



Please write clearly in block capitals.

Centre number

Candidate number

Surname _____

Forename(s) _____

Candidate signature _____

I declare this is my own work.

A-level BIOLOGY

Paper 2

Time allowed: 2 hours

Materials

For this paper you must have:

- a ruler with millimetre measurements
- a scientific 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.
- If you need extra space for your answer(s), use the lined pages at the end of this book. Write the question number against your answer(s).
- Show all your working.
- 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	



Answer all questions in the spaces provided.

0 1 . 1 Describe the process of glycolysis.

[4 marks]

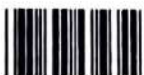
Glucose is phosphorylated by an ATP molecule. Then the resultant triose phosphate is oxidised to form two molecules of pyruvate. In this process ATP molecules are made, so that overall they counteract and more the initially used ATP molecules. So that, there is a net gain of ATP molecules from the process. Also, in this step NAD gets reduced into NADH.

0 1 . 2 Malonate inhibits a reaction in the Krebs cycle.

Explain why malonate would decrease the uptake of oxygen in a respiring cell.

[2 marks]

Less reduced NAD, so need more oxygen as its acting as the terminal electron acceptor!



0 2 . 1

Explain how a resting potential is maintained across the axon membrane in a neurone.

[3 marks]

At resting potential there is a higher concentration of sodium ions on the outside of a neurone and lower concentration of potassium than on the inside.

The membrane is more permeable to potassium ions diffusing out of the cell than for sodium ions to diffuse in. Also, sodium ions are transported out, while potassium gets transported out.

0 2 . 2

Explain why the speed of transmission of impulses is faster along a myelinated axon than along a non-myelinated axon.

[3 marks]

Myelination provides electrical insulation along the axon. So depolarisation occurs at the nodes only, while for non-myelinated it occurs all along its length.

Question 2 continues on the next page

Turn over ►



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outside the
box

0 2 . 3

A scientist investigated the effect of inhibitors on neurones. She added a respiratory inhibitor to a neurone. The resting potential of the neurone changed from -70 mV to 0 mV.

Explain why.

[3 marks]

Respiration is inhibited in the neurone so no ATP is produced. ATP is required by sodium and potassium pumps in active transport, to create the electrochemical gradient across the membrane. The diffusion of ions causes change to 0 mV.

9



0 3

Figure 1 shows an investigation into growth factors in plants.

Figure 1



Tip removed
from shoot
of plant



Then, tip replaced
on one side of
cut shoot



Then, growth curvature
occurred **without** a
directional light source

0 3 . 1

Use your knowledge of indoleacetic acid (IAA) to explain the growth curvature shown in Figure 1.

[3 marks]

Top of the plant produces IAA, which diffuses to
the shoot side down the plant shoot causing cells
to elongating on the side its in higher concentration.
This causes plant shoot to bend in a direction.

Question 3 continues on the next page

Turn over ►



A bioassay is a method to determine the concentration of a substance by its effect on living tissues.

Figure 2 shows the practical procedure used in a growth curvature bioassay to determine the concentration of IAA in shoot tips.

