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**Pearson Edexcel**  
**Level 3 GCE**

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**Monday 17 June 2019**

Morning (Time: 2 hours)

Paper Reference **9BN0/03**

**Biology A (Salters-Nuffield)**

**Advanced**

**Paper 3: General and Practical Applications in Biology**

**You must have:**

Calculator, HB pencil, ruler and a copy of the scientific article adapted from *The Biologist* (enclosed)

Total Marks

**37**

### Instructions

- Use black ink or ball-point pen.
- Fill in the boxes at the top of this page with your name, centre number and candidate number.
- Answer all questions.
- Show your working in any calculation questions and include units in your answer where appropriate.
- Answer the questions in the spaces provided  
– there may be more space than you need.

### Information

- The total mark for this paper is 100.
- The marks for each question are shown in brackets  
– use this as a guide as to how much time to spend on each question.
- You may use a scientific calculator.
- In questions marked with an asterisk (\*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

### Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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Answer ALL questions.

Write your answers in the spaces provided.

1 Many animals possess a heart and a circulatory system.

(a) Changes in the cardiac cycle can be observed by recording an electrocardiogram (ECG).

The ECG for a resting person is shown in the diagram.



Calculate the heart rate for this person.

(1) 1 Q01a

Answer 60 bpm



(b) Anabolic steroids stimulate muscle development.

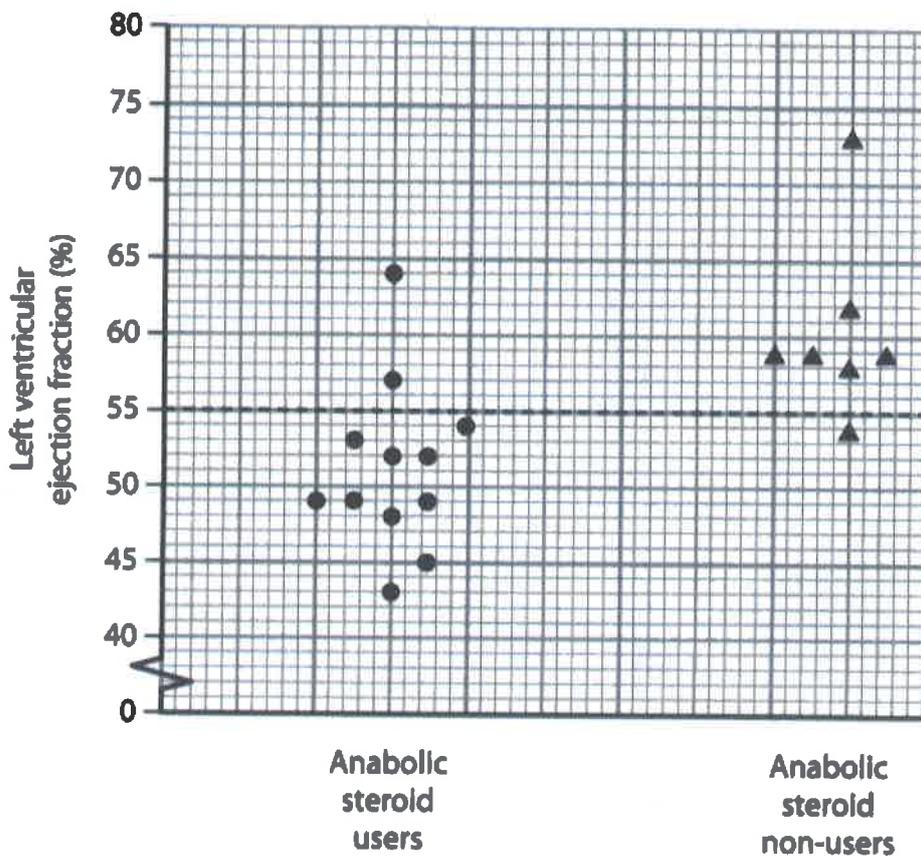
Some athletes use anabolic steroids in an attempt to improve their performance.

