Please write clearly in block capitals.

Centre number | | | | | | Candidate number | | | | |

Surname _____

Forename(s) _____

Candidate signature _____

A-level
BIOLOGY

Paper 2

Tuesday 20 June 2017 Morning Time allowed: 2 hours

Materials

For this paper you must have:
- a ruler with millimetre measurements
- a calculator.

Instructions
- Use black ink or black ball-point pen.
- Fill in the boxes at the top of this page.
- Answer **all** questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- All work must be shown.
- Do all rough work in this book. Cross through any work you do not want to be marked.

Information
- The marks for the questions are shown in brackets.
- The maximum mark for this paper is 91.

For Examiner's Use	
Question	Mark
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
TOTAL	

Do not write outside the box

Answer **all** questions in the spaces provided.

0 1 . 1 Exercise causes an increase in heart rate.

Describe the role of receptors and of the nervous system in this process.

[4 marks]

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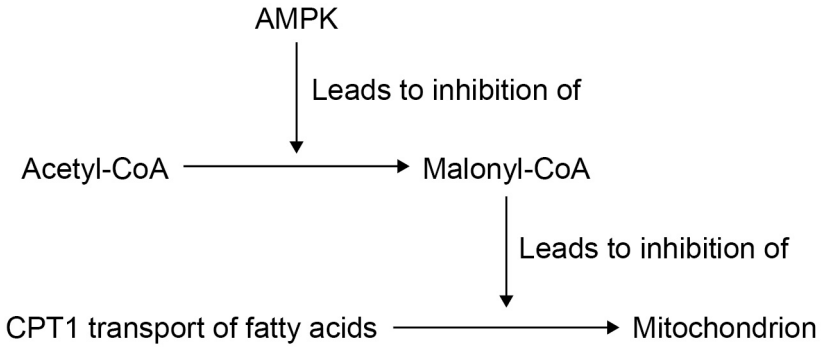
0 1 . 2 AMP-activated protein kinase (AMPK) is an enzyme that regulates a number of cellular processes. Exercise leads to activation of AMPK.

Figure 1 shows one effect of activation of AMPK during exercise.

Figure 1



CPT1 is a channel protein that transports fatty acids into mitochondria.

Using **Figure 1**, explain the benefit of activation of AMPK during exercise.

[3 marks]

7

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ANSWER IN THE SPACES PROVIDED

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0 2 Dengue is a serious disease that is caused by a virus. The virus is carried from one person to another by a mosquito, *Aedes aegypti*. One method used to try to reduce transmission of this disease is the Sterile Insect Technique (SIT). This involves releasing large numbers of sterile (infertile) male *A. aegypti* into the habitat. These males have been made infertile by using radiation.

0 2 . 1 Explain how using the SIT could reduce transmission of dengue.

[2 marks]

0 2 . 2 Describe how the mark-release-recapture method could be used to determine the population of *A. aegypti* at the start of the investigation.

[3 marks]

Question 2 continues on the next page

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0 2 . 3 The release of radiation-sterilised *A. aegypti* has not been very successful in controlling the transmission of dengue.

Suggest **one** reason why.

