Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
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**Pearson Edexcel Level 3 GCE**

Centre Number | Candidate Number

**Time** 2 hours

**Paper reference** **9BN0/03**

# Biology A (Salters Nuffield)

## Advanced

## PAPER 3: General and Practical Applications in Biology

**You must have:**
Ruler, HB pencil and scientific calculator and a copy of the scientific article adapted from National Geographic (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.*
- 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.

## 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.*

## 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.
- Good luck with your examination.

*Turn over*


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**Answer ALL questions.**

**Write your answers in the spaces provided.**

**1** Plants can respond to and use light.

The photograph shows a seedling starting to grow from a germinating seed.

(a) Explain why the seedling needs a supply of magnesium ions.

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(b) Describe the role of IAA (auxin) in the phototropic response of plants.

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**(Total for Question 1 = 6 marks)**

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**2** Acetylcholinesterase is an enzyme involved in regulating the transmission of nerve impulses across some synapses.

(a) Acetylcholinesterase is found on the cell surface membranes of neurones and red blood cells.

These acetylcholinesterase molecules have different primary structures.

In humans, a single gene codes for acetylcholinesterase.

(i) Explain how a single gene can give rise to acetylcholinesterase molecules with different primary structures.

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(ii) Explain how the acetylcholinesterase gene can be expressed in some tissues but not others.

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(b) Alzheimer's disease is associated with the loss of neurones that produce acetylcholine.

It has been suggested that inhibitors of acetylcholinesterase may be useful in the treatment of Alzheimer's disease.

(i) Explain why inhibitors of acetylcholinesterase could be useful in the treatment of Alzheimer's disease.

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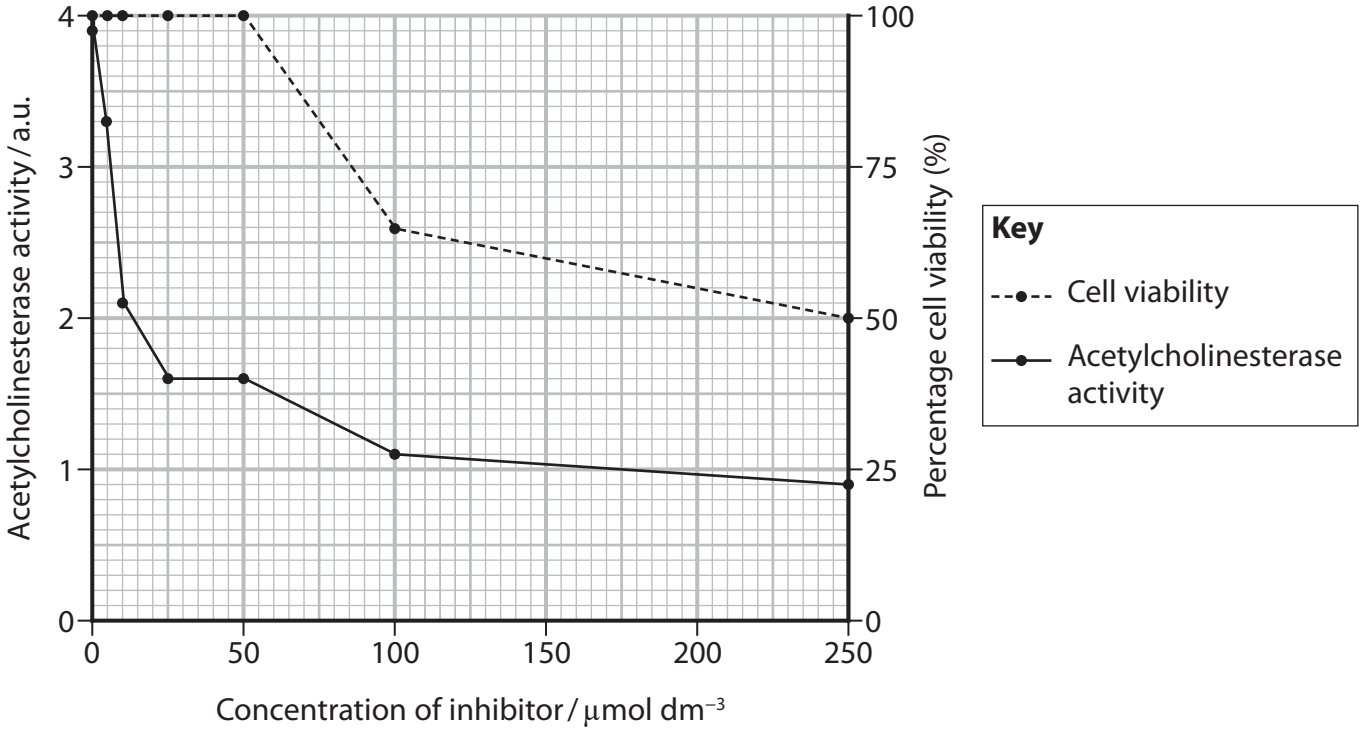
(ii) Trials of a new inhibitor were carried out using tissue cultures.

The effect of the concentration of the inhibitor on acetylcholinesterase activity and cell viability was measured.

Percentage cell viability was measured as the percentage of cells that were not killed by the inhibitor.

The graph shows the results for this inhibitor.




State and justify a suitable concentration of inhibitor to use in clinical trials.

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**(Total for Question 2 = 11 marks)**



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**3** Doctors sometimes prescribe beta-blockers for their patients.

Beta-blockers are a type of drug with antihypertensive properties.

(a) In one study, the effect of beta-blockers on the heart rate during exercise was investigated.

