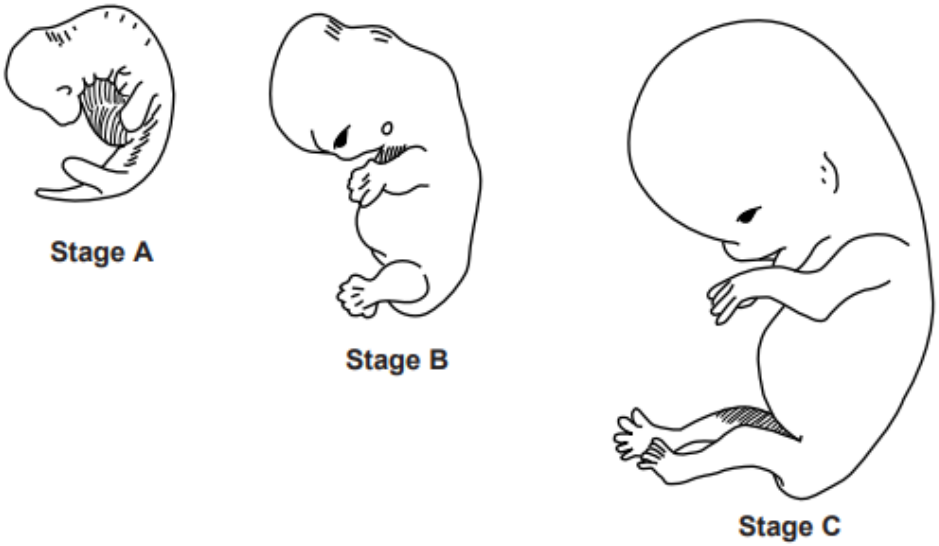

Fig. 2.1

(ii) How can the control of development by homeobox genes be seen in **Stage A** in Fig. 2.1?

[1]

(iii) Describe how the process of apoptosis can be seen between **Stages A** and **B**, and between **Stages B** and **C**, in Fig. 2.1.

[2]

Stages A to **B**

Stages B to **C**

(c) Different forms of genes (alleles) control cells in different ways. In mice, the allele for grey colour is dominant to the allele for black. Black mice are unusual in the wild. Natural selection favours grey as the mice are better camouflaged.

Starting with a supply of grey mice, explain how **artificial** selection could be used to breed a population of grey mice whose offspring were always grey.

In your answer, you should provide a logical explanation of the sequence of steps.

[5]

[Total: 12]

Question 2

Bread contains a mixture of polypeptides known as gluten.

Gluten consists of two types of polypeptide: gliadins and glutenins.

(a) (i) The table below contains statements about the structures of gluten polypeptides.

In the boxes next to each statement, write the level of protein structure (primary, secondary, tertiary, or quaternary) to which the statement refers.

Statement	Level of protein structure
Short α-helical sections are present in both polypeptides because of their high proline content	
Intermolecular bonds form between glutenin and gliadin polypeptides	
Up to 45% of the amino acids in gliadins are glutamine	
Hydrophobic amino acids such as glutamine and proline are not found on the surface of gluten proteins	

[2]

(ii) Coeliac disease is caused by an immune reaction to gliadins in a person's digestive system. The immune system produces antibodies that bind to part of the gliadin polypeptides, which causes inflammation.

Some people who stop eating foods that contain gluten still occasionally experience the symptoms of coeliac disease.

What can you conclude about:

- the structure of the antibody that causes coeliac disease; and
- what the antibody binds to when producing the symptoms of coeliac disease?

[2]

(b) Gluten helps to trap carbon dioxide within bread dough. This enables bread to rise when it is baked.

The carbon dioxide is produced by baker's yeast, *Saccharomyces cerevisiae*. This species of yeast is able to convert ethanol to acetyl CoA at low glucose concentrations.

Fig. 2 shows the oxygen consumption and carbon dioxide production of a population of *S. cerevisiae* grown in batch culture. The population was provided with glucose as their only initial source of carbon.