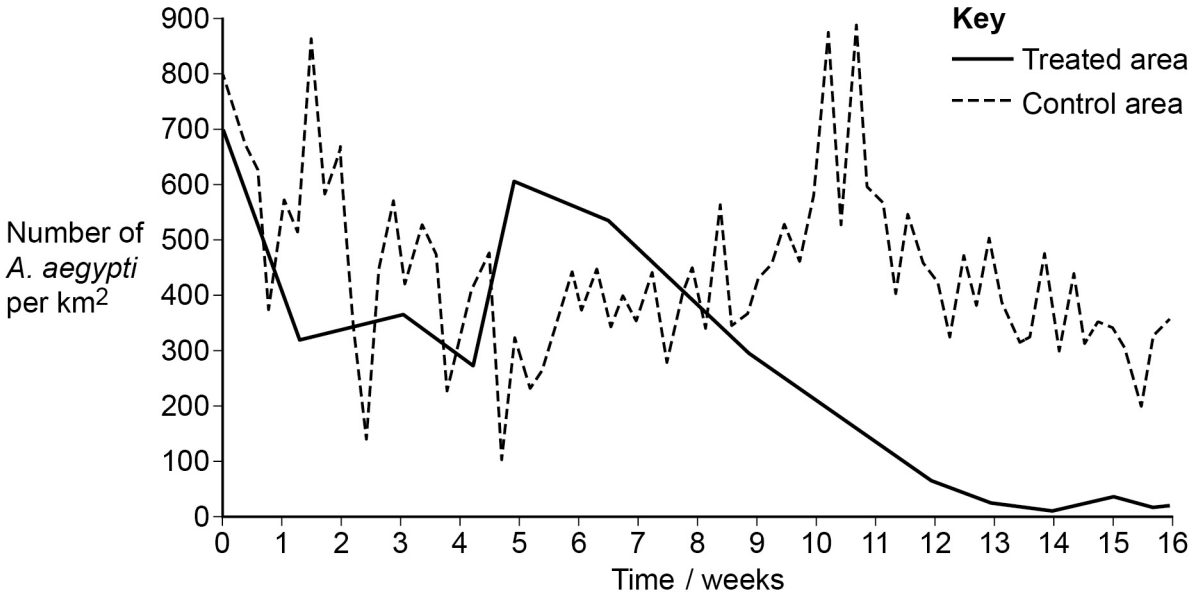
[1 mark]

0 2 . 4 Recently a new method was developed to control *A. aegypti*. Scientists produced transgenic males carrying a 'lethal gene' which kills their offspring before they can reproduce.

The scientists released transgenic males every week in one area of a city in Brazil. At regular intervals they determined the number of *A. aegypti* per km^2 in the area where transgenic males were released and in a control area where no transgenic males were released.

Figure 2 shows their results.

Figure 2



Suggest why the scientists released more transgenic males every week.

[1 mark]

Do not write outside the box

0 2 . 5 The release of transgenic males proved successful in reducing the number of *A. aegypti.*

Describe how the results in **Figure 2** support this conclusion.

[2 marks]

_____

_____

_____

_____

_____

_____

9

Turn over for the next question

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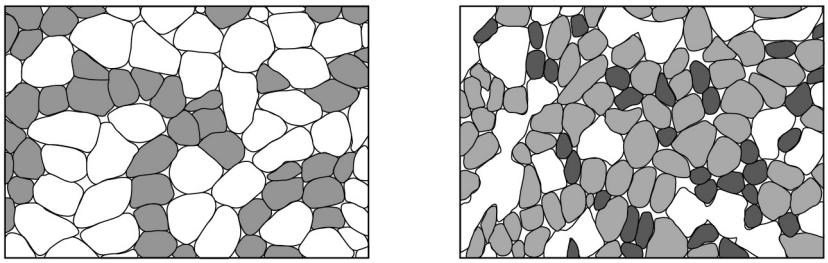
0 3 Scientists investigated the effect of regular exercise on skeletal muscle fibres in mice. The scientists compared the muscle fibres of mice after six weeks of regular exercise (trained mice) with those of mice that had not exercised (control mice). The scientists stained the muscle fibres from both sets of mice to show succinic acid dehydrogenase activity. The darker the stain the greater the succinic acid dehydrogenase activity.

Figure 3 shows a typical set of results they obtained.

Figure 3

Control mice **Trained mice**



0 3 . 1 Succinic acid dehydrogenase is an enzyme used in the Krebs cycle.

Suggest **one** reason for the difference in the staining between the muscle fibres of the control mice and the trained mice.

[1 mark]

_____

_____

_____

Do not write outside the box

0 3 . 2 The scientists then compared the length of time that the control mice and the trained mice could carry out prolonged exercise. The trained mice were able to exercise for a longer time period than control mice.

Explain why.

[3 marks]

0 3 . 3 The scientists determined the mean diameter of muscle fibres in trained mice using an optical microscope to examine sections of muscle tissue. The circular area (πr^2) of one field of view was 1.25 mm^2. The diameter of this area was equal to the diameter of 15 muscle fibres.

