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Centre number

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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	73

80%



J U N 1 7 7 4 0 2 2 0 1

IB/M/Jun17/E5

7402/2

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]

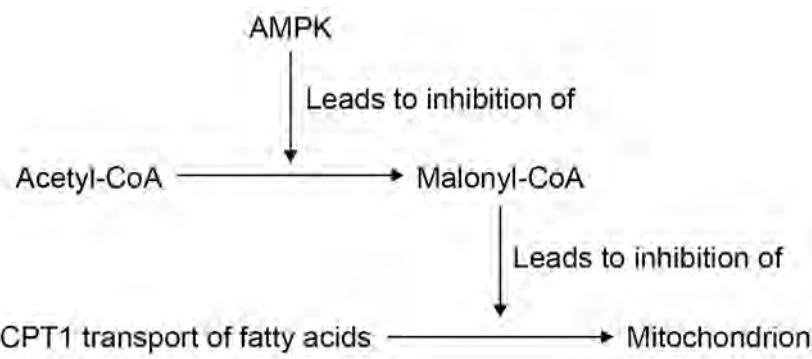
- Higher CO_2 conc in blood due to higher rate of respiration for energy gain ATP
- Chemoreceptors in aorta/carotid artery detect high CO_2 conc / higher pH and send signals to medulla oblongata Kidney - water
- Medulla sends higher frequency of signals to SAN through sympathetic nervous system causing increase of heart rate



- 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]

AMPK activation inhibits Malonyl-CoA
so less inhibition of CPT1 transportation
of fatty acids into mitochondria. This
means fatty acids can be used in the
Krebs cycle for ATP production for more
energy (in form of ATP) for exercise.

7
7

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0 3

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ANSWER IN THE SPACES PROVIDED**



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]

- Compete for resources with fertile males
so they cannot reproduce ^{as much} and population
of *Aedes aegypti* decreases over
time.

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]

- Capture sample and mark without harming
or affecting ordinary lifestyle in any way.
- Release and leave time for them to mix into
population again
- Capture second sample and count number
recaptured. Estimate = num captured in first
sample divided by proportion of 2nd sample who
were marked.

Question 2 continues on the next page



0 5

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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]

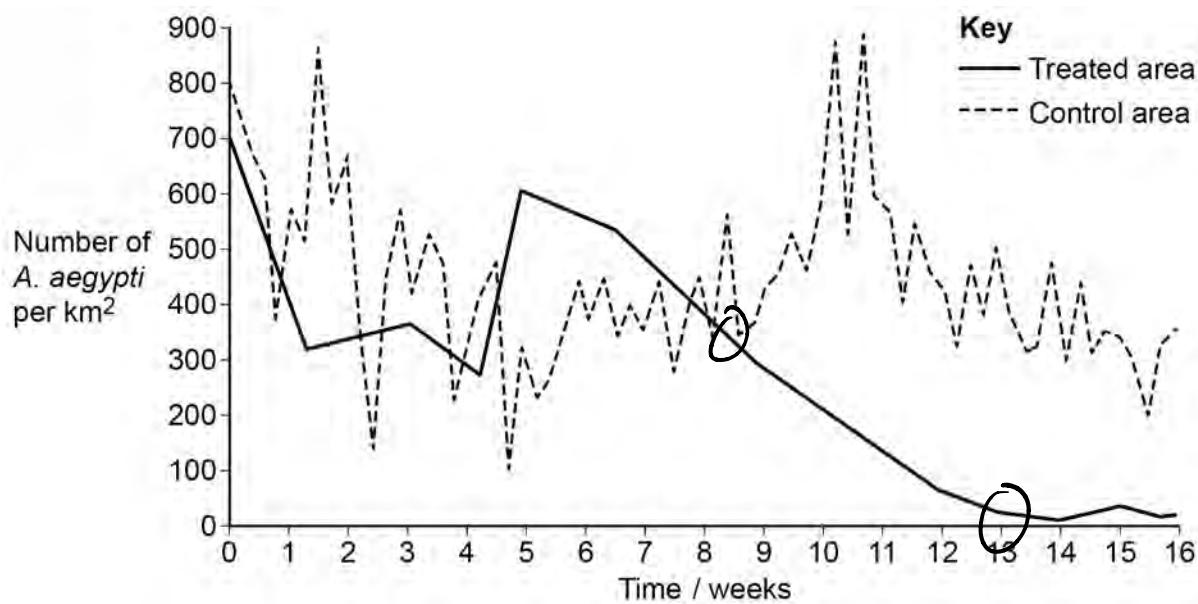
Radiation shortens their lifespan so die faster
and do not compete for resources

- 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 km² 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]

To replace the transgenic males that died off.



