Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | Candidate Number

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

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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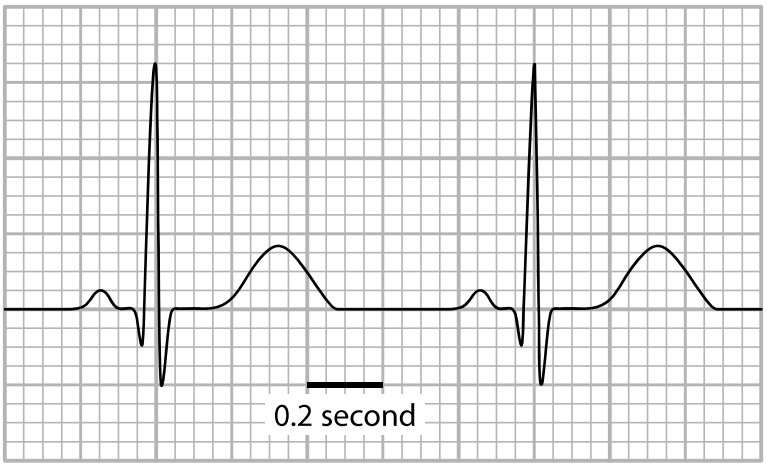
Answer ALL questions.

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)

Answer .....

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(b) Anabolic steroids stimulate muscle development.

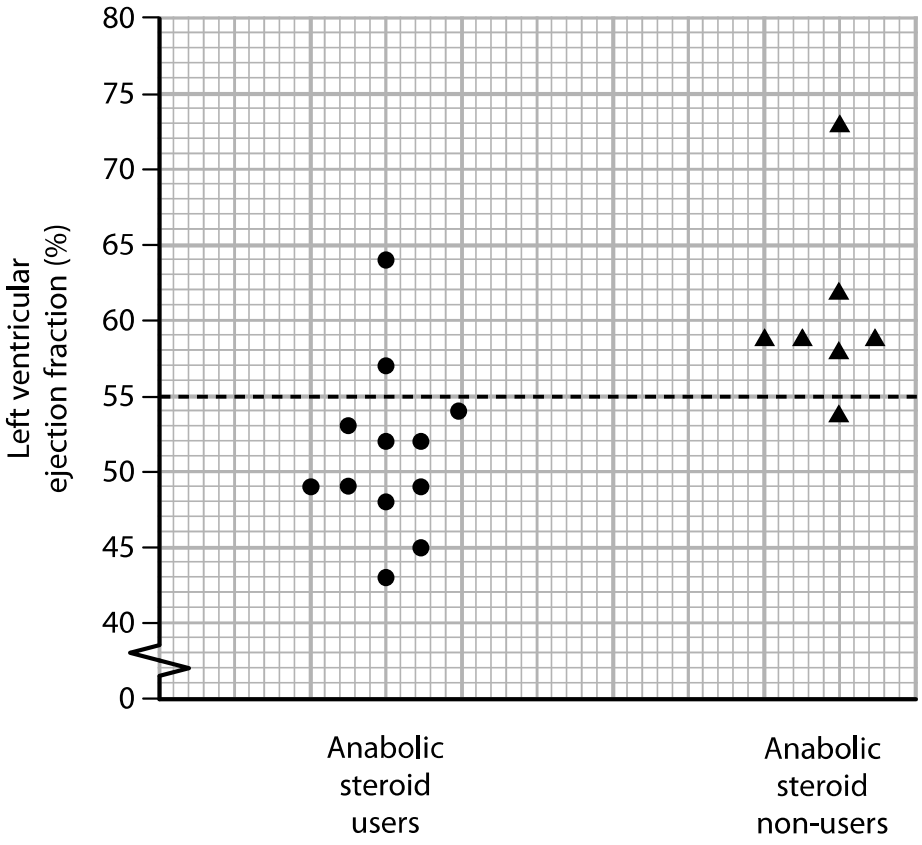
Some athletes use anabolic steroids in an attempt to improve their performance.

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)

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(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)

(Total for Question 1 = 6 marks)

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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 mm^2.