Using this information, calculate the mean diameter in μm (micrometres) of muscle fibres in this section of tissue.

[2 marks]

Answer = _____ μm

Question 3 continues on the next page

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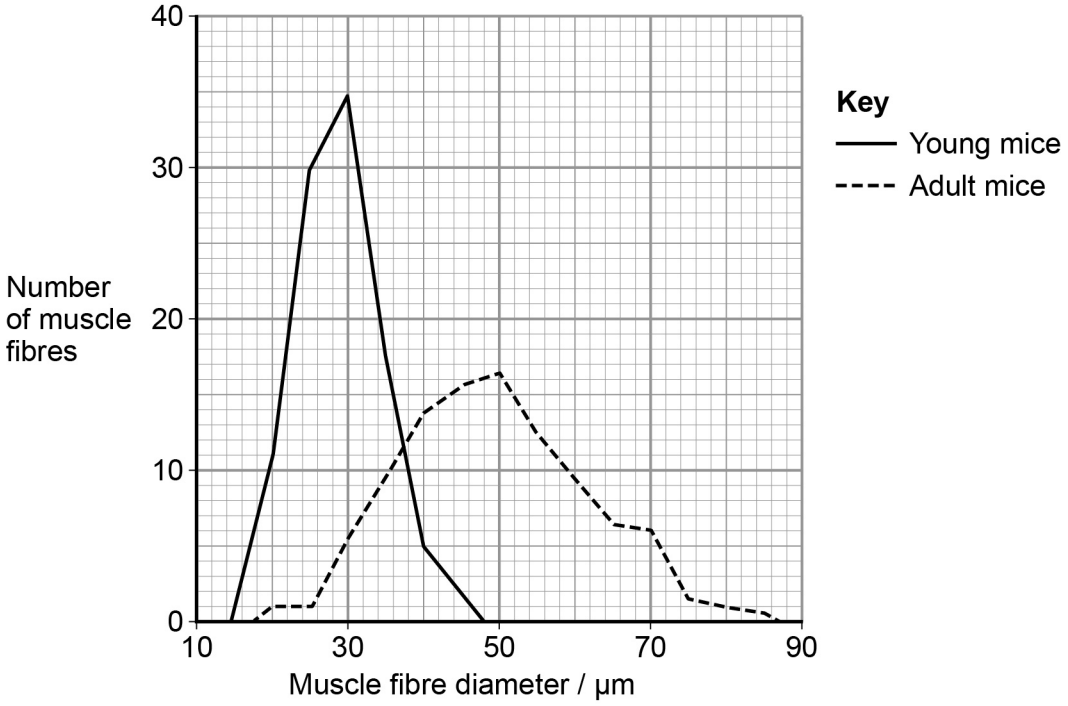
0 3 . 4 The scientists also compared the diameter of samples of muscle fibres taken from young mice and adult mice.

Some of their results are shown in **Figure 4**.

Figure 4



Describe **two** differences between these samples of muscle fibres.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

8

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ANSWER IN THE SPACES PROVIDED

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0 4 A student isolated chloroplasts from spinach leaves into a solution to form a chloroplast suspension. He used the chloroplast suspension and DCPIP solution to investigate the light-dependent reaction of photosynthesis. DCPIP solution is blue when oxidised and colourless when reduced.

The student set up three test tubes as follows:

- **Tube 1** – 1 cm^3 of solution without chloroplasts and 9 cm^3 of DCPIP solution in light.
- **Tube 2** – 1 cm^3 of chloroplast suspension and 9 cm^3 of DCPIP solution in darkness.
- **Tube 3** – 1 cm^3 of chloroplast suspension and 9 cm^3 of DCPIP solution in light.

The student recorded the colour of the DCPIP in each of the tubes at the start and after the tubes had been left at 20 °C for 30 minutes.

His results are shown in **Table 1**.

