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

Thursday 11 June 2020 Morning 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** | |

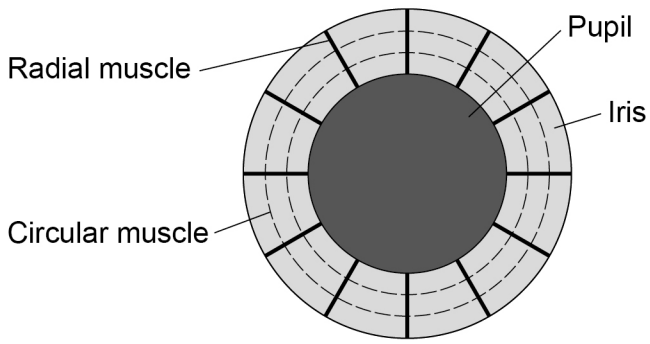
Do not write outside the box

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

**0 1** The iris in the human eye is a muscular structure. The iris changes the size of the pupil.

**Figure 1** shows the muscles in the iris.

**Figure 1**




**0 1 . 1** Suggest and explain how the interaction between the muscles labelled in **Figure 1** could cause the pupil to constrict (narrow).

**[2 marks]**

Do not write outside the box

**0 1 . 2** The fovea of the eye of an eagle has a high density of cones. An eagle focuses the image of its prey onto the fovea.

Explain how the fovea enables an eagle to see its prey in detail.

Do **not** refer to colour vision in your answer.

**[3 marks]**

**0 1 . 3** The retina of the human eye has an area of approximately $1.094 \times 10^3$ mm$^2$

The circular fovea in a human eye has a diameter of $3 \times 10^3$ μm

Calculate the area of the fovea as a percentage of the area of the retina.

The area of a circle is $\pi r^2$. Use $\pi = 3.14$ in your calculation.

Show your working.

**[2 marks]**

Answer _____ %

**Question 1 continues on the next page**

Do not write outside the box

**0 1 . 4** The retina of an owl has a high density of rod cells.

Explain how this enables an owl to hunt its prey at night.

Do **not** refer to rhodopsin in your answer.

**[3 marks]**

10

Do not write outside the box

**0 2** Testosterone is a steroid hormone that belongs to a group of male sex hormones called androgens.

**0 2 . 1** Steroid hormones are hydrophobic.

Explain why steroid hormones can rapidly enter a cell by passing through its cell-surface membrane.

**[2 marks]**

**0 2 . 2** In the cytoplasm, testosterone binds to a specific androgen receptor (AR). An AR is a protein.

Suggest and explain why testosterone binds to a specific AR.

**[2 marks]**

**Question 2 continues on the next page**

Do not write outside the box

**0 2 . 3** The binding of testosterone to an AR changes the shape of the AR. This AR molecule now enters the nucleus and stimulates gene expression.

Suggest how the AR could stimulate gene expression.

**[2 marks]**

The gene that codes for the AR has a variable number of CAG repeats.
Some studies have shown an association between the number of CAG repeats and the risk of developing prostate cancer.

**Table 1** shows the results of a statistical test from one study.

**Table 1**

| **Number of CAG repeats in the *AR* gene** | **Probability (P) value** |
|---|---|
| ⩽ 16 | 0.02 |
| ⩽ 17 | 0.30 |
| ⩽ 18 | 0.07 |
| ⩽ 19 | 0.09 |
| ⩾ 20 | 0.06 |