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

(2)

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)

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(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)

(Total for Question 2 = 7 marks)

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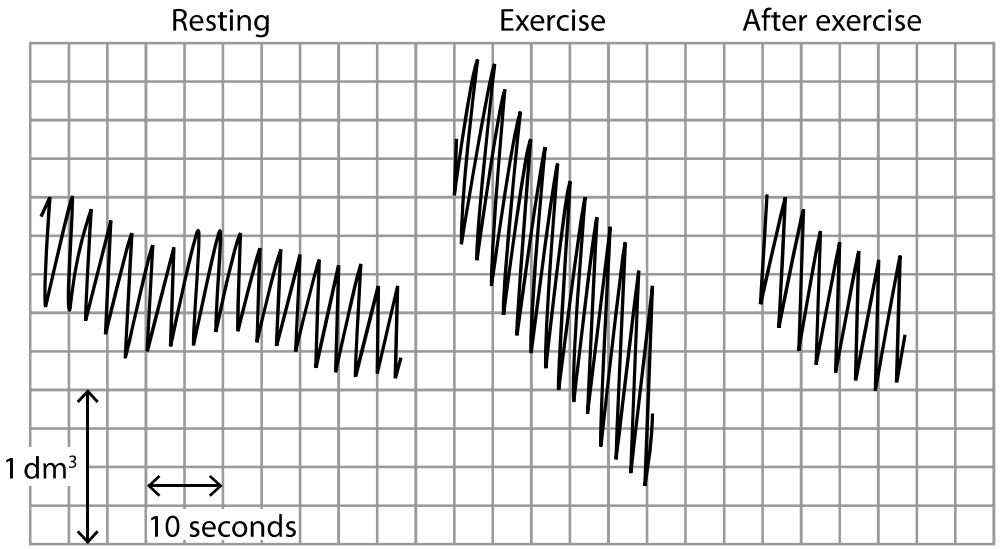
3 The demand for oxygen changes during exercise.

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)

..... $dm^3 s^{-1}$

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

(4)

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

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

(3)

(Total for Question 3 = 9 marks)

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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 / g m^{-2}	Number per square metre	Mass per square metre / 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
Total	833	1 631	6 583	10 004

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

(4)

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

(4)

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

(3)

(Total for Question 4 = 11 marks)

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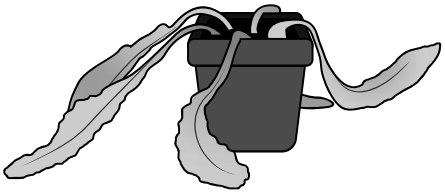
5 Lettuce plants usually grow upright. This is the 'upright' phenotype.

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 (χ^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

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

(3)

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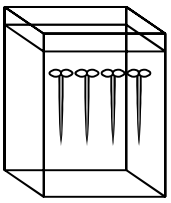
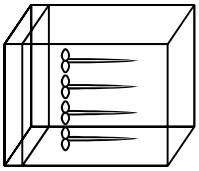
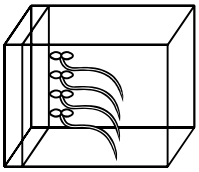
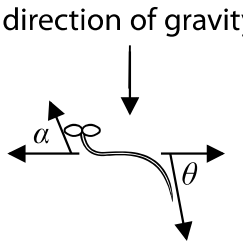
(b) The effect of gravity on the growth of lettuce plants with either upright or weary phenotype was investigated.

The diagram shows the stages in this investigation.

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

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

(3)