Table 1

Tube	Colour of DCPIP in tube	
	At start	After 30 minutes
1	blue	blue
2	blue	blue
3	blue	colourless

0 4 . 1 The solution that the student used to produce the chloroplast suspension had the same water potential as the chloroplasts.

Explain why it was important that these water potentials were the same.

[2 marks]

Do not write outside the box

0 4 . 2 Explain why the student set up **Tube 1**.

[2 marks]

0 4 . 3 Explain the results in **Tube 3**.

[2 marks]

0 4 . 4 The student evaluated the effectiveness of different chemicals as weed-killers by assessing their ability to prevent the decolourisation of DCPIP in chloroplast suspensions.

He added different concentrations of each chemical to illuminated chloroplast suspensions containing DCPIP. He then determined the IC_{50} for each chemical. The IC_{50} is the concentration of chemical which inhibits the decolourisation of DCPIP by 50%.

Explain the advantage of the student using the IC_{50} in this investigation.

[1 mark]

Question 4 continues on the next page

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0 4 . 5 Explain how chemicals which inhibit the decolourisation of DCPIP could slow the growth of weeds.

[2 marks]

9

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0 5 Arbuscular mycorrhiza fungi (AMF) are fungi which grow on, and into, the roots of plants. AMF can increase the uptake of inorganic ions such as phosphate.

0 5 . 1 Suggest **one** way in which an increase in the uptake of phosphate could increase plant growth.

[1 mark]

0 5 . 2 Suggest **one** way in which AMF may benefit from their association with plants.

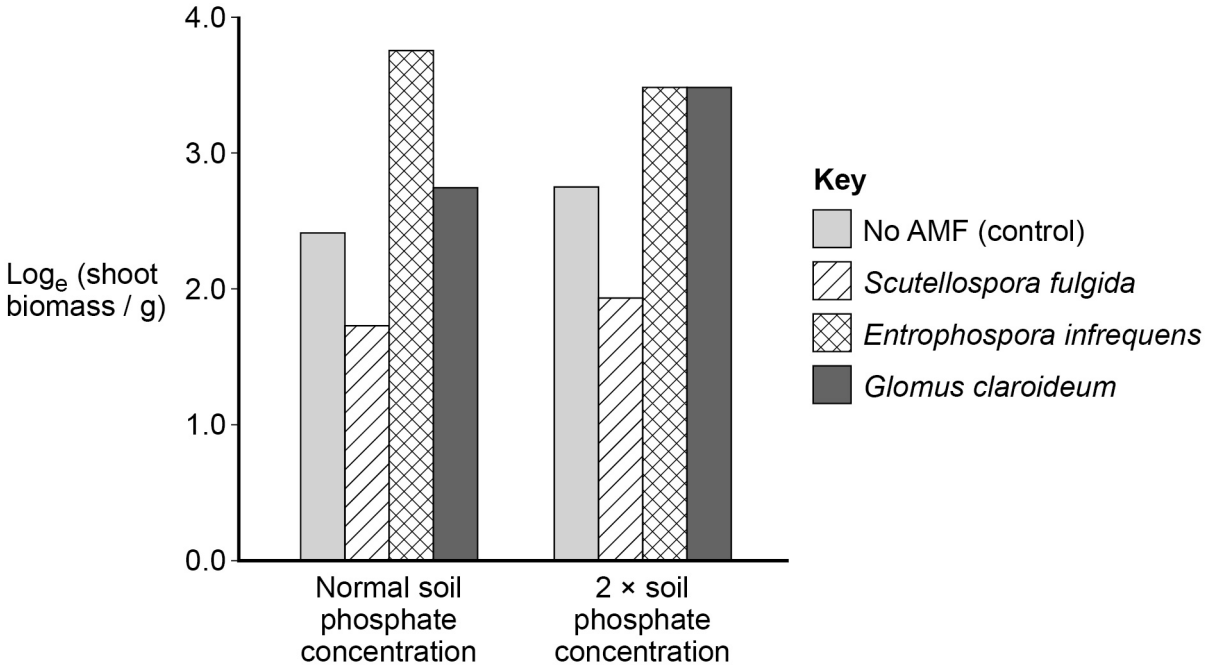
[1 mark]

0 5 . 3 Scientists investigated the effects of different AMF species on the productivity of the plant community of a prairie grassland ecosystem when growing in/on soil containing different phosphate concentrations.