**0 2 . 4** What can you conclude from the data in **Table 1**?

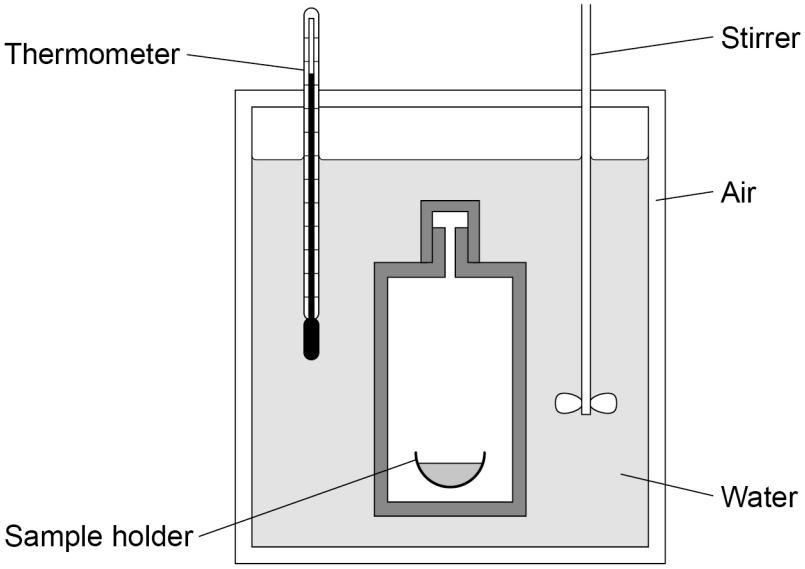
**[3 marks]**

9

Do not write outside the box

**0 3** **Figure 2** shows one type of calorimeter.

**Figure 2**




A calorimeter can be used to determine the chemical energy store of biomass.
A known mass of biomass is fully combusted in a calorimeter. The heat energy released from this combustion increases the temperature of the water in the calorimeter. The increase in the temperature of a known volume of water is recorded.

**0 3 . 1** Other than the thermometer, explain how **two** features of the calorimeter shown in **Figure 2** would enable a valid measurement of the total heat energy released.

**[2 marks]**

1 _____

_____

_____

2 _____

_____

_____

**Question 3 continues on the next page**

Do not write outside the box

**0 3 . 2** A 2 g sample of biomass was fully combusted in a calorimeter.

The volume of water in the calorimeter was 100 $cm^3$

The increase in temperature recorded was 15.7 °C

4.18 J of energy are needed to increase the temperature of 1 $cm^3$ of water by 1 °C

Use this information to calculate the heat energy released in kJ per g of biomass.

Show your working.

**[2 marks]**

Answer _____ $kJg^{-1}$

Plants and algae produce fuels called biofuels. Scientists have used *Chlorella* to produce biofuel. *Chlorella* is a genus of single-celled photosynthetic alga. *Chlorella* can be grown in open ponds and fermenters.

**0 3 . 3** In natural ecosystems, most of the light falling on producers is **not** used in photosynthesis.

Suggest **two** reasons why.

**[2 marks]**

1 _____

_____

_____

2 _____

_____

_____

Do not write outside the box

**0 3 . 4** The light absorbed by chlorophyll is used in the light-dependent reaction.

Name the **two** products of the light-dependent reaction that are required for the light-independent reaction.

**[2 marks]**

1 _____

2 _____

**0 3 . 5** *Chlorella* cells can divide rapidly. A culture of 2000 *Chlorella* cells was set up in a fermenter. The cells divided every 90 minutes.

You can assume that there were no limiting factors and that no cells died during the 24 hours.

Calculate the number of cells in the culture after 24 hours.

Give your answer in standard form.

Show your working.

**[2 marks]**

10

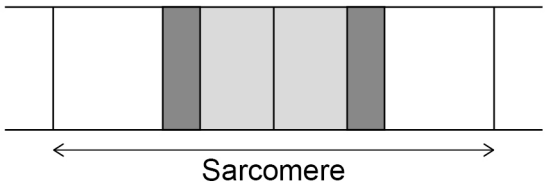
Answer _____

**Turn over for the next question**

Do not write outside the box

**0 4** **Figure 3** shows the banding pattern of a single sarcomere.

**Figure 3**




**0 4 . 1** Explain the banding pattern shown in **Figure 3**.

**[3 marks]**

Do not write outside the box

Creatinine is produced in muscle tissues. Creatinine diffuses into the blood. The kidneys then excrete creatinine.

A calibration curve can be used to determine the concentration of creatinine in urine. One method of producing a calibration curve needs:

- creatinine solution of known concentration
- distilled water
- creatinine-detecting solution
- a colorimeter.