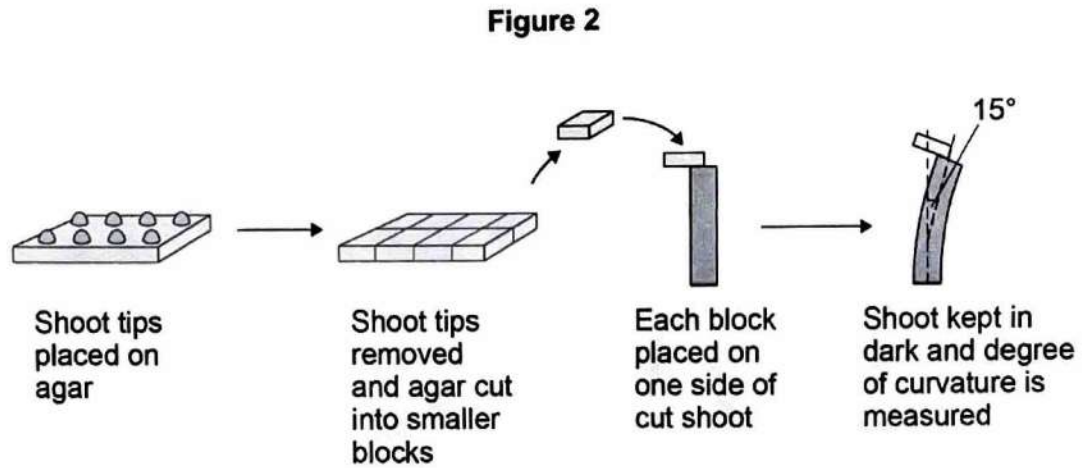
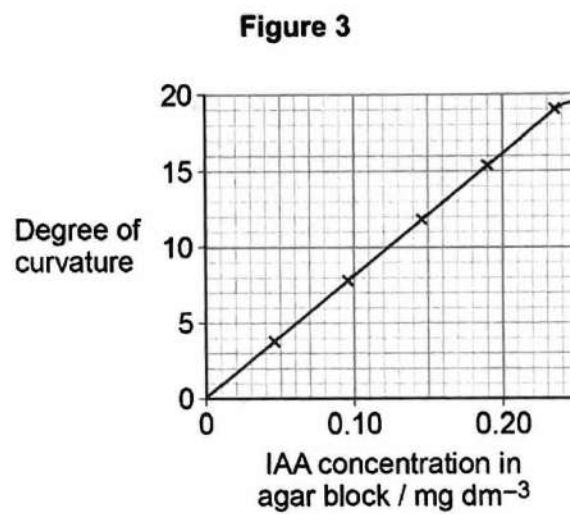


Figure 3 shows the calibration curve for this growth curvature bioassay.



0 3 . 2 Using the procedure in **Figure 2** and the calibration curve in **Figure 3**, describe how you could compare the IAA concentration in shoot tips from two different plant species.

In your answer you should refer to all the variables that should be controlled to produce a valid comparison.

[5 marks]

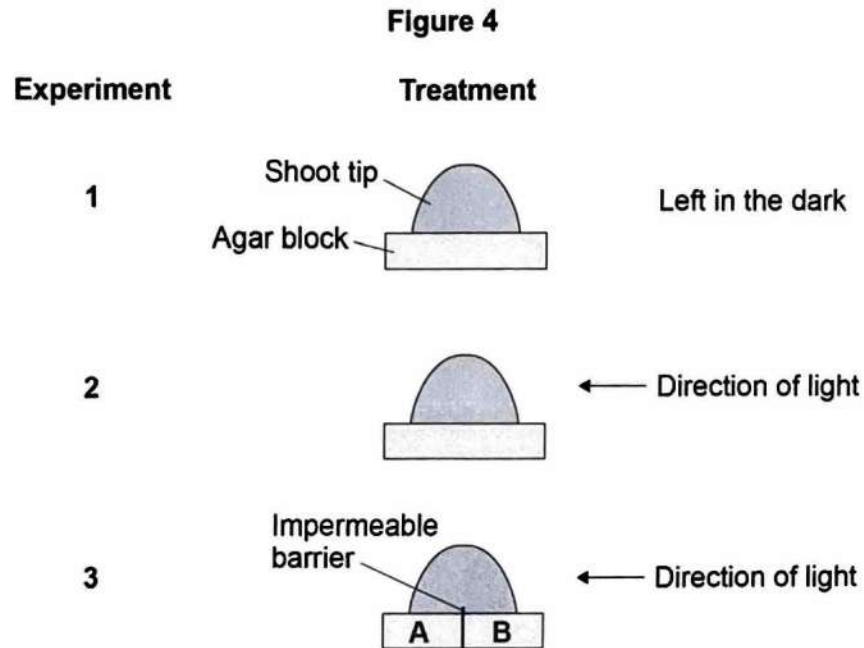
IAA causes curvature as the side it is in away. The more IAA is present in the agar block, the higher degree of curvature we will experience. To make the comparison valid you should use shoots from plants of the same developmental stage and cut of the same size from the shoot. The agar block should also be kept the same size between blocks tests. The conditions in the room, like temperature should be maintained at the same for all experiments. Measurements for the curvature should be taken exactly after the same time after the agar block has been placed.