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]

- Past 9 weeks number of *A. aegypti* is lower in treated than control
- By 13 weeks number of *aegypti* in treated area is very close to zero

9

9

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0 7

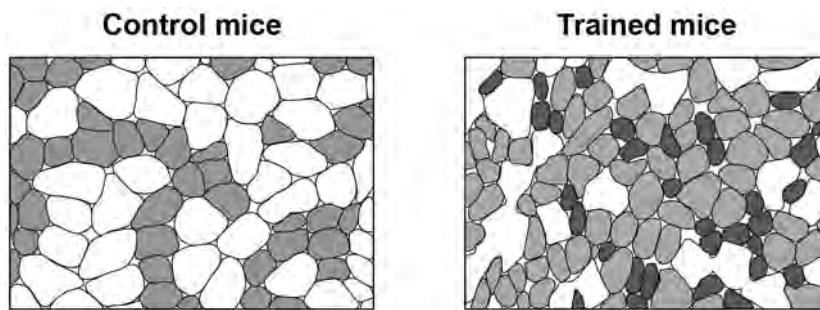
IB/M/Jun17/E5

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

**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]

Trained mice respire aerobically more than control due to exercise so more Krebs cycle so more succinic acid dehydrogenase



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]

Trained mice gone through training so
more slow twitch muscle fibres and more
mitochondria for aerobic respiration.
Slow twitch fatigued less easily so trained
mice could exercise for longer

More aerobic \rightarrow more ATP

Less anaerobic respiration

so less or no lactate

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]

$$\pi r^2 = 1.25$$

$$r^2 = \frac{1.25}{\pi} = 0.3971$$

$$r = 0.631$$

$$d = 1.2616 \text{ mm}$$

$$\div 15$$

$$0.0841 \text{ mm}$$

$$84.1 \mu\text{m}$$

Answer = 84.1 μm

Question 3 continues on the next page

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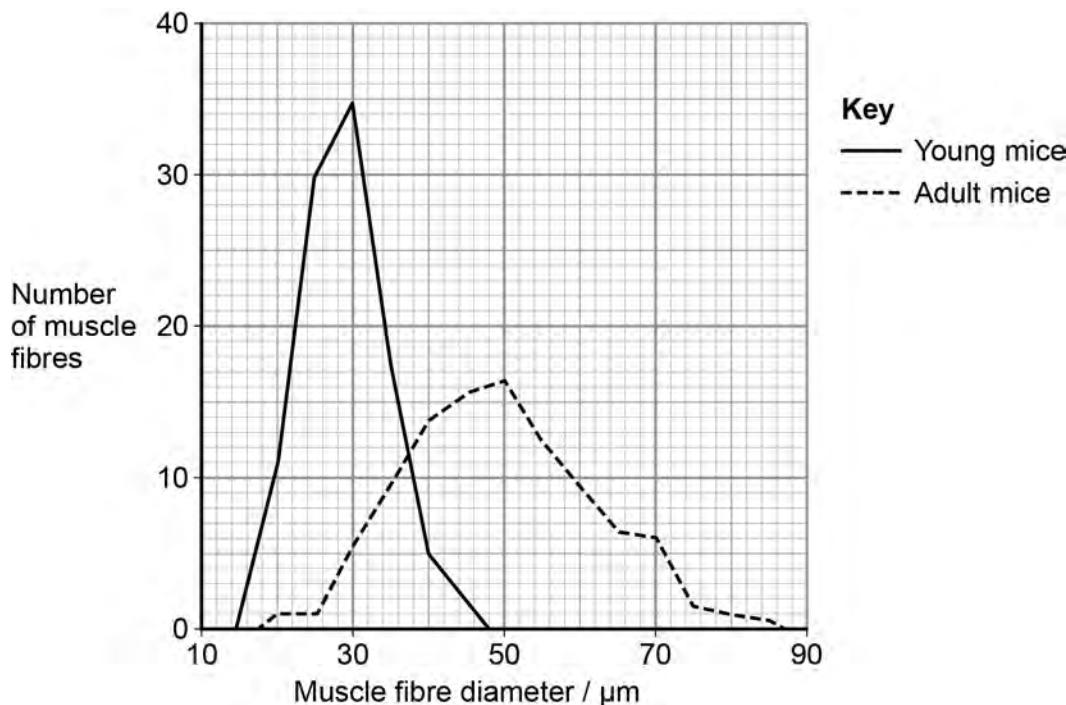