The effect of long-term anabolic steroid use on heart function has been investigated.

The left ventricular ejection fraction is the percentage of blood that leaves the left ventricle when it contracts.

The left ventricular ejection fraction for a healthy heart should be greater than 55%.

The results of a small study are shown in the graph.



(i) Analyse the data to determine the effect of anabolic steroid use on heart function.

(2)<sup>1</sup> Q01bi

People who use anabolic steroids have a lower left ventricular ejection fraction than people who do not. In fact, most steroid users have an ejection fraction of less than 55%. Therefore they have an unhealthy heart. A steroid user's heart will pump less blood around the body.

- (ii) Some drugs used to treat cancer have also been shown to reduce the ventricular ejection fraction.

Describe how the safe dose of a cancer drug could be determined.

(3) 0 Q01bi

The Test ~~every~~<sup>every</sup> patient's heart before the drug is administered. If it is above 55% (a safe level) then the drug can be administered. Once the patient has taken the drug for a week, they must have a heart scan and see if their ventricular ejection fraction is still at a healthy level. If not, the dosage may need to be smaller. Each patient should go for monthly check-ups until the treatment is complete.

(Total for Question 1 = 6 marks)

2

2 The largest blood vessels in the body are the aorta and the vena cava.

(a) For one person, the cross-sectional area of the lumen of the aorta is  $193.6 \text{ mm}^2$ .

The diameter of the lumen of the vena cava is  $22.0 \text{ mm}$ . Calculate the percentage increase in the cross-sectional area of the lumen of the vena cava compared with that of the aorta.

$$\begin{aligned} & 22 \checkmark \quad \pi \times 11^2 = 380 \text{ mm}^2 \quad (2) \text{ Q02a} \\ & \text{19} \cdot \left( \frac{380 - 193.6}{380} \right) \times 100 = 49\% \end{aligned}$$

Answer .....

(b) The wall of the aorta is thicker than the wall of the vena cava.

Explain why there is a difference in the thickness of the walls of the aorta and the vena cava.

(2) Q02b

The aortic blood pressure is much higher to get blood all around the body. To withstand this pressure, the aorta has thick, muscle muscular wall that prevent it from bursting. The vena cava has thinner walls because the blood pressure in the vena cava is much less.

(c) In some individuals, the wall of the aorta splits. This can result in rapid blood loss and death.

It has been suggested that this splitting is a result of a loss of tensile strength in the wall of the aorta.

Describe how the tensile strength of the aorta wall can be determined.

(3) 1 Q02c

Measure the blood pressure of the patient and measure how much the aorta expands with each ventricular systole. Due to the blood pressure, it is possible to understand how much the aorta should expand, if it is not enough, then there is a risk of splitting. If the patient is already dead, take a sample of the aorta. Then fold it over a metal rod and at each end attach equal weights. These weights should then be measured and if the aorta hasn't torn, add more weights until it does break. This is the tensile strength of the aorta wall. Repeat multiple times to gain valid results.

(Total for Question 2 = 7 marks)