Creatinine-detecting solution reacts with creatinine to produce an orange colour.

**0 4 . 2** Use the information provided to describe how you could produce a calibration curve for creatinine.

Do **not** include details on the use of glassware in your answer.

**[4 marks]**

Do not write outside the box

**0 4 . 3** Describe how you would determine the concentration of creatinine in a urine sample using your calibration curve.

**[2 marks]**

9

Do not write outside the box

**0 5** Describe the sequence of events involved in transmission across a cholinergic synapse.

Do **not** include details on the breakdown of acetylcholine in your answer.

**[5 marks]**

5

Do not write outside the box

**0 6 . 1** Mutation is one cause of genetic variation in organisms.

Give **two** other causes of genetic variation.

**[2 marks]**

1 _____

_____

2 _____

_____

In a species of flowering plant, the **T** allele for tallness is dominant to the **t** allele for dwarfness. In the same species, two alleles $\mathbf{C^R}$ (red) and $\mathbf{C^W}$ (white) code for the colour of flowers. When homozygous red-flowered plants were crossed with homozygous white-flowered plants, all the offspring had pink flowers.

**0 6 . 2** Name the relationship between the two alleles that code for flower colour.

**[1 mark]**

_____

Do not write outside the box

**0 6 . 3** A dwarf, pink-flowered plant was crossed with a heterozygous tall, white-flowered plant.

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

**[3 marks]**

Phenotypes of parents: Dwarf, pink-flowered × Tall, white-flowered

Genotypes of parents: _____ _____

Genotypes of offspring: _____

Phenotypes of offspring: _____

_____

Ratio of phenotypes: _____

**0 6 . 4** A population of this species of plant contained 9% of red-flowered plants.

Use the Hardy–Weinberg equation to calculate the percentage of pink-flowered plants in this population.

Show your working.