0 3 . 4

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 Mode for young mice is 30 μm but 50 in adult mice

2 Young mice do not have any muscle fibres wider than 48 μm while adults have up to $\sim 87 \mu\text{m}$

5

8



1 0

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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 cm³ of solution without chloroplasts and 9 cm³ of DCPIP solution in light.
- **Tube 2** – 1 cm³ of chloroplast suspension and 9 cm³ of DCPIP solution in darkness.
- **Tube 3** – 1 cm³ of chloroplast suspension and 9 cm³ 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]

To ensure water does not move out of chloroplasts by osmosis * as water is needed to restore chlorophyll electrons in photolysis during the LDR. * into lower water potential in suspension.
So chloroplast does not burst



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

[2 marks]

As a control to monitor DCPIP behavior when exposed to light without the effects of the LDR as no chloroplasts

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

[2 marks]

Light dependent reaction occurs in chloroplast thylakoids that are exposed to light and DCPIP accepts electrons so is reduced and turns colourless

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 IC₅₀ for each chemical. The IC₅₀ is the concentration of chemical which inhibits the decolourisation of DCPIP by 50%.

Explain the advantage of the student using the IC₅₀ in this investigation.

[1 mark]

Allows comparison of chemicals for purpose of preventing LDR and photosynthesis

Question 4 continues on the next page

Turn over ►



1 3

0 4 . 5

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

[2 marks]

Inhibiting DCPIP decolourisation means LDR is prevented so no NADPH or ATP produced so LTR cannot happen and no triose phosphate for biosynthesis of polymers for plant growth.

8**9**

1 4

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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]

More phosphates for ATP production so more energy for growth/biosynthesis

0 5 . 2

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

[1 mark]

Receive organic C compounds such as sucrose for respiration.

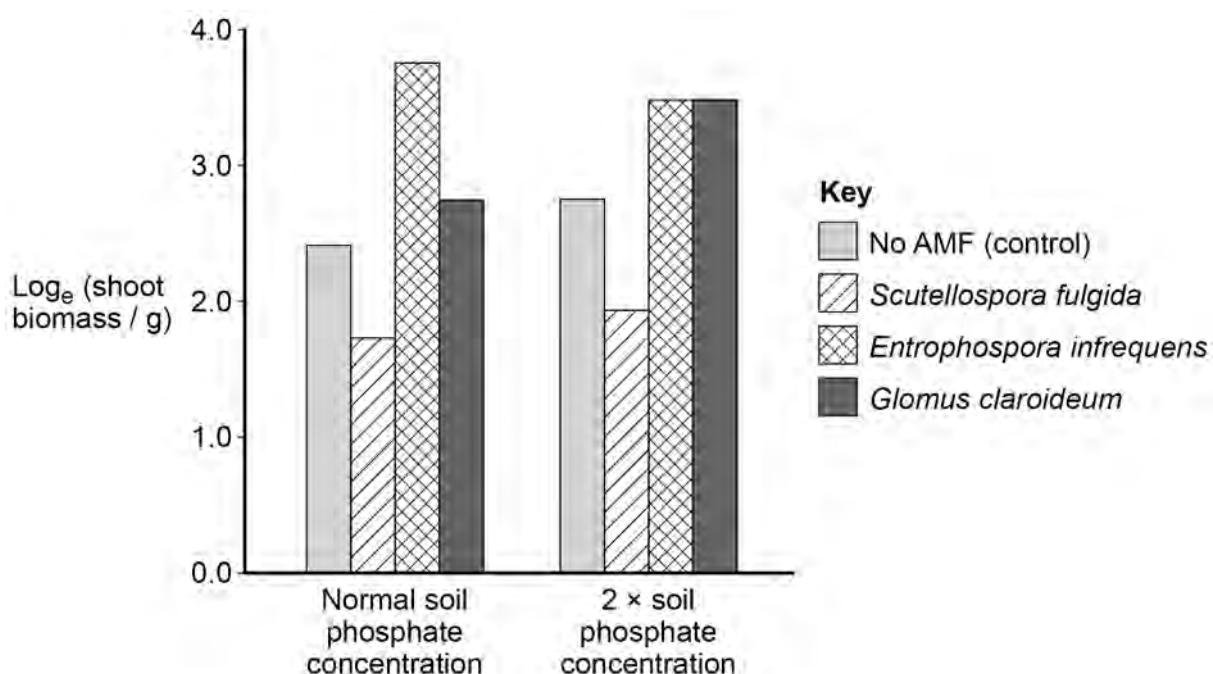
0 5 . 3

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



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

[2 marks]

Increase in biomass represents gross primary production - energy used in respiration which is NPP.