3

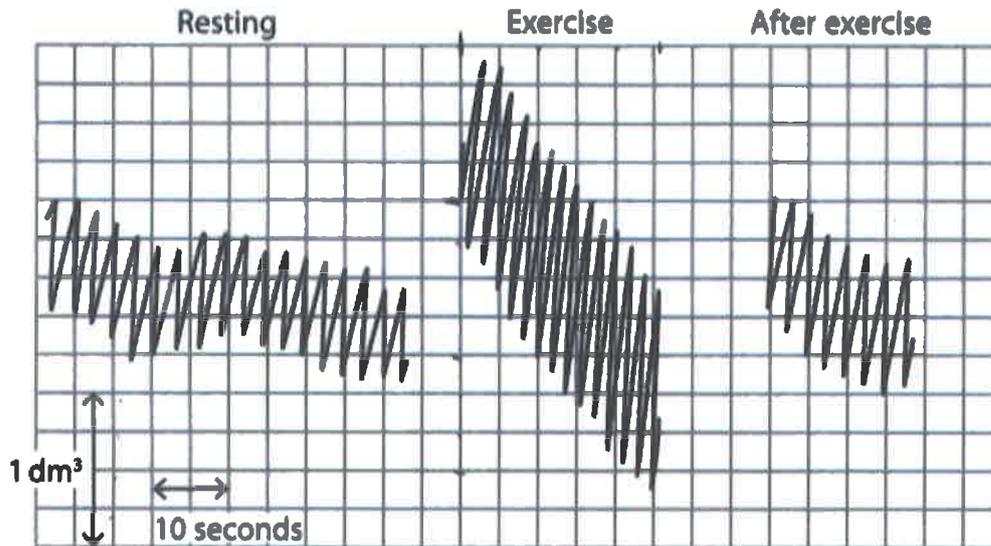
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3 The demand for oxygen changes during exercise.

The change in demand affects the breathing rate.

(a) Changes in breathing can be investigated using a spirometer.

Spirometer traces taken from the same individual before, during and two minutes after exercise are shown.



Calculate the rate of oxygen consumption during exercise.

(2) 0 Q03a

26 sec

2.75 dm<sup>3</sup>

$$\frac{2.75}{26} = 0.1057$$

0.106 dm<sup>3</sup>s<sup>-1</sup>



(b) Explain the effect of exercise on the changes in oxygen consumption.

(4) Q03b

Exercise requires more oxygen than at rest. This is because the muscles that are contracting need a lot of ATP. This ATP is made in respiration all around the body. One vital ~~comp~~ feedstock of respiration is oxygen, without it, the anaerobic respiration will occur which is less efficient and cannot happen for very long. Oxygen is taken in through the lungs and put into the blood stream where it is transported to all areas of the body, <sup>specifically</sup> ~~specifically~~ the muscles.

(c) At the start of exercise, breathing rate increases.

Explain how starting to exercise causes an increase in breathing rate.

(3) Q03c

Exercise will cause a slight increase in the heart rate. This is sent to the medulla which controls heart rate and breathing rate. The signal from the medulla goes through the sympathetic nervous system to the lungs which releases ~~new~~ excitatory neurotransmitters like noradrenaline. The release of the neurotransmitters tells the lungs that exercise has started and the breathing rate needs to increase.

(Total for Question 3 = 9 marks)

2

- 4 The earthworm, (*Lumbricus terrestris*), feeds on dead organic matter found in soil.



Soil pH is one of the abiotic factors that affects the population size of earthworms.

The populations of earthworms in fields with either acidic soil or alkaline soil have been investigated.

The results of this investigation are summarised in the table.

Sample	Earthworms in field with acidic soil		Earthworms in field with alkaline soil	
	Number per square metre	Mass per square metre / $\text{g m}^{-2}$	Number per square metre	Mass per square metre / $\text{g m}^{-2}$
1	80	184	723	1 164
2	59	110	1 613	1 968
3	106	253	354	439
4	31	70	728	961
5	121	238	214	233
6	75	139	874	1 739
7	97	149	668	1 096
8	138	309	121	213
9	63	95	791	1 455
10	63	84	497	736
<b>Total</b>	<b>833</b>	<b>1 631</b>	<b>6 583</b>	<b>10 004</b>



(a) Deduce the effect of pH on the number and mass of earthworms in these two types of soil.

(4) Q04a

The lower the pH, the fewer earthworms there appear to be. They also seem to have less mass per square meter. At a higher pH, the earthworms increase in population and therefore have a higher mass per meter squared. There is an average of 690% increase in the number of earthworms in the alkaline soil compared to the acidic soil. With a total mass per square meter increase of 513.4%.

(b) Describe a sampling method that could be used to collect the data in this table.