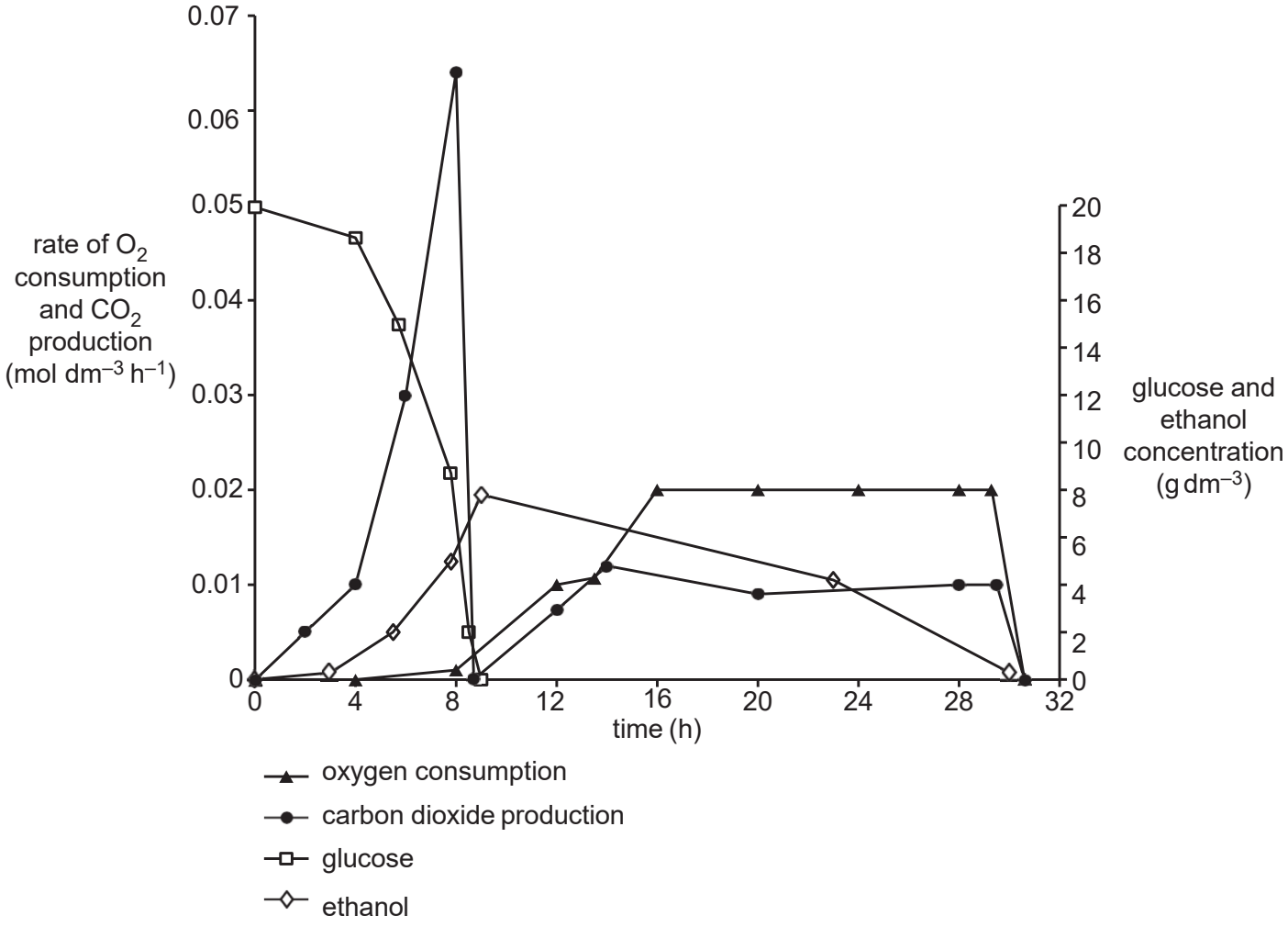

Fig. 2

(i) Suggest and explain what conclusions can be drawn from Fig. 2 about the factors that affected the rate and type of respiration carried out by *S. cerevisiae* in this batch culture.

[3]

(ii) Describe **two** practical considerations to ensure the *S. cerevisiae* population grows successfully when the initial culture is established.

. **[2]**

(iii) Scientists wanted to estimate the number of yeast cells in a 25 cm^3 solution of *S. cerevisiae*. They carried out the following two dilutions:

- 1 cm^3 of the original solution was mixed with 9 cm^3 of nutrient solution to make solution 2.
- 1 cm^3 of solution 2 was mixed with 9 cm^3 of nutrient solution to make solution 3.

The scientists transferred 0.1 cm^3 of solution 3 onto an agar plate. 15 separate colonies grew on the plate.

Calculate the number of yeast cells in the original 25 cm^3 solution.

Express your answer in standard form to **three** significant figures. Show your working.

. **[2]**

(iv) A group of students were designing an experiment to investigate the effect of temperature on the respiration rate of *S. cerevisiae*.