Increase in biomass = more dry mass

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]

- In both soils, adding SF decreased shoot biomass greatly compared to control
- EI higher increase in normal than 2X highest increase in sand out of all 4
- GC higher increase in sand than 2X Tied highest in 2X with EI
- all but EI increased in 2X compared to normal
- No S.D or stats test so may not be significant

Question 5 continues on the next page

Turn over ►



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.

11.02 grams in 140 days [2 marks]

Answer = 0.0787 g day⁻¹
2.56

9
—
10



1 8

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 Type II diabetics pancreas cells still produce insulin so transplant will not treat T2

2 Can be rejected/attacked by immune system.
Cells less responsive to insulin so new pancreas will not help

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

Turn over ►



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.

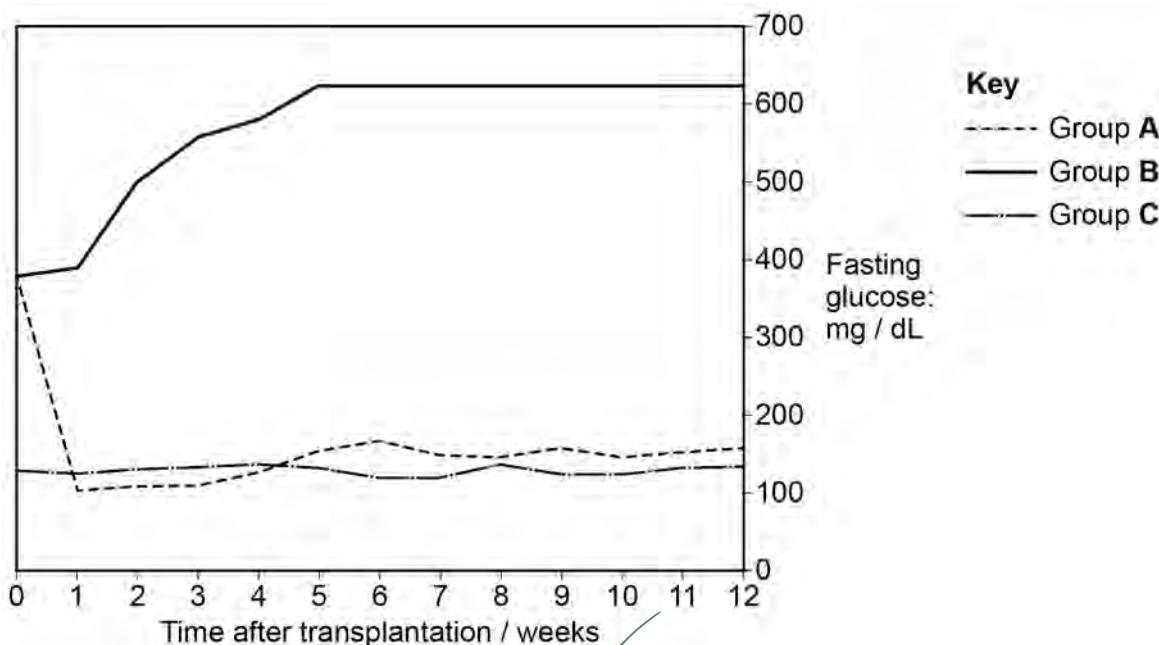
The scientists set up three experimental groups:

- 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]

* Bind to promoter regions of specific parts of DNA to undo differentiation of pluripotent stem cell into skin cell

Inhibit RNA polymerase binding so no expression of "Skin cell genes"



0 6 . 4

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

[4 marks]

- Group A mice treated by iPS cells had much lower fasting glucose than untreated and very close to healthy so treatment was effective
- Only after 1st week so takes time for treatment to work
- Only done on mice → may not work as well or at all in humans
- No stats test done + only 30 per group so results may not be significant
- Could have side effects not shown in graph
- May not work in long term/ past 12 weeks.