Perpendicular

(4) 2 Q04b

Lay out 2 tape measures<sup>h</sup> in an acidic or alkaline field. These will be your ~~ax~~ axis. Next, have a random number calculator and set the parameters to ~~within~~ the length length of the tape measures. Select a random number and place a transect in on the corner of it. Next use a ~~s~~ shovel and dig a 30cm hole within the transect, capturing any worms. Do this 20 times in the field. With each transect's worms, measure their mass, and note it down and put them back and also ~~cover~~ fill in the ~~is~~ hole.



(c) Explain how differences between the mass of earthworms in these two soils could be shown to be statistically significant.

(3) Q04c

The ~~Chi-squared~~ Student's t-test can be done. This can show the researchers whether the mass of the earthworms is ~~stat~~ statistically ~~different~~ significant and not just down to chance. If the student's t-test ~~is~~ ~~re~~ calculated value is higher than the critical value or equal to the ~~the~~ critical value at 0.05, then the null hypothesis can be rejected and the ~~the~~ alternative hypothesis accepted.

(Total for Question 4 = 11 marks)

7

5 Lettuce plants usually grow upright. This is the 'upright' phenotype.

In one variety of lettuce the stem of the lettuce grows along the ground. This is the 'weary' phenotype.

These two phenotypes are shown in the diagram.



Upright



Weary

(a) Inheritance of the weary phenotype has been investigated.

Scientists crossed weary lettuce plants with upright lettuce plants. The  $F_1$  generation produced from this cross were all upright.

In the second cross, two of the  $F_1$  lettuce plants were crossed with each other to produce the  $F_2$  generation.

The phenotypes of the  $F_2$  generation and the results of a statistical test are shown in the table.

Number of offspring with weary phenotype	Number of offspring with upright phenotype	Chi-squared ( $\chi^2$ )
159	414	2.31

Degrees of freedom	Probability		
	0.01	0.05	0.1
1	2.71	3.84	6.64
2	4.61	5.99	9.21
3	6.25	7.82	11.35
4	7.78	9.49	13.28



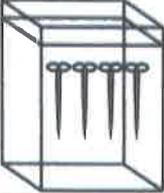
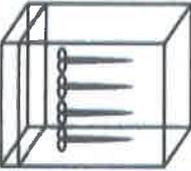
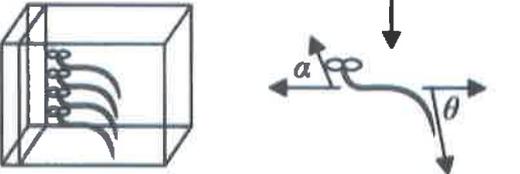
Justify the conclusion that the weary phenotype was inherited as a recessive trait.

(3) Q05a

The  $F_1$  generation was all upright. This had to mean that the upright gene had to be dominant whilst the weary gene had to be recessive. This is because the  $F_1$  generation could be heterozygous for upright or weary (Ll). The phenotype that shows either upright or weary, must be the dominant (upright). Therefore the gene that is not expressed must be recessive (weary).

(b) The effect of gravity on the growth of lettuce plants with either upright or weary phenotype was investigated.

The diagram shows the stages in this investigation.

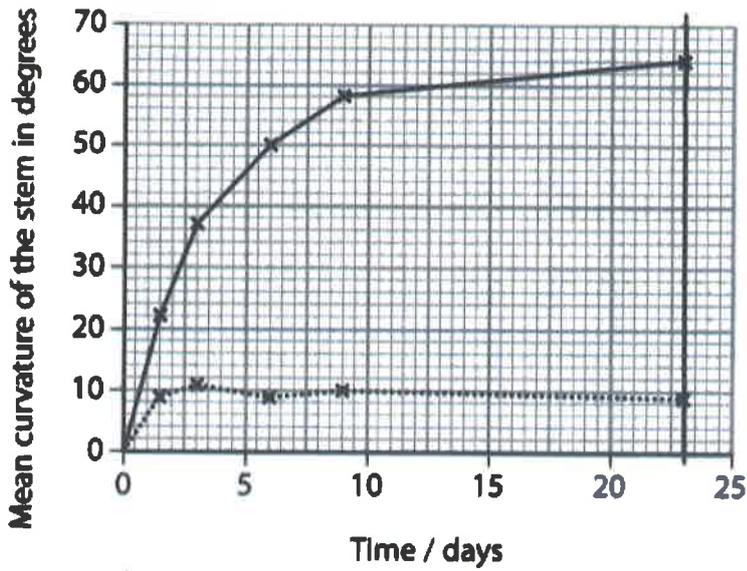
<p>Stage A</p> 	<p>Lettuce plants were grown until their stems were 15 cm long.</p>
<p>Stage B</p> 	<p>The lettuce plants were then placed in complete darkness and rotated so that they were at 90° to the direction of gravity.</p>
<p>Stage C</p> 	<p>The curvatures of the stems (<math>\alpha</math>) and roots (<math>\theta</math>) were measured for the next 23 days.</p>