The scientists set up identical plots of prairie grassland soil containing seeds of the plant species found in the ecosystem. The scientists added different AMF species and different concentrations of phosphate to particular plots. Control plots without AMF species were also set up. After 20 weeks the scientists determined the shoot biomass for each plot.

The results the scientists obtained are shown in **Figure 5**.

Figure 5



Do not write outside the box

Explain why an increase in shoot biomass can be taken as a measurement of **net** primary productivity.

[2 marks]

0 5 . 4 Using the data from **Figure 5**, evaluate the effect on plant productivity of adding AMF species and adding phosphate to the soil.

[4 marks]

Question 5 continues on the next page

Do not write outside the box

0 5 . 5 Using the e^x button on your calculator, determine the rate of shoot biomass production in grams per day for the control plot in soil with normal phosphate concentration.

[2 marks]

Answer = _____ g day^{-1}

10

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0 6 . 1 Each year, a few people with type I diabetes are given a pancreas transplant. Pancreas transplants are not used to treat people with type II diabetes.

Give **two** reasons why pancreas transplants are not used for the treatment of type II diabetes.

[2 marks]

1 _____

_____

_____

2 _____

_____

_____

0 6 . 2 The pancreas produces the hormone insulin.

Put a tick (✓) in the box next to the statement which describes **incorrectly** the action of insulin.

[1 mark]

Activates enzymes involved in the conversion of glucose to glycogen. ☐

Controls the uptake of glucose by regulating the inclusion of channel proteins in the surface membranes of target cells. ☐

Attaches to receptors on the surfaces of target cells. ☐

Activates enzymes involved in the conversion of glycerol to glucose. ☐

Question 6 continues on the next page

Do not write outside the box

0 6 . 3 Scientists investigated the use of induced pluripotent stem cells (iPS cells) to treat type I diabetes in mice. The scientists used four transcription factors to reprogramme skin cells to form iPS cells. The scientists then stimulated the *in vitro* differentiation of iPS cells into pancreatic cells.

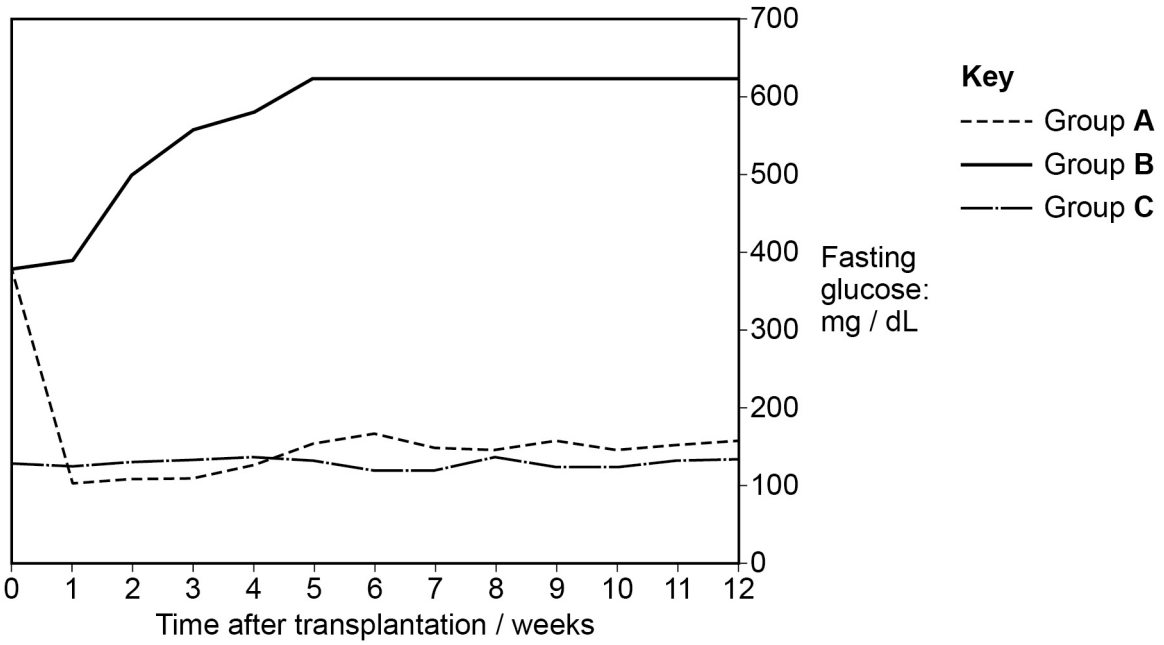
The scientists set up three experimental groups:

- Group **A** – 30 mice with type I diabetes received pancreatic cell transplants derived from iPS cells.
- Group **B** – 30 mice with type I diabetes were left untreated.
- Group **C** – 30 mice without diabetes were left untreated.

The scientists measured the blood glucose concentration of all the mice on a weekly basis for 12 weeks.

The results the scientists obtained are shown in **Figure 6**.

Figure 6



Suggest how transcription factors can **reprogramme** cells to form iPS cells.

[2 marks]

Do not write outside the box

0 6 . 4 Using all the information provided, evaluate the use of iPS cells to treat type I diabetes in humans.

[4 marks]

9

Turn over for the next question

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0 7 . 1 What is meant by the term phenotype?

[2 marks]

_____

_____

_____

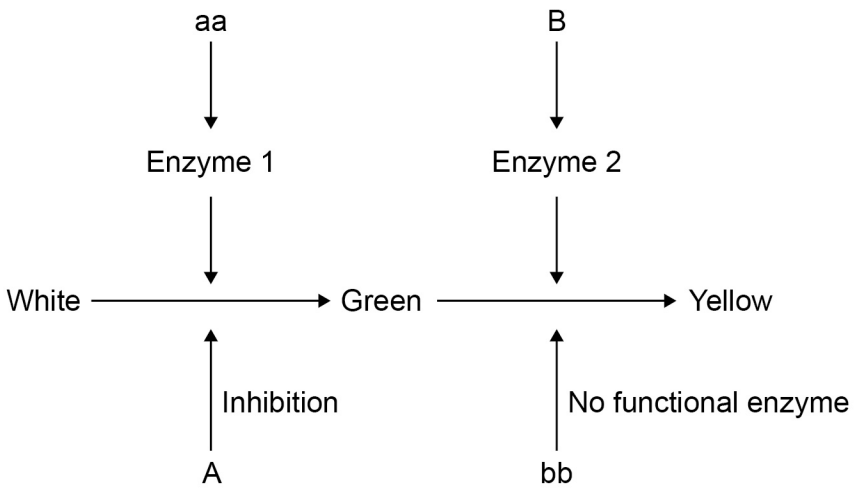
_____

_____

0 7 . 2 The inheritance of fruit colour in summer squash plants is controlled by two genes, **A** and **B**. Each gene has two alleles.

Figure 7 shows the interaction of these two genes in controlling fruit colour in summer squash plants.

Figure 7



Name the type of gene interaction shown in **Figure 7**.

[1 mark]

_____

0 7 . 3 What fruit colour would you expect the following genotypes to have?

[1 mark]

AAbb _____

aaBB _____

Do not write outside the box

0 7 . 4 Genes **A** and **B** are **not** linked.

Complete the genetic diagram to show all the possible genotypes and the ratio of phenotypes expected in the offspring of this cross.

[3 marks]

Genotypes of parents **aabb** × **AaBb**

Genotypes of offspring _____

Phenotypes of offspring _____

Ratio of phenotypes _____

0 7 . 5 A population of summer squash plants produced only green and yellow fruit. The percentage of plants producing yellow fruit in this population was 36%.

Use the Hardy−Weinberg equation to calculate the percentage of plants that were heterozygous for gene **B**.