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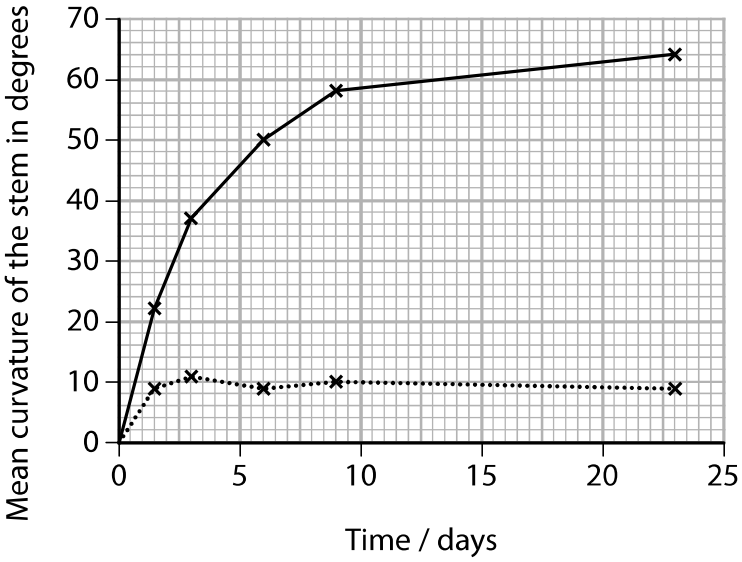
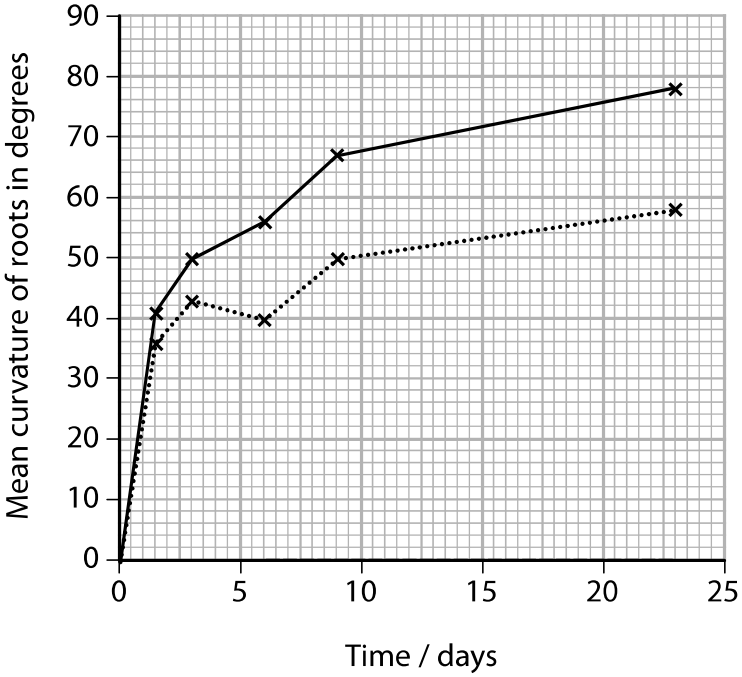
(ii) The mean curvatures of the stems and the roots are shown in the graphs.





Key

upright lettuce rotated 90°

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)

Answer .....

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(iii) Explain why the stems of weary lettuce do not respond to gravity.

(2)

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(Total for Question 5 = 10 marks)

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6 Enzymes control biochemical pathways.

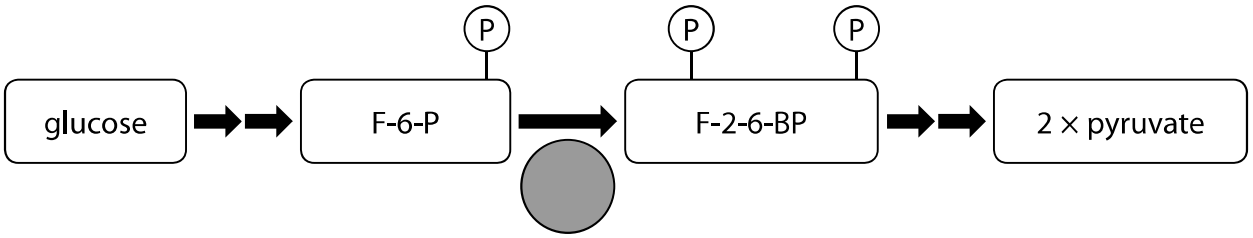
Phosphofructokinase is an enzyme involved in controlling the rate of glycolysis.

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

(2)

(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)