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2 1

IB/M/Jun17/E5

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

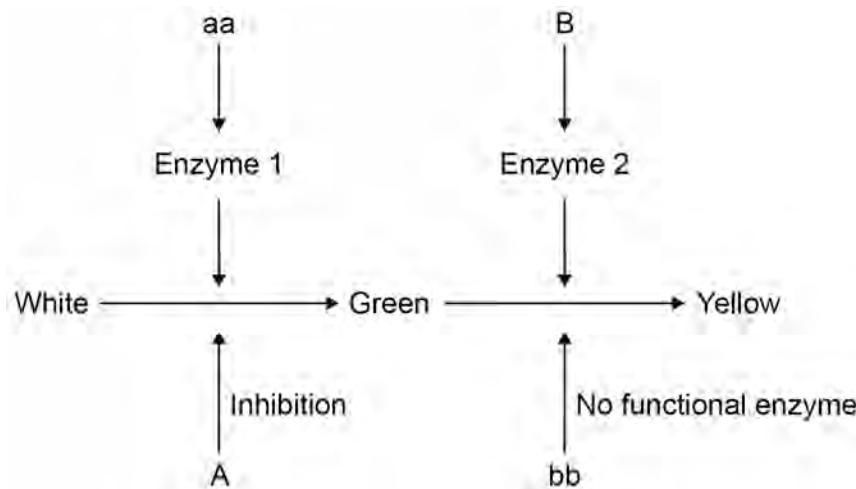
1
[2 marks]

Observable characteristic caused by the expression of an allele or environment

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]

Epistasis

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

[1 mark]

AA^bb White ✓

aaBB Yellow ✓



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

	a b
A b	A- bb
A B	Aa Bb
a b	aa bb
a B	aa Bb

Genotypes of offspring A- bb, A- Bb, aa bb, aa Bb

Phenotypes of offspring white, green, yellow

Ratio of phenotypes 2 : 1 : 1

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.

all have aa

[2 marks]

$$\text{green} = bb = 0.64$$

$$p^2 = 0.64$$

$$p = 0.8$$

$$q = 0.2$$

$$2 \times 0.2 \times 0.8 \times 100 = 32\%$$

Answer = 32 %

9
9

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2 3

0 8

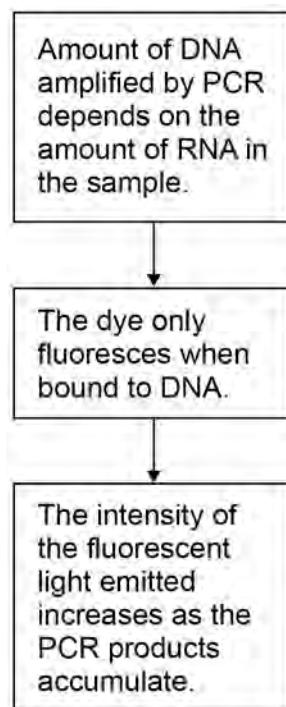
One way to detect and measure accurately the amount of RNA in a tissue sample is by RT-PCR (reverse transcriptase-polymerase chain reaction).

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]

Converts RNA to DNA to be amplified
by PCR



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

[1 mark]

Catalyses phosphodiester bond formation between
free nucleotides bond to expose DNA to
synthesise new DNA strand

- 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]

To ensure it is single stranded
and short enough for primers and
free DNA nucleotides to bind to
Remove DNA present and avoid it being
amplified