[2 marks]

Answer = _____ %

9

Turn over for the next question

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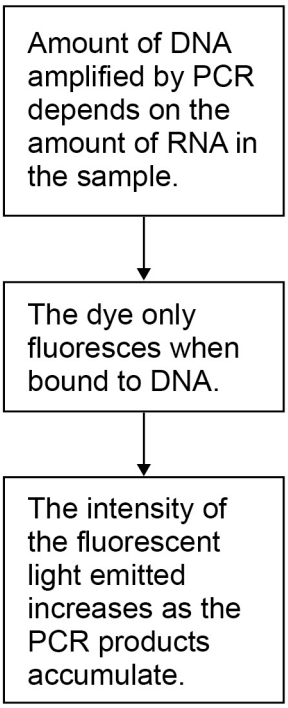
0 8 One way to detect and measure accurately the amount of RNA in a tissue sample is by RT-PCR (reverse transcriptase-polymerase chain reaction).

RT-PCR uses a reaction mixture containing:

- the sample for testing
- reverse transcriptase
- DNA nucleotides
- primers
- DNA polymerase
- fluorescent dye.

The principle behind this method is shown in **Figure 8**.

Figure 8



0 8 . 1 Explain the role of reverse transcriptase in RT-PCR.

[1 mark]

_____

_____

_____

Do not write outside the box

0 8 . 2 Explain the role of DNA polymerase in RT-PCR.

[1 mark]

0 8 . 3 Any DNA in the sample is hydrolysed by enzymes before the sample is added to the reaction mixture.

Explain why.

[2 marks]

Question 8 continues on the next page

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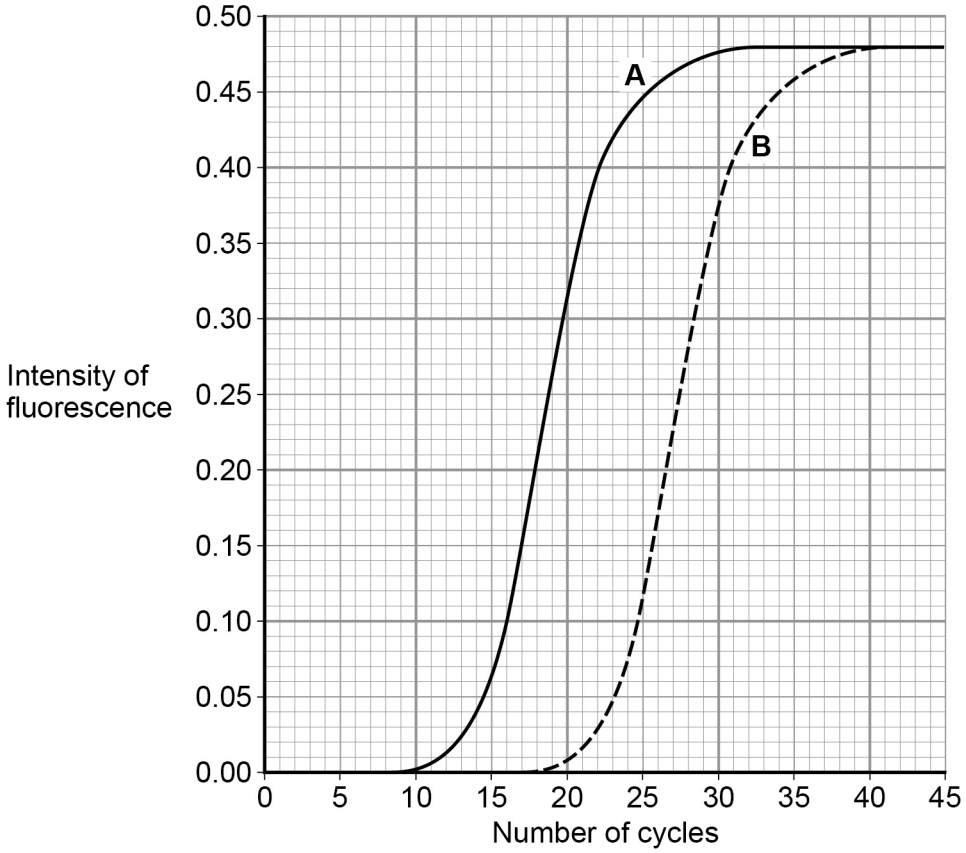
0 8 . 4 **Figure 9** shows the results from using RT-PCR to detect RNA in two different samples, **A** and **B**.