(i) Explain why the plants were placed in a box in complete darkness.

(3) 1 Q05b

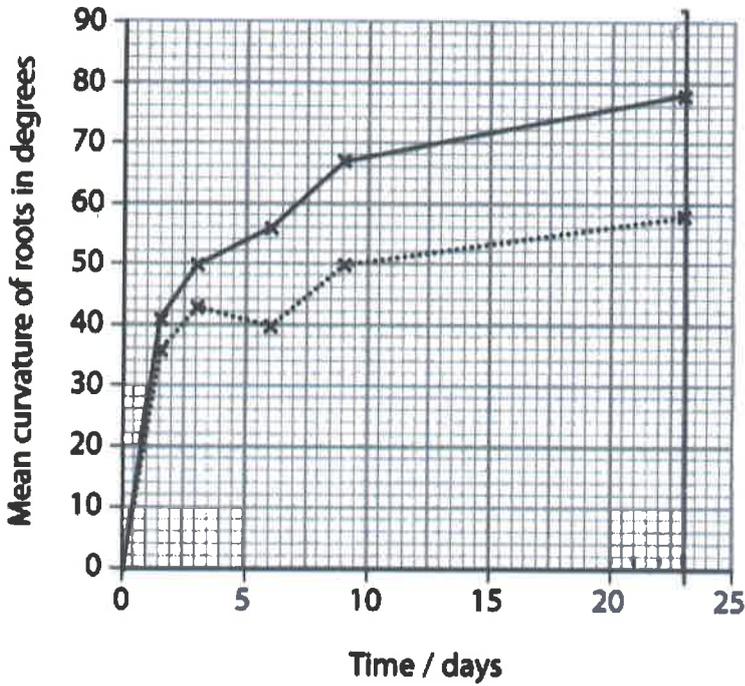
To avoid phototropism. This is when axes in the plant shoot make the plant grow towards light. This would result in the effect of gravity being less effective and the outcome would be different.

(ii) The mean curvatures of the stems and the roots are shown in the graphs.



**Key**

- x— upright lettuce rotated 90°
- ...x... weary lettuce rotated 90°



Calculate the difference in the mean rate of curvature of the stems and roots of the weary lettuce plants over 23 days.

(2) Q05bii

$$58 - 9 = 49$$

Answer 49°

(III) Explain why the stems of weedy lettuce do not respond to gravity.

(2) 0 Q5biii

~~They do not have the structure to~~ Upright lettuces start to grow upright and then when the gravity is changed, they want to grow upright again and change their direction of growth. Weedy lettuces do not grow in any particular structure to begin with. Instead, they grow outwards. When gravity is changed, they do the same.

(Total for Question 5 = 10 marks)

3



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6 Enzymes control biochemical pathways.

Phosphofructokinase is an enzyme involved in controlling the rate of glycolysis.