Their planned method included the following:

- *S. cerevisiae* yeast suspension will be divided into six equal volumes to form the experimental groups.
- Six temperatures will be tested: 15 °C, 20 °C, 25 °C, 30 °C, 35 °C and 40 °C.
- Beakers of *S. cerevisiae* will be placed in water baths to control the temperature.
- Respiration rate will be measured by using a pH probe to monitor changes in the pH of the suspensions.
- The experiment will be repeated four times.

Evaluate whether the students' method is likely to produce **valid** results. [3]

(v) The students used a Student's *t*-test to compare the results at 30 °C and 35 °C.

They calculated a *t* value of 2.200.

The critical value for $p = 0.05$ is 2.306.

Assuming their final method was valid, what can the students conclude from the result of the *t*-test?

[1]

[Total: 15]

Botulism is a condition resulting from the action of botulinum toxin. The main symptom of botulism is skeletal muscle weakness, which can be fatal.

(a) **(i)** Botulinum toxin is produced by the anaerobic bacterium *Clostridium botulinum*. What information does the word 'anaerobic' suggest about the bacterium?

[1]

(ii) The toxin is initially produced as a large single polypeptide that has low potency. After the toxin has been acted upon by a protease, two chains are produced which remain connected by a disulfide bond. In this form it is far more toxic.

Describe the action of the protease when it acts on the toxin.

[1]

(b) A mouse assay, using 99 mice, was used to determine the median lethal dose of the toxin.

(i) Suggest what is meant by the term *median lethal dose*. **[1]**

(ii) The median lethal dose of the toxin is in the range of 5 – 50 ng kg^{-1} body mass, depending on the toxin type and the method of introduction into the body.

Calculate the probable lethal dose of the **least toxic** botulinum toxin for an individual with a body mass of 85 kg.

Give your answer in μg.

[2]

(iii) The toxin acts primarily at the cholinergic nerve terminals of stimulatory motor neurones. Part of the molecule binds irreversibly to specific receptors on the presynaptic membrane. The toxin–receptor complex is then taken into the cytoplasm of the neurone where the disulfide bond is broken, releasing the section of the molecule which acts to block the release of the neurotransmitter.

Explain why botulism can be fatal. **[2]**

(c)* There are a number of different strains of the *Clostridium botulinum* bacterium. Different strains produce immunologically distinct forms of the toxin.

Explain why the toxins produced by the different strains are described as being 'immunologically distinct' and how they will be dealt with by the immune system. **[6]**

[Total: 13]

This question looks at two ways of using mathematical concepts in Biology.

(a) When a new road system was constructed, it split a population of a rare snail species into three smaller populations, **A**, **B** and **C**. As a result, each of these populations became reproductively isolated.

The Hardy-Weinberg principle was used to calculate the relative frequencies, p and q, of a dominant and a recessive allele in each population.

Table 4.1 shows the values of p and q, and the estimated sizes of these three populations.

Snail population	Estimated population size	Immediately after road building		10 years after road building	
		p (frequency of dominant allele)	q (frequency of recessive allele)	p (frequency of dominant allele)	q (frequency of recessive allele)
A	1000	0.50	0.50	0.52	0.48
B	100	0.49	0.51	0.63	0.37
C	10	0.40	0.60	0.20	0.80

Table 4.1

(i) Name the type of isolating mechanism that prevents interbreeding between these three snail populations.

[1]

(ii) The habitat of these snail populations did not change over the ten years.

State the term used to describe the **random** changes in allele frequency in a small population.

[1]

(iii) Explain which of the populations, **A**, **B** or **C**, experienced most genetic change.

[2]

(b) The inheritance of different alleles in fruit flies, *Drosophila* spp., has been studied extensively in the laboratory.

Two genes that affect the appearance of *Drosophila* are:

R / r red / pink eyes
Y / y yellow / ebony body

Flies known to be heterozygous at both of these loci were crossed with homozygous pink-eyed ebony flies.

Based on the hypothesis that the two genes assort independently, the offspring expected from this cross would be four different phenotypes in a ratio of 1:1:1:1.
The results obtained, however, are shown in Table 4.2.

Phenotype	Expected number	Observed number
Red eye, yellow body	360	6
Pink eye, yellow body	360	701
Red eye, ebony body	360	729
Pink eye, ebony body	360	4

Table 4.2

The chi-squared (χ^2) test can be used to assess whether the results in Table 4.2 are significantly different from the expected results.

The equation for working out the value of χ^2 is given below.

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

where Σ = 'sum of …'
O = observed value
E = expected value

(i) Calculate the value of χ^2 **to the nearest whole number** for the genetic cross results shown in Table 4.2.