Question 3 continues on the next page

Turn over ►



A scientist investigated the effect of a directional light stimulus on the distribution of IAA in shoot tips. The scientist set up three experiments as shown in **Figure 4**. All variables were controlled apart from exposure to light.



She then used the growth curvature bioassay to compare the IAA concentrations in the agar blocks from:

- experiment 1
- experiment 2
- experiment 3 section A
- experiment 3 section B.

Table 1 shows the scientist's results.

Table 1

Experiment	Degree of curvature in Bioassay / degrees
1	17.69
2	17.61
3A	11.22
3B	6.50



0 3 . 3

State **two** conclusions about IAA that you can make from the results shown in Table 1.

[2 marks]

- 1 IAA is not broken down by light
- 2 IAA moves away from the light to shaded side

10

Turn over for the next question

Turn over ►



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0 4

In fruit flies, males have the sex chromosomes XY and the females have XX. In fruit flies, a gene for eye colour is carried on the X chromosome. The allele for red eyes, R, is dominant to the allele for white eyes, r.

0 4 . 1

Male fruit flies are more likely than female fruit flies to have white eyes.

Explain why.

[2 marks]

Males have only one allele. Females have 2 alleles, both have to be recessive for the trait to show.

0 4 . 2

A female fruit fly with white eyes was crossed with a male fruit fly with red eyes to produce a large number of offspring.

Tick (✓) one box next to the statement which correctly describes the phenotypes produced from this cross.

[1 mark]

All offspring red-eyed

All females red-eyed, all males white-eyed

All males red-eyed, all females white-eyed

All males white-eyed, females red-eyed and females white-eyed



Do not write outside the box

In fruit flies, the genes for body colour and for wing development are **not** on the sex chromosomes. The allele for grey body colour, **G**, is dominant to the allele for black body colour, **g**. The allele for long wings, **L**, is dominant to the allele for short wings, **l**.

A geneticist carried out a cross between fruit flies with grey bodies and long wings (heterozygous for both genes) and fruit flies with black bodies and short wings.

Table 2 shows the results of this cross.

Table 2

Phenotype of offspring	Number of offspring
Grey body and long wings	223
Black body and short wings	218

0 4 . 3

Explain the results in **Table 2**.

[3 marks]

There is indication of the two genes being linked to each other. And no crossing over happens between chromatids chromosomes.

Question 4 continues on the next page

Turn over ►



0 4 . 4 The **first** generation of a population of fruit flies had 50 females.

Calculate how many female fruit flies would be produced from this population in the **fifth** generation.

You can assume:

- each female produces 400 offspring each generation
- half the offspring produced each generation are female
- there is no immigration or emigration
- no flies die before reproducing.

Show your working.

Give your answer in standard form.

[3 marks]

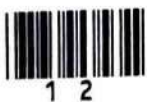
$$\frac{400}{2} = 200$$

$$5 \text{ generations so } 200^4 = 16\,000\,000\,000$$

$$16\,000\,000\,000 \times 50 = \underline{8 \times 10^{10}}$$

Answer 8 × 10¹⁰

9



0 5 . 1

Neonatal diabetes is a disease that affects newly born children. The disease is caused by a change in the amino acid sequence of insulin.

This change prevents insulin binding to its receptor. Explain why this change prevents insulin binding to its receptor.

[2 marks]

Amino acid sequence change changes the tertiary structure of a protein, so that it is no longer the right or complementary shape for it to bind to the receptor.