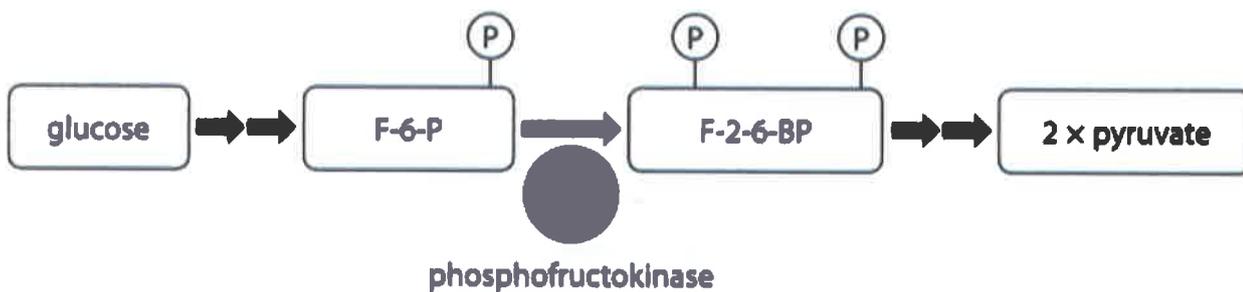
(a) State what is meant by the term enzyme.

(2) 2 Q06a

A biological catalyst that reduces the activation energy needed for a reaction to occur by making an enzyme substrate complex.

(b) Phosphofructokinase is an enzyme that uses ATP to convert fructose-6-phosphate (F-6-P) into fructose-2,6-bisphosphate (F-2,6-BP).

The conversion of F-6-P by this enzyme is a rate-determining step in glycolysis. This is shown in the diagram.



(i) Explain why ATP is required for this reaction.