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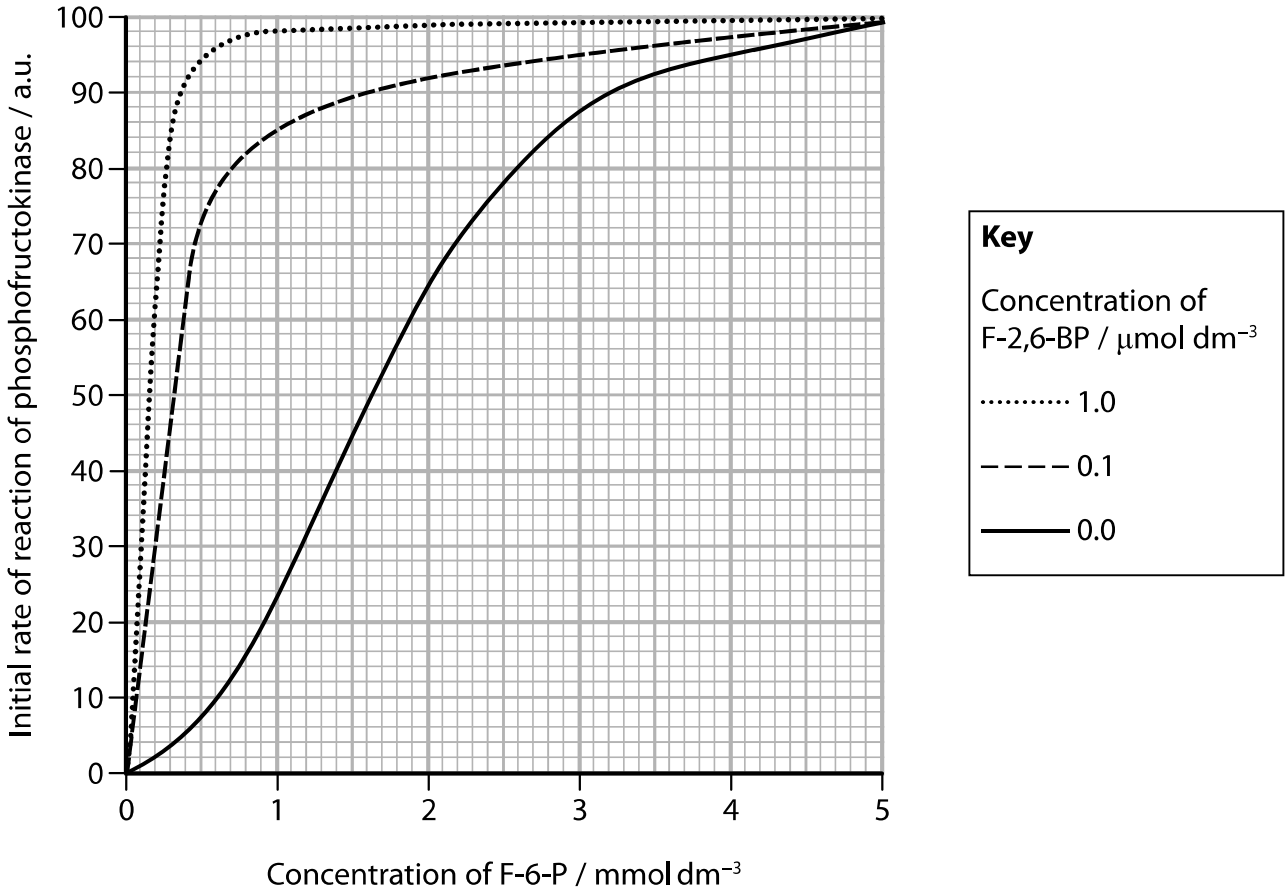
(ii) The effect of substrate concentration on the initial rate of reaction of phosphofructokinase was investigated.

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)

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(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)

(Total for Question 6 = 12 marks)

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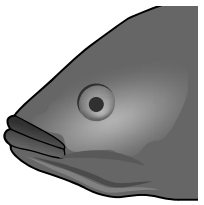
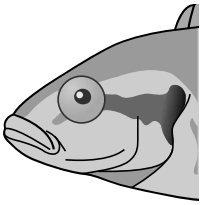
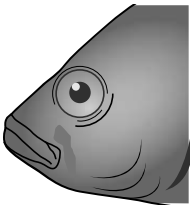
7 More than 2000 different species of cichlid fish have been identified in lakes and rivers in Africa.