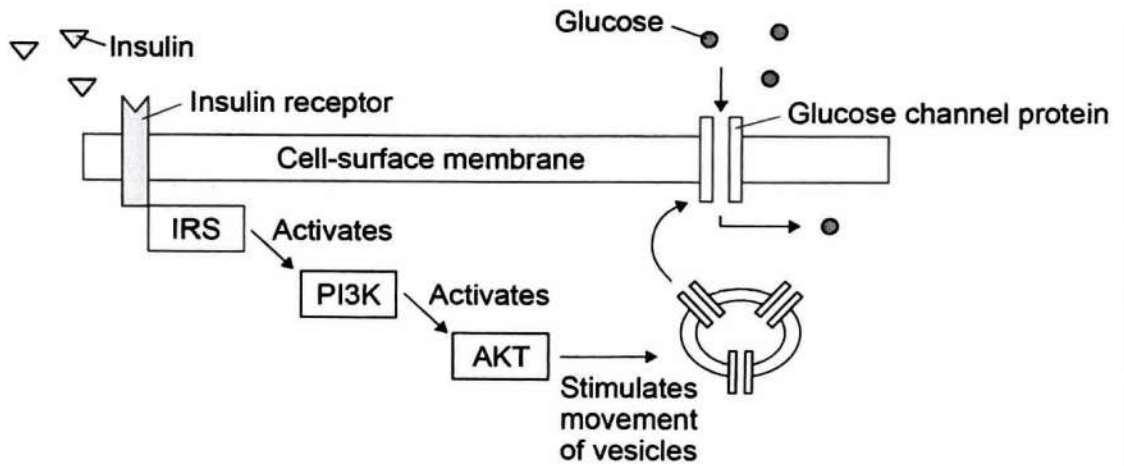
Question 5 continues on the next page

Turn over ►

Phosphoinositide 3-kinase (PI3K) is an enzyme in several metabolic processes.

Figure 5 shows the role of PI3K in the control of blood glucose concentration.

Figure 5



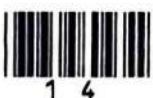
0 5 . 2

A decrease in the activity of PI3K can cause type II diabetes.

Use Figure 5 to explain why.

[3 marks]

Less PI3K activity means less AKT is activated.
 so less vesicles are stimulated to move to
 membrane and expose more glucose channel
 proteins. less glucose is transported into cells
 so blood glucose remains high.



0 5 . 3

Using your knowledge of the kidney, explain why glucose is found in the urine of a person with untreated diabetes.

[3 marks]

They will have a high concentration of glucose in their blood, so in the filtrate as well at kidneys. As concentration is high not all glucose is reabsorbed at the proximal convoluted tubule. The carrier proteins transport back into blood as much as they can, but at full capacity they still can't transport all. Glucose is left in urine therefore.

8

Turn over for the next question

Turn over ►



0 6

Myelodysplastic syndromes (MDS) are a group of malignant cancers. In MDS, the bone marrow does not produce healthy blood cells.

Haematopoietic stem cell transplantation (HSCT) is one treatment for MDS. In HSCT, the patient receives stem cells from the bone marrow of a person who does not have MDS. Before the treatment starts, the patient's faulty bone marrow is destroyed.

0 6 . 1

For some patients, HSCT is an effective treatment for MDS.

Explain how.

[3 marks]

No more faulty, cancerous cells produced as previous bone marrow is destroyed. But, will have healthy blood cells as stem cells transplanted will replicate and become blood cells.

0 6 . 2

MDS can develop from epigenetic changes to tumour suppressor genes. In some patients, the drug AZA has reduced the effects of MDS. AZA is an inhibitor of DNA methyltransferases. These enzymes add methyl groups to cytosine bases.

Suggest and explain how AZA can reduce the effects of MDS in some patients.