**[2 marks]**

Answer _____ %

8

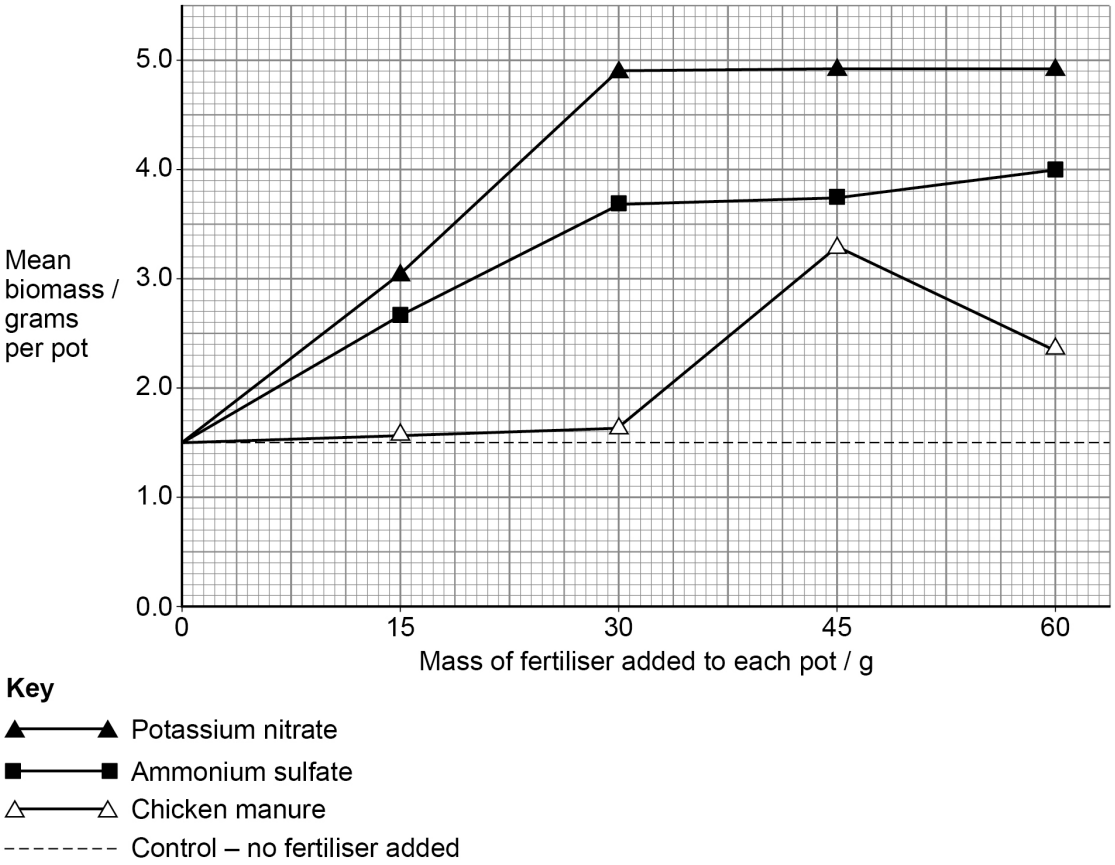
Do not write outside the box

**0 7** A scientist investigated the effects of different fertilisers on the growth of spinach plants. The scientist:

- set up a large sample of identical pots of soil
- added different masses of different fertilisers to selected pots
- did not add fertiliser to the control pots
- planted the same number of young spinach plants in each pot
- after 20 days, determined the biomass of spinach plants in each pot.

The results the scientist obtained after 20 days are shown in **Figure 4**.

**Figure 4**




**0 7 . 1** Calculate how many times greater the mean growth rate per day was using 37.5 g potassium nitrate than using 37.5 g ammonium sulfate.

Assume the mean biomass of the spinach plants at the start of the investigation was 0.5 g per pot.

**[1 mark]**

Answer _____

Do not write outside the box

**0 7 . 2** Using all the information, evaluate the effect on plant growth of adding the different fertilisers to the soil.

**[5 marks]**

**0 7 . 3** The scientist determined the dry mass of the spinach plants. First, he heated each sample at 80 °C for 2 hours.

Suggest what the scientist should do to ensure that he has removed all the water from the sample.

**[2 marks]**

8

Do not write outside the box

**0 8** Alport syndrome (AS) is an inherited disorder that affects kidney glomeruli of both men and women. Affected individuals have proteinuria (high quantities of protein in their urine).

**0 8 . 1** Suggest how AS could cause proteinuria.

**[2 marks]**

_____

_____

_____

_____

_____

_____

**0 8 . 2** AS results from a sex-linked mutation.

In a male with AS, where would the sex-linked mutation be located?

Tick (✓) **one** box.

**[1 mark]**

The homologous section of a Y chromosome ☐

The homologous section of an X chromosome ☐

The non-homologous section of a Y chromosome ☐

The non-homologous section of an X chromosome ☐

Do not write outside the box

Scientists investigated the use of transplanted stem cells to treat AS in mice.

The scientists set up four experimental groups.

Group **A** – 40 wild type* mice
Group **B** – 40 AS mice
Group **C** – 40 AS mice that received stem cells from AS mice
Group **D** – 40 AS mice that received stem cells from wild type mice

*Wild type mice are mice **not** affected by AS.

After 20 weeks, the scientists measured the quantity of protein in the urine using a scale from 0 (lowest quantity) to +++++ (highest quantity).

The results the scientists obtained are shown in **Table 2**.

**Table 2**

| Group | Maximum quantity of protein in urine at 20 weeks | Percentage of mice with this quantity of protein |
|---|---|---|
| **A** | 0 | 100 |
| **B** | +++++ | 97.5 |
| **C** | +++++ | 100 |
| **D** | ++ | 68 |

**0 8 . 3** Using all the information, evaluate the use of stem cells to treat AS in humans.

**[4 marks]**

**Answer space for this question continues on the next page**

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**0 8 . 4** The scientists carried out further work to investigate how the transplanted stem cells developed after transplantation.

- The scientists transplanted stem cells from wild type male mice into AS female mice.
- After 20 weeks, they found that the quantity of protein in the urine of these female mice had significantly decreased.
- They examined cells from glomeruli in the female mice. Some of these cells contained a Y chromosome.