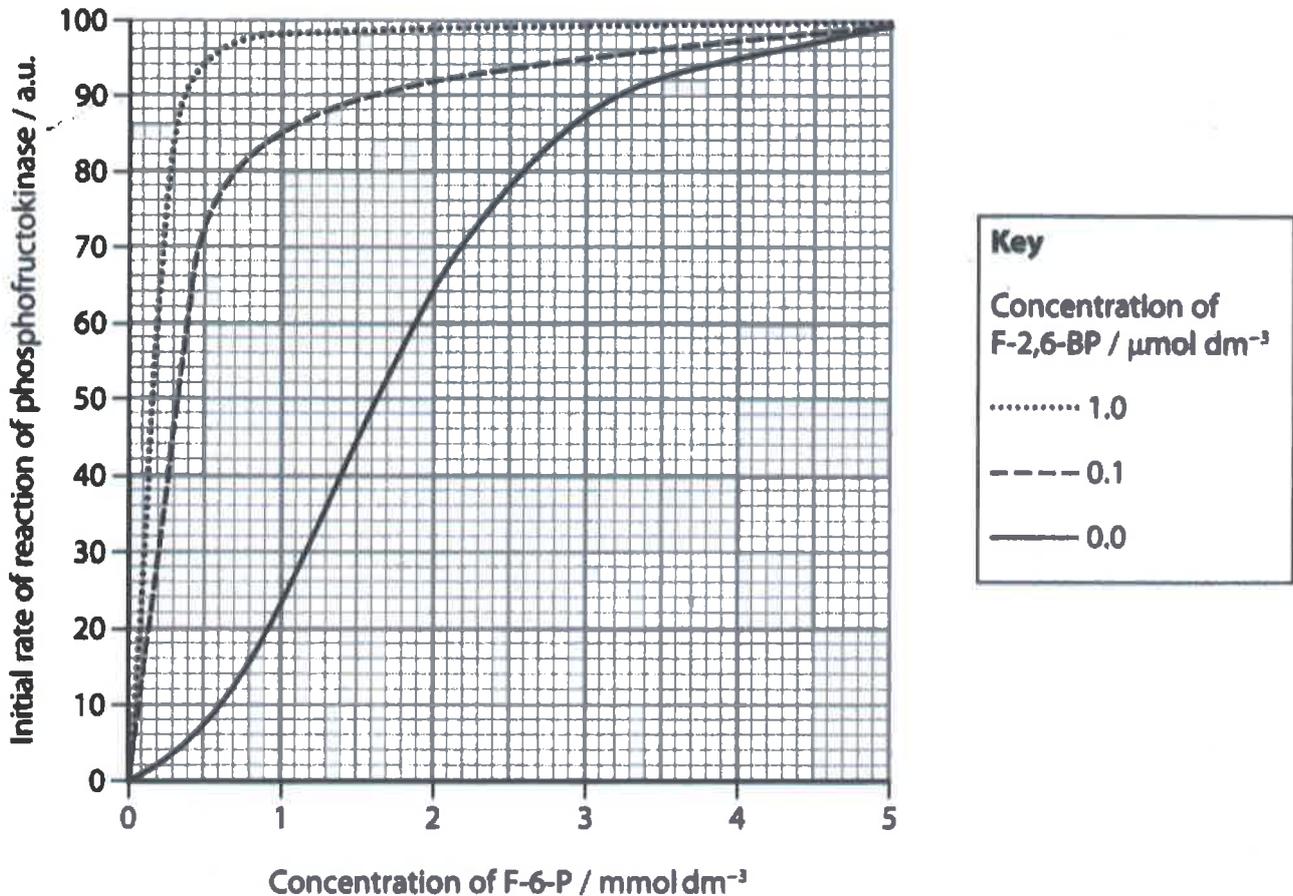
(3) 1 Q06bi

You are adding another phosphate group onto the F-6-P, making another bond. This requires extra energy as making more bond is endothermic. The use of ATP is necessary because it provides this energy for the phosphate group to be attached with the help of phosphofructokinase.

(ii) The effect of substrate concentration on the initial rate of reaction of phosphofructokinase was investigated.

This investigation was repeated with the addition of two concentrations of F-2,6-BP.

The graph shows the results of this investigation.



Comment on the effects of F-6-P and F-2,6-BP concentrations on the rate of glycolysis.

(3) Q06bii

A high concentration of F-2,6-BP ( $\mu\text{mol dm}^{-3}$ ) and F-6-P ( $5\text{ mmol dm}^{-3}$ ) has the steepest increase in rate of reaction. They both seem to increase the rate of phosphofructokinase. A higher rate of the enzyme will result in a faster rate of glycolysis. Even though at  $5\text{ mmol dm}^{-3}$  F-6-P and no F-2,6-BP, the rate is still at its highest.

(c) Glycolysis is inhibited by acidic conditions.

Devise an investigation to determine the effect of acidic conditions on the initial rate of reaction of phosphofructokinase.

(4) 0 Q06c

I have 2 experiments, one where the pH is 7 (neutral) and another where it is 5 (acidic). Add the same amount of glucose and phosphofructokinase in each. The only difference being the pH. At every 20 second interval, measure the concentration of pyruvate as all of the glucose that has been turned into pyruvate will have been catalysed by the enzyme. Do this for 5 minutes and repeat 10 more times.

(Total for Question 6 = 12 marks)

5

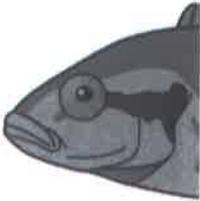
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- 7 More than 2000 different species of cichlid fish have been identified in lakes and rivers in Africa.

The different species of cichlid fish have evolved from a common ancestor over a short period of time.

The table shows some of the different species of cichlid fish found in lakes and rivers in Africa.

Species	Information	Mouth shape
<i>Oreochromis niloticus</i>	Lives in rivers across northern Africa. Herbivore feeding on plankton and plants. Lays eggs in gravel.	
<i>Neolamprologus brichardi</i>	Lives in shallow but steep rocky habitat in Lake Tanganyika. Carnivore feeding on small crustaceans and invertebrates. Lays eggs between rocks.	
<i>Astatotilapia burtoni</i>	Lives in muddy rivers flowing into Lake Tanganyika. Omnivore feeding on small fish, insect larvae, algae and plant debris. Lays eggs in gravel.	
<i>Pundamilia nyererei</i>	Lives in shallow water in Lake Victoria. Omnivore feeding on insect larvae and zooplankton. Lays eggs between rocks.	
<i>Maylandia zebra</i>	Lives in deep, clear waters of Lake Malawi. Herbivore feeding on plant material. Lays eggs in gravel.	