Complete the table below and determine the value of χ^2. **[3]**

Phenotype of fly	**O – E**	**$(O - E)^2$**	**$\frac{(O - E)^2}{E}$**
Red eye, yellow body	–354	125316	348
Pink eye, yellow body	341	116281	323
Red eye, ebony body			
Pink eye, ebony body			

(ii) Statistical tables show that, for this data set, if χ^2 has a value of 11.35, the observed results would only be produced by chance in 1% of trials.

Use this information and the value for χ^2 that you have calculated in **(i)** to explain whether the original hypothesis should be accepted or rejected.

[1]

(iii) The difference in the observed numbers from the cross compared with the expected numbers has **not** occurred by chance. Suggest a genetic explanation for this difference.

[3]

[Total: 11]

(a) The Calvin cycle is the stage of photosynthesis during which carbon dioxide is fixed. The Calvin cycle uses the products of the light dependent stage.

(i) Name the products of the light dependent stage that are used in the Calvin cycle. . **[2]**

(ii) Discuss the fate of triose phosphate (TP) in the Calvin cycle.

[3]

(b) A process known as **photorespiration** also takes place in photosynthetic cells. In this process, oxygen competes with carbon dioxide for the active site of the enzyme RuBP carboxylase (Rubisco).

Fig. 3.1 (a) and Fig. 3.1 (b) outline the processes of photosynthesis and photorespiration.

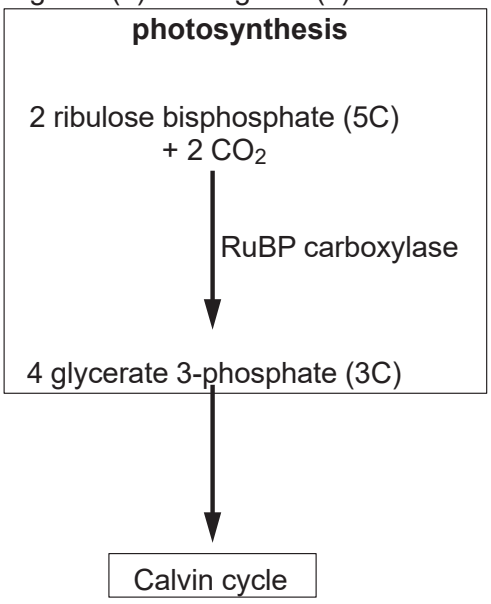

Fig. 3.1 (a)

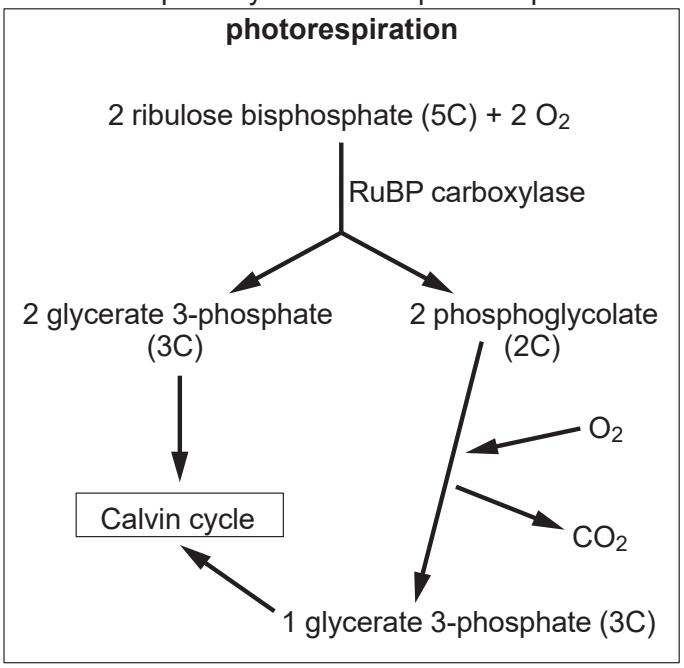

Fig. 3.1 (b)

(i) Suggest why the process outlined in Fig. 3.1 (b) is known as photorespiration. **[2]**

(ii) Using Fig. 3.1 (a) and Fig. 3.1 (b), describe and explain the likely effect on photosynthesis of an increase in the oxygen concentration.

[3]

(iii) Some plants, known as C_4 plants, use an enzyme called PEP carboxylase, instead of Rubisco, to fix carbon dioxide.

Suggest why these plants do **not** show photorespiration.

[1]

[Total: 11]