Suggest how the transplanted stem cells reduce proteinuria.

**[2 marks]**

9

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**Turn over for the next question**

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**ANSWER IN THE SPACES PROVIDED**

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**0 9** A scientist produced transgenic zebrafish.

She obtained a gene from silverside fish. The gene codes for a growth hormone (GH).

She inserted copies of this *GH* gene into plasmids. She then microinjected these recombinant plasmids into fertilised egg cells of zebrafish.

**0 9 . 1** Describe how enzymes could be used to insert the *GH* gene into a plasmid.

**[2 marks]**

**0 9 . 2** Microinjection of DNA into fertilised egg cells is a frequent method of producing transgenic fish. However, the insertion of the transferred gene into nuclear DNA may be delayed. Consequently, the offspring of transgenic fish may not possess the desired characteristic.

Suggest and explain how delayed insertion of the *GH* gene could produce offspring of transgenic fish without the desired characteristic.

**[2 marks]**

Do not write outside the box

The scientist investigated whether the transferred *GH* gene increased the growth of transgenic zebrafish. She microinjected 2000 fertilised egg cells with the *GH* plasmid and left 2000 fertilised egg cells untreated. After 12 months, she determined the mean mass of the transgenic and non-transgenic fish.

The results the scientist obtained are shown in **Table 3**.

**Table 3**

A value of ±2 × SD from the mean includes over 95% of the data.

| **Type of zebrafish** | **Mean mass of zebrafish / g (± 2 × SD)** |
|---|---|
| Transgenic | 1.79 (± 0.37) |
| Non-transgenic | 0.68 (± 0.13) |

**0 9 . 3** Using **Table 3**, what can you conclude about the effectiveness of the *GH* gene on the growth of zebrafish?

**[2 marks]**

_____

_____

_____

_____

_____

_____

**0 9 . 4** Explain how **two** features of the design of this investigation helped to ensure the validity of any conclusions obtained.

Do **not** include calculating the mean or SD in your answer.

**[2 marks]**

1 _____

_____

2 _____

_____

8

**Turn over ►**

Do not write outside the box

**1 0** Read the following passage.

North American black bears can hibernate for up to 7 months without food or water. The bears survive using the fat stores in their bodies. The bears build up the fat stores during the summer. During hibernation, the heart rate of black bears decreases from a summer mean of 55 beats per minute to 14 beats per minute. Their metabolic rate falls by 75%. 5

In many mammals, 'uncoupling proteins' help to maintain a constant body temperature during hibernation. Uncoupling proteins are found in the inner mitochondrial membrane and act as proton channels during chemiosmosis. However, these proton channels do not generate ATP.

In the mountains of North America, when winter changes into spring, the coat 10 colour of snowshoe hares changes from white to brown. Climatic changes have caused the snow to melt earlier. This has reduced the survival rate of snowshoe hares in these habitats. The change in coat colour occurs when new fur replaces old fur. This is called moulting. Recent research has shown that snowshoe hares within a population moult at different times. Moulting at 15 different times could be a major factor in ensuring the survival of snowshoe hare populations.

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

**1 0 . 1** Black bears can hibernate for up to 7 months without food or water (lines 1–2).

Suggest and explain how.

**[3 marks]**

Do not write outside the box

**1 0 . 2** During hibernation, the heart rate and the metabolic rate of black bears decrease (lines 3–5).

Use your knowledge of the nervous control of heart rate to describe how these are linked.

**[4 marks]**

**1 0 . 3** In many mammals, 'uncoupling proteins' help to maintain a constant body temperature during hibernation (lines 6–7).

Suggest and explain how.

**[2 marks]**

**Question 10 continues on the next page**

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**1 0 . 4** Climatic change has reduced the survival rate of snowshoe hares in mountain habitats (lines 11–13).

Suggest and explain how.

**[2 marks]**

**1 0 . 5** Snowshoe hares within a population moult at different times (line 15).

Explain how this could ensure the survival of snowshoe hare populations in these mountain habitats.

**[4 marks]**

15

**END OF QUESTIONS**

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