(a) Describe how different species of cichlid fish have evolved in lakes and rivers in Africa.

(5) Q07a

All of the fish have adapted to survive in their surroundings. Fish that lay their eggs in gravel often live in rivers or deep underwater. Compared to fish that lives in lake shallow waters lay their eggs in rocks. This is because this is the best place to hide their offspring with the highest chance of them surviving. They have also adapted to eating what is in their environment, eating what they can, whether it be meat or vegetation. Omnivores will have a mouth that is slanted to a higher degree to house their sharp fast teeth for eating prey whilst the herbivores have more molars to chew their food.

\*(b) The genomes of some species of cichlid fish have been sequenced and analysed.

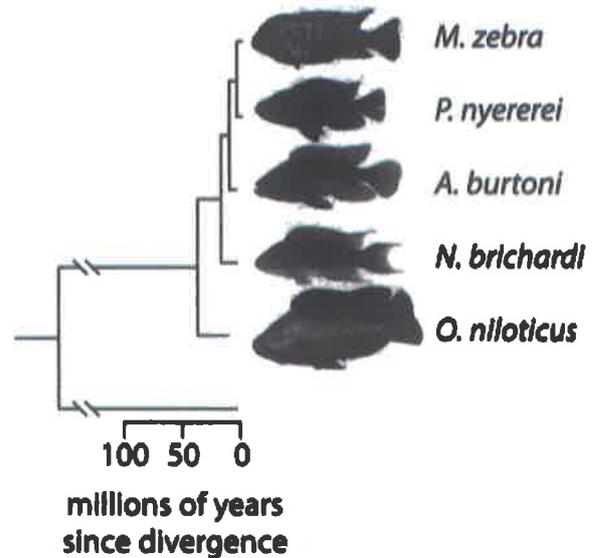
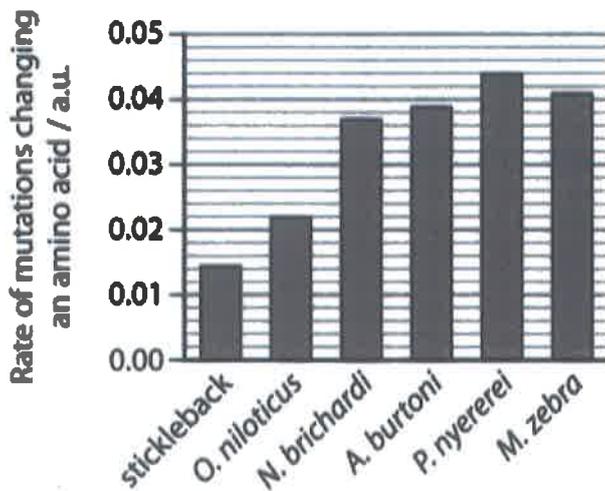
The data collected included:

- the rate at which genes have been duplicated to produce additional copies of genes on a chromosome
- the frequency of mutations in transcription factor binding sites
- the rate of mutations that result in a change of an amino acid in a protein.

This information was used to produce a phylogenetic tree.

A comparison was made with a stickleback, which is a slowly evolving fish.

Speed of evolution	Fish	Rate of gene duplication / a.u.	Number of mutations in transcription factor binding sites (compared to <i>O. niloticus</i> )
Rapidly evolving cichlid fish	<i>O. niloticus</i>	45	0
	<i>N. brichardi</i>	45	214
	<i>A. burtoni</i>	55	140
	<i>P. nyererei</i>	45	129
	<i>M. zebra</i>	60	142
Slowly evolving fish	stickleback	10	0



Phylogenetic tree