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

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

(5)

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

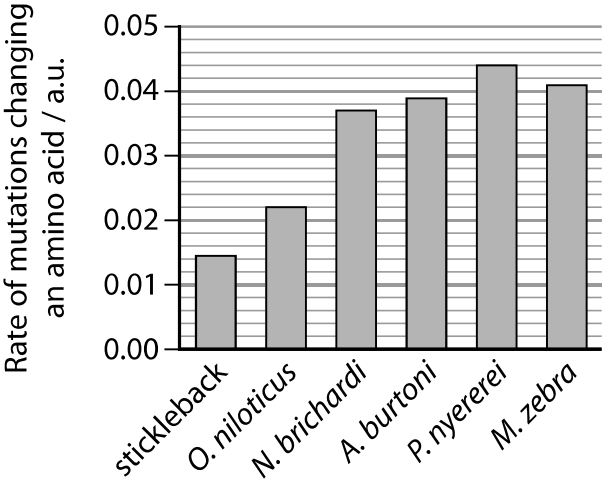
The data collected included:

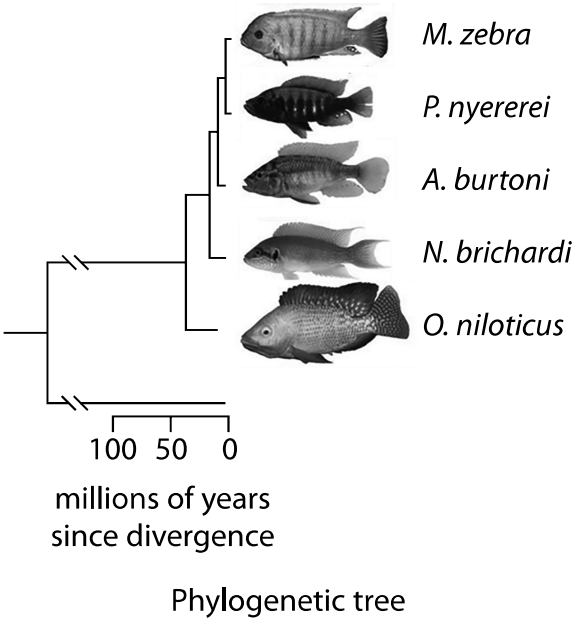
- the rate at which genes have been duplicated to produce additional copies of genes on a chromosome
- the frequency of mutations in transcription factor binding sites
- the rate of mutations that result in a change of an amino acid in a protein.

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 *O. niloticus*)
Rapidly evolving cichlid fish	*O. niloticus*	45	0
	N. brichardi	45	214
	A. burtoni	55	140
	P. nyererei	45	129
	M. zebra	60	142
Slowly evolving fish	stickleback	10	0





Phylogenetic tree

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Analyse all the data provided to discuss how several species of cichlid fish have evolved over a short period of time.

(9)

(Total for Question 7 = 14 marks)

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8 The scientific article you have studied is adapted from *The Biologist*.

Use the information from the scientific article and your own knowledge to answer the following questions.

(a) State the meaning of the term stem cell (paragraph 1).

(2)

(b) Describe how a 'single fertilised egg' can produce many different cell types (paragraph 2).

(3)

(c) Name the property shown by 'spontaneously beating regions' in cardiac muscle (paragraph 15).

(1)

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(d) Mice used in research have a number of limitations (paragraph 6). Mice that are homozygous for a recessive trait are rare in the population, but can be produced in genetic crosses.

Explain how genetic crosses could be used to generate a mouse line expressing a recessive trait.

(3)

(e) Retinoic acid affects the expression of genes in embryonic stem cells (ESCs) leading to the development of neural tissues (paragraph 11).

Explain how chemicals such as retinoic acid could affect gene expression.

(3)

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(f) The Zika virus can cause microcephaly. This condition is a result of brain tissue not developing in the foetus (paragraphs 20 and 21).

Explain how the Zika virus can cause microcephaly.

(3)

(g) Tissue rejection can occur in organs transplanted from other individuals (paragraph 22).

Explain how the immune system is involved in tissue rejection.

(4)

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(h) Human cells can be grown in monolayers using tissue culture (Figure 1).

Devise a procedure to investigate the effect of temperature on the growth rate of a monolayer of human cells.

(5)

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(i) Describe how a gastruloid differs from an organoid (paragraphs 21, 26 and 28).

(2)

(j) Describe two ethical issues concerning the use of human embryonic stem cells in research (paragraph 32).

(2)

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(k) Explain the advantages of using iPSCs compared to ESCs for the production of transplant material (paragraphs 33 and 34).

(3)

(Total for Question 8 = 31 marks)

TOTAL FOR PAPER = 100 MARKS

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