Figure 9



A quantitative comparison can be made of the amount of RNA in samples **A** and **B**. This involves determining the number of cycles required to reach 50% maximum concentration of DNA (**C**).

The amount of RNA in a sample can be measured as: $\frac{1}{\mathbf{C}}$

Use this information to calculate the ratio for RNA content in sample **A** : RNA content in sample **B**.

[2 marks]

Answer = _____

Do not write outside the box

0 8 . 5 Suggest **one** reason why DNA replication stops in the polymerase chain reaction.

[1 mark]

0 8 . 6 Scientists have used the RT-PCR method to detect the presence of different RNA viruses in patients suffering from respiratory diseases.

The scientists produced a variety of primers for this procedure.

Explain why.

[2 marks]

9

Turn over for the next question

Do not write outside the box

0 9 . 1 What is a gene pool?

[1 mark]

0 9 . 2 Lord Howe Island in the Tasman Sea possesses two species of palm tree which have arisen via sympatric speciation. The two species diverged from each other after the island was formed 6.5 million years ago. The flowering times of the two species are different.

Using this information, suggest how these two species of palm tree arose by sympatric speciation.

[5 marks]

6

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1 0 Alzheimer's disease (AD) is a non-reversible brain disorder that develops over a number of years. At the start of 2014 the number of Americans with AD was estimated to be 5.4 million. Every 30 seconds another person in America develops AD.

In the brain of a person with AD there is a lower concentration of acetylcholine. This affects communication between nerve cells and initially results in memory loss and confusion. Some of the symptoms of AD that are associated with communication between nerve cells are reduced by taking the drug donepezil. Donepezil inhibits the enzyme acetylcholinesterase.

A gene mutation called E280A found on chromosome 14 causes early-onset AD at a mean age of 49 years. The age at which the E280A mutation is expressed to cause AD varies.

Yaramul is a town in a historically isolated region of the Andes Mountains. The population of this town has the highest frequency of the E280A mutation in the world. The origin of the E280A mutation in this population has been traced back to a common ancestor in the 17th century. Natural selection has not reduced the frequency of the E280A mutation in the population.

This autosomal dominant mutation involves a change in triplet 280 from GAA to GCA. Scientists analysed chromosome 14 from 102 individuals from Yaramul. They recorded a sample size of 204 and detected 75 E280A mutations but only 74 potential AD cases. The scientists identified individuals with the mutation by whole genome sequencing. They had decided that a DNA probe would not be a suitable method to detect the E280A mutation.

1 0 . 1 Assuming no one with AD died in 2014, calculate the annual percentage increase in AD cases in America for 2014 (lines 2–4).

[2 marks]

Answer _____ %

Question 10 continues on the next page

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1 0 . 2 Explain how donepezil could improve communication between nerve cells (lines 7–9).

[3 marks]

1 0 . 3 Suggest and explain **two** reasons why there is a high frequency of the E280A mutation in Yaramul (lines 13–15).

[2 marks]

1

2

1 0 . 4 Explain why natural selection has **not** reduced the frequency of the E280A mutation in the population (lines 16–17).

[2 marks]

Do not write outside the box

1 0 . 5 The age at which the E280A mutation is expressed to cause AD can vary (lines 11–12).

Suggest and explain **one** reason for this.

[2 marks]

1 0 . 6 One scientific study which analysed chromosome 14 involved 102 individuals. The scientists recorded a sample size of 204. In this sample they detected 75 E280A mutations but only 74 potential AD cases (lines 19–21).

Suggest explanations for the figures the scientists recorded.

[2 marks]

1 0 . 7 Suggest why a DNA probe for the mutated triplet was **not** considered a suitable method for detection of the E280A mutation (lines 22–23).

[2 marks]

END OF QUESTIONS

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