[3 marks]

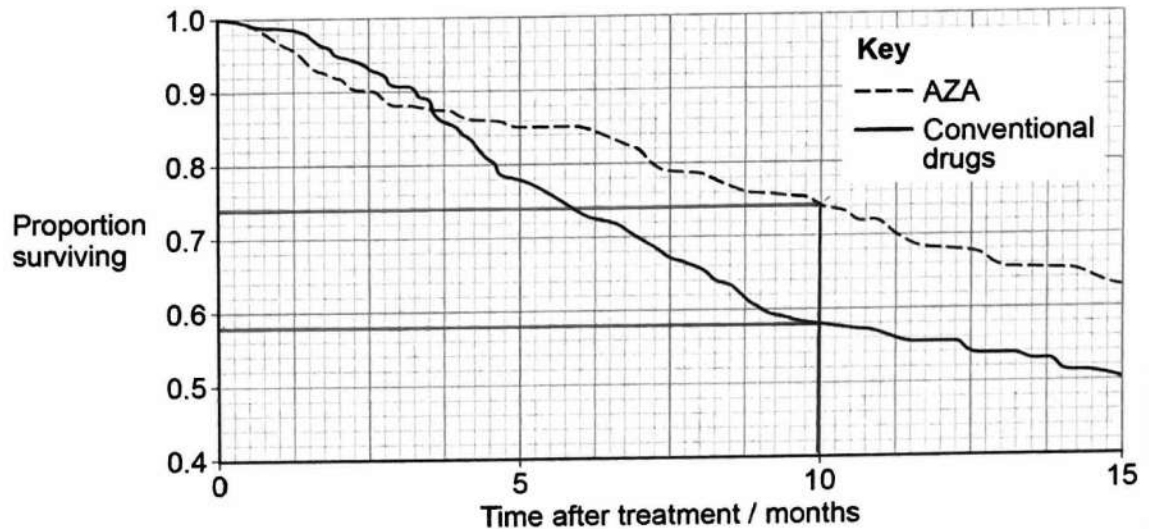
AZA reduces the methylation of tumour suppressor genes. So these genes can be expressed again. These genes will then act as tumour suppressors suppressing the rapid out of control division of cells.



Scientists investigated the effectiveness of AZA in patients with MDS. A total of 360 patients were randomised in the ratio of 1:1 to receive AZA or conventional drugs (control).

Figure 6 shows the scientists' results.

Figure 6



0 6 . 3 The control patients were treated with conventional drugs.

Give two reasons why.

[2 marks]

- Allows for comparison between AZA and conventional drug.
- It would be unethical to ~~treat~~ not treat control group at all.

0 6 . 4 Use Figure 6 and the information provided to calculate the difference in the number of patients surviving at 10 months after treatment with AZA compared with conventional drugs.

[2 marks]

AZA - 0.74 portion survives ¹⁸⁰

Conventional - 0.58 portion survives.