Question 8 continues on the next page

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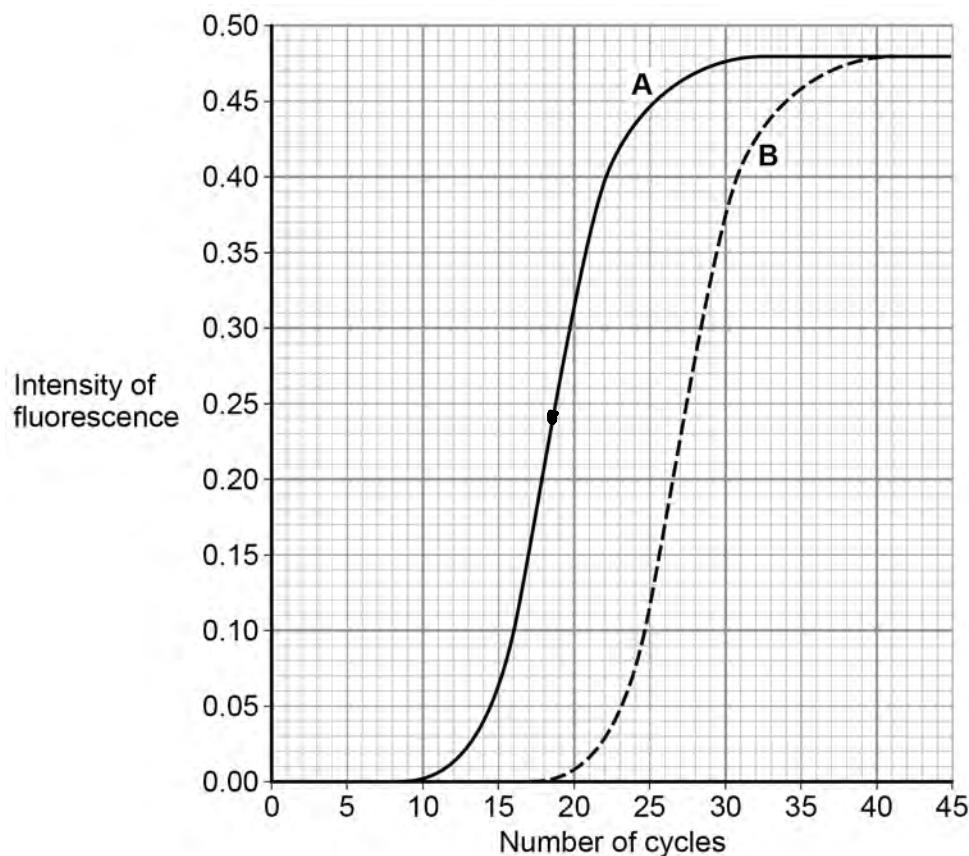


2 5

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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: $\frac{1}{C}$

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

[2 marks]

Max conc at 0.46
at 0.24
 $C_A = 18.5 \quad C_B = 27$

$$\frac{1}{18.5} : \frac{1}{27}$$

$$\frac{2}{37} : \frac{1}{27}$$

$$1 : 0.685$$

$$1.46 : 1$$

Answer = 1 : 0.685

X



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

[**1** mark]

Temperature too high for polymerase enzyme
to work

Not enough nucleotides?

- 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]

Different viruses will have different RNA
so different DNA with different promoter regions
and each prime complementary to one type of
DNA's promoter region so variety needed.

4

9

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2 7

IB/M/Jun17/E5

0 9 . 1 What is a gene pool?

[1 mark]

Number of different alleles in a population

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]

2 populations are on different parts of the island so isolated and no gene flow between them. Each population has different random mutations and different selection pressures so different reproductive success. This means frequency of diff alleles increases in each population until they either cannot produce fertile offspring and/or do not recognise each other as mating partners.

Same habitat - Sympatric

5
6



2 8

IB/M/Jun17/E5

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. 5 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 10 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 15 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 20 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).

$$3.1536 \times 10^7 \text{ seconds} \curvearrowright 2014$$

[2 marks]

$$\div 30 \\ 1051200 \text{ new AD}$$

check
answer?

$$100 \times \frac{1051200}{5.4 \times 10^6} = 20.6118 \\ 19.4\%$$

Answer 20.6 %

Question 10 continues on the next page

Turn over ►



1 0 . 2

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

2 [3 marks]

- * Less acetylcholinesterase means acetylcholine is broken down at a slower rate so stays attached to receptors in post synaptic hub so temporal summation of signals leads to better synaptic transmission and communication between nerve cells. More Na^+ enters for action potential
- * Inhibited by donepezil

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 On mountain so more exposure to UV rays so most mutations
- 2 Allele inherited from shared ancestor
- 3 Isolated so less genetic variation and therefore more likely for allele frequency to increase

1 0 . 4

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

[2 marks]

Causes AD onset at 49 years on average so does not prevent those with the allele reaching reproductive maturity and reproducing/passing down allele so no selection pressure against E280A allele.



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]

Different amount of expression of the gene due to different epigenetics so each individual will have different sets of methylation of genes

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]

Sample size of 204 because each of 102 has 2 copies of chromosome 14. The mutation without potential AD may have been too young, or had the effect of the mutation masked by another gene through epistasis. 1 person was homozygous dominant

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]

GCA triplet appears in other genes so probe will bind to other genes and show false positive for E280A.

END OF QUESTIONS

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3 1

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