$$\frac{360}{2} = 180 \text{ in each}$$

$$180 \times 0.74 = 133.2$$

$$180 \times 0.58 = 104.4$$

$$133.2 - 104.4 = 28.8$$

Can't have 0.8 person so round to 29

Answer 29

10

Turn over ►

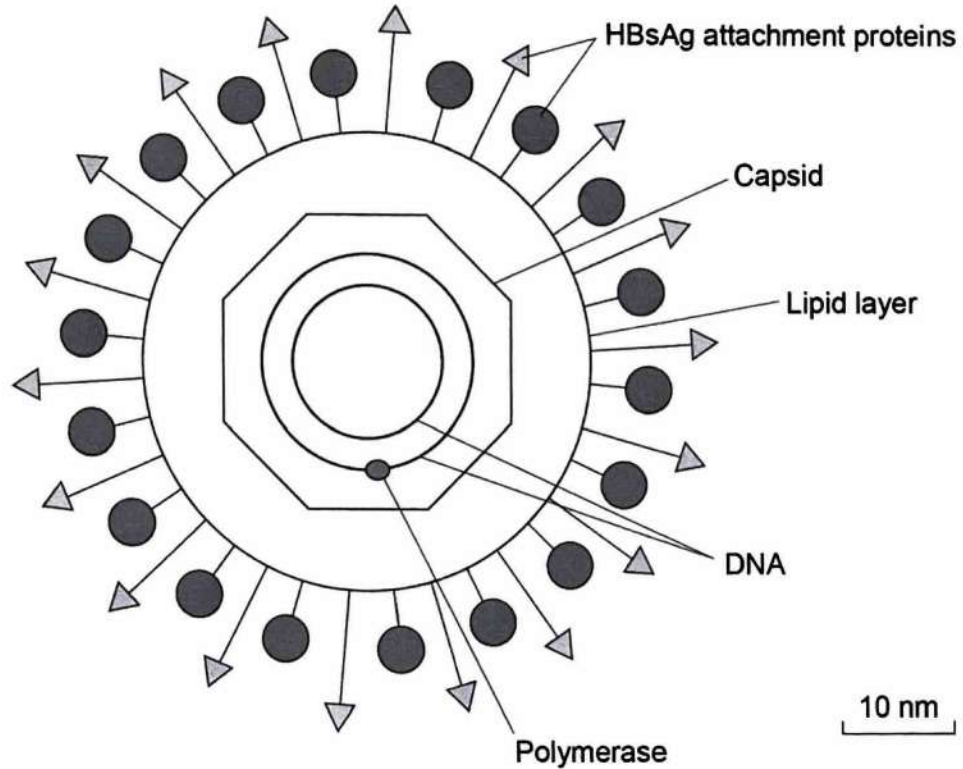


07

Hepatitis B is a life-threatening liver infection caused by the hepatitis B virus (HBV).

Figure 7 shows the structure of HBV.

Figure 7



07.1

HBV infects a liver cell. The liver cell is $25\mu\text{m}$ in diameter.

Use Figure 7 to calculate how many times larger in diameter this cell is than HBV. You should use the lipid layer to measure the diameter of HBV.

[2 marks]

$$\text{HBV} = 60 \text{ nm on diagram}$$

$$\frac{60}{15} = 40 \text{ nm}$$

$$1 \mu\text{m} = 1000 \text{ nm}$$

$$25 \mu\text{m} = 25000 \text{ nm}$$

$$\frac{25000 \text{ nm}}{40 \text{ nm}} = \underline{\underline{625}}$$

Answer 625 times larger



Scientists investigated the effectiveness of two types of RNA interference (RNAi) molecules on reducing HBV replication. These molecules were:

- short hairpin RNA (shRNA)
- long hairpin RNA (lhRNA).

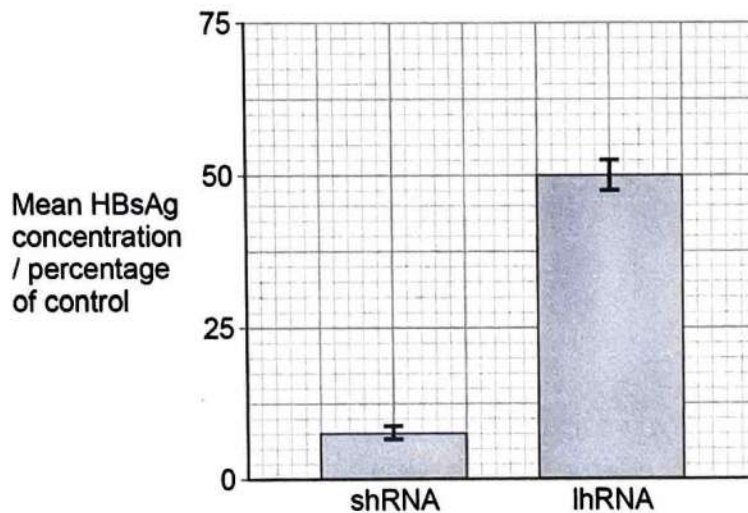
The scientists infected mouse liver cells with HBV and transferred either shRNA or lhRNA into these cells. Then they determined the concentration of the attachment proteins, HBsAg, in these cells.

The concentration of HBsAg is a measure of HBV replication.

Figure 8 shows the scientists' results.

The error bars represent ± 2 standard deviations from the mean, which includes over 95% of the data.

Figure 8



07.2

One method of transferring RNAi molecules into cells involves combining these molecules with a lipid. Suggest why this increases uptake of RNAi molecules into cells.

[1 mark]

Cell membrane is a phospholipid bilayer, so no channel protein is needed.

Question 7 continues on the next page

Turn over ►



07.3

Using all the information provided, evaluate the use of the two types of RNAi in treating hepatitis B in humans.

Do not refer in your answer to how RNAi reduces HBV replication.

[5 marks]

Both are more effective than the control, but replication is still not zero, as HBsAg level is only reduced. There is a significantly higher effectiveness of shRNA than LRNA by 42.5% difference. This difference is not due to chance as standard deviations do not overlap.



0 8 . 1

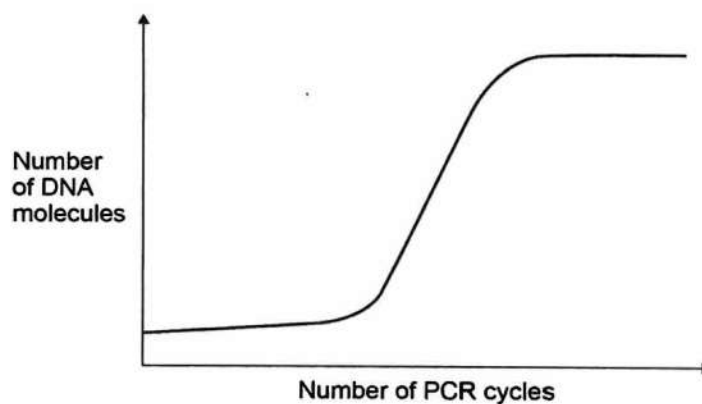
Describe and explain how the polymerase chain reaction (PCR) is used to amplify a DNA fragment.

[4 marks]

Add the sample DNA to DNA polymerase and nucleotides and primers. Heat mixture to 95°C to break hydrogen bonds between DNA strands. Then reduce temperature, to allow primers to attach to template strands. Then increase temperature again to $70-75^{\circ}\text{C}$ to make it ideal for DNA polymerase to join nucleotides. Repeat the same process several times to get replicated over again.

Figure 9 shows the number of DNA molecules produced using a PCR.

Figure 9



0 8 . 2

Explain the shape of the curve in Figure 9.

[2 marks]

Initially there are few template strands that can be used in replication, but as it doubles every time eventually replicating exponentially. It plateaus as free nucleotides run out and also the primers,

Turn over ►



0 9

A coral reef is an underwater ecosystem formed as a ridge of mainly calcium carbonate deposits. Algae are photosynthesising organisms. Some algae grow on coral reefs. Succession results in a wide variety of fish living on coral reefs.

0 9 . 1

Describe a method that could be used to determine the mean percentage cover of algae on a coral reef.

Do **not** include information on the difficulties of using your method underwater.

[3 marks]

Place quadrats randomly by generating random coordinates. Repeat with several other coordinates to sample several other quadrats. Then divide the total percentage cover by the number of quadrats that have been placed.

0 9 . 2

Explain how succession results in a wide variety of fish living on coral reefs.

Do **not** describe the process of succession in your answer.

[2 marks]

As the diversity of species increases it increases the number of new niches provided by the ~~total~~ habitat open, providing conditions for even greater variety of organisms to live there, hence increasing diversity even further.



Ecologists investigated the effect of two fish species, the redband parrotfish and the ocean surgeonfish, on algal growth on an artificial reef. They made this artificial reef by submerging many large concrete blocks at a depth of 16–18 metres off the coast of Florida. They attached four large wire cages, **A**, **B**, **C** and **D**, to each block and populated the cages as shown.

A – No fish

B – Two redband parrotfish

C – Two ocean surgeonfish

D – One redband parrotfish and one ocean surgeonfish

After 34 weeks, the ecologists measured the mean percentage cover of all algae within each set of wire cages. The ecologists used a statistical test to find out whether the mean for each set of cages was significantly lower than the mean for set **A**.

Table 3 shows the probability (*P*) values that the ecologists obtained using this statistical test.

Table 3

Set of cages	<i>P</i> value
B	=0.841
C	<0.001
D	=0.634

09.3

Using all the information, evaluate the effect of the two fish species on algal growth on coral reefs.

[5 marks]

C is less than 0.05 so there is less than 5% of chance it's due to chance. So surgeon fish alone do decrease the percentage cover of algae. However, **B** and **C** are not significantly different, suggesting parrotfish alone does not make a significant change, neither does it alone with just 1 parrot surgeonfish. We can not say for sure this is true for everywhere, as it was only conducted in Florida. Also species of algae is not considered, different algae may be affected differently.

10

Turn over ►



1 0

Read the following passage.

Lake Malawi in East Africa has more species of fish than any other lake in the world. Many of these species have evolved from a common ancestor. Lake Malawi is one of the largest lakes in the world and was formed several million years ago. Since then, the water level has fluctuated greatly. As a result, what is now a large lake was at one time many smaller, separate lakes. 5

The country of Malawi has a total area of 118 000 km². The actual land area is only 94 080 km², because approximately one-fifth of the country is Lake Malawi.

In December 1990, forests covered 41.4% of the actual land area of Malawi. In December 2016, forests covered 26.4% of the actual land area of Malawi. 10

Deforestation and farming along the shores of Lake Malawi have caused increased soil erosion and loss of nutrients into the lake. This has resulted in a decrease in some fish populations. The mark-release-recapture method can be used to estimate the size of a fish population. However, this method can produce unreliable results in very large lakes. 15

Use the information in the passage and your own knowledge to answer the following questions.

1 0

1

Lake Malawi in East Africa has more species of fish than any other lake in the world (line 1).

Suggest and explain how this speciation may have occurred.

[4 marks]

There is natural variation in any population, arising due to mutations. ~~to individuals~~ When the lakes are at lower levels different populations go through allopatric speciation. The two smaller lakes are subject to different conditions of the environment. There is no gene flow between the populations and they are reproductively isolated. Different alleles are selected for over time due to different selection pressures in each. Over time two populations change so much they become separate species, so can't produce fertile offspring anymore.



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outside the
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- 1 0 . 2 The percentage of forest cover in Malawi decreased between December 1990 and December 2016 (lines 9–10).

Calculate the mean loss of forest cover in km² per week during this time period.

$$94080 \text{ km}^2 \quad 41.4\% - 26.4\% = 15\% \quad [2 \text{ marks}]$$

$$94080 \times 0.15 = \underline{14112 \text{ km}^2 \text{ lost}}$$

$$2016 - 1990 = \underline{26 \text{ years}} \quad 26 \times 52 =$$

$$\frac{14112}{26 \times 52} = 10.43786... \text{ km}^2/\text{w} \rightarrow 10.4 \text{ km}^2/\text{w}$$

Answer 10.4 km² per week

- 1 0 . 3 Loss of nutrients into Lake Malawi has resulted in a decrease in some fish populations (lines 12–13).

Explain why.

[4 marks]

Nutrients leaching into the lake provide conditions for algal bloom, blocking light from plants living in the lake. These plants die and saprobionts break them down ~~or~~ aerobically, using up oxygen from the water. This leaves less oxygen for fish to use in respiration, so they die.

Turn over ►



- 1 0 . 4 The mark-release-recapture method can be used to estimate the size of a fish population (lines 13–14).

Explain how.

[4 marks]

Capture a number of individuals from the population, mark them and release them back. This marking should not affect their chances of survival or their life. Leave fish for sufficient time to randomly distribute again. Then collect a second sample recording how many already have the marking from the first sampling. Use:

$$\text{Population} = \frac{\text{no. in first sample} \times \text{no. in second sample}}{\text{no. recaptured}}$$

to calculate population size.

- 1 0 . 5 Suggest why the mark-release-recapture method can produce unreliable results in very large lakes (lines 14–15).

[1 mark]

It is unlikely fish distribute randomly over such large distances.

15

END OF QUESTIONS