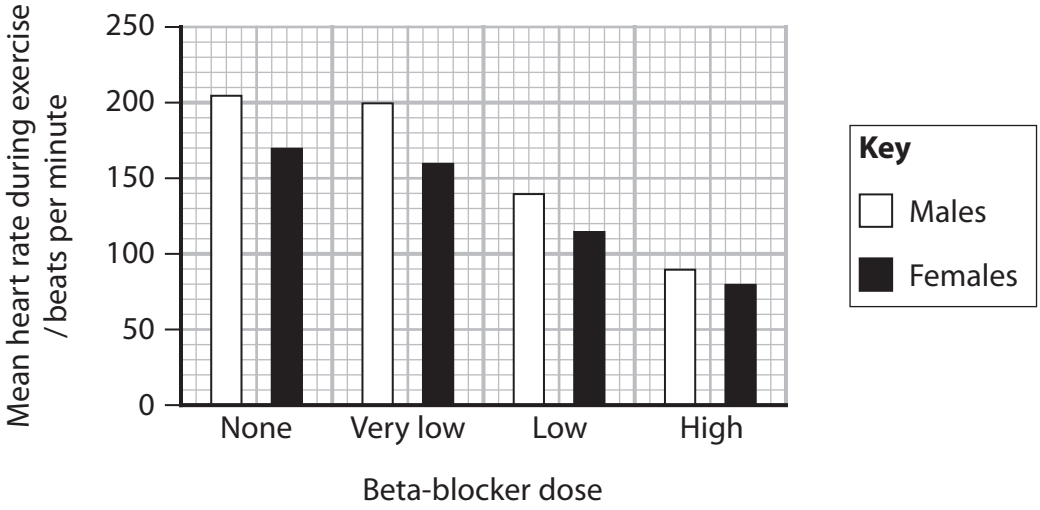
In this study, volunteers were placed randomly into one of four groups shown in the table.

| Group | Dose of beta-blocker |
|---|---|
| A | none |
| B | very low |
| C | low |
| D | high |

The heart rate of each volunteer was recorded during a period of exercise.

A mean value was calculated separately for the males and females in each group.

The graph shows the results of this study.




(i) Calculate the percentage change in male heart rate caused by increasing the dose of beta-blocker from very low to high.

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Answer .....

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(ii) Deduce the effect of beta-blockers on the supply of blood to muscle during exercise.

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(b) Explain why beta-blockers are prescribed for some people.

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(c) Beta-blockers work by blocking the effects of a hormone called adrenaline.

Adrenaline is produced by the adrenal glands located on top of each kidney.

Adrenaline acts on the heart to cause changes in heart rate.

Deduce how adrenaline can cause a change in heart rate.

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**(Total for Question 3 = 12 marks)**

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**4** Lipoprotein lipase is an enzyme found in different tissues including the brain.

(a) The enzyme lipoprotein lipase is involved in the metabolism of lipids in the brain.

The effect of temperature on lipid metabolism in the brain tissue of a species of fish was investigated.

The results of this investigation are shown in the table.

| Temperature / °C | Lipoprotein lipase mRNA / a.u. | Triglyceride concentration / mmol $mg^{-1}$ | Fatty acid concentration / μmol $mg^{-1}$ | Lipoprotein lipase activity per milligram of tissue / a.u. |
|---|---|---|---|---|
| 5 | 4.50 | 0.58 | 0.84 | 1.70 |
| 17 | 1.00 | 0.60 | 0.69 | 1.55 |
| 30 | 1.10 | 0.70 | 0.64 | 0.99 |

Comment on the effect of temperature on lipid metabolism in this species of fish.

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(b) Lipoprotein lipase can be extracted from brain tissue to investigate the effect of temperature on the rate of reaction of this enzyme.

(i) State what is meant by the term $Q_{10}$ temperature coefficient.

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(ii) Devise an investigation to determine $Q_{10}$ for an extract of lipoprotein lipase enzyme.

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**(Total for Question 4 = 9 marks)**

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**5** Forests are important habitats.

(a) The effect of cutting down trees on the number of bird species observed in two different forest habitats was investigated.

(i) Give two biotic factors, other than cutting down trees, that could affect the number of bird species observed in a forest.

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(ii) Some of the results of the investigation are shown in the table.

| Forest | Number of bird species in areas of the forest where no trees are cut down | Number of bird species in areas of the forest where some trees are cut down |
|---|---|---|
| A | 35 | 19 |
| B | 16 | 10 |

Calculate the Chi-squared value ($\chi^2$) for forest B using the formula shown.

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

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Answer .....

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(iii) The table gives some critical values for the Chi-squared test.

| Probability level | Critical value |
|---|---|
| 0.05 | 3.84 |
| 0.01 | 6.64 |
| 0.001 | 10.83 |

The Chi-squared value for forest A is 4.74.

Deduce the effect of some trees being cut down on the number of species of birds in these two forests.

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(b) Many forests are exploited by humans.

(i) Describe how forests can be managed as a sustainable resource.

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(ii) Explain the impact of cutting down trees on climate change.

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**(Total for Question 5 = 13 marks)**

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**6** The neurones of the central nervous system contain TAU proteins. These proteins help to maintain cell structure.

In humans, six different TAU proteins can be produced from a single gene.

Parkinson's disease has been linked to the different forms of the TAU proteins present in neurones.

Scientists are studying the effect of these different TAU proteins in animal models.

One model used is the fruit fly, *Drosophila*.

(a) Describe how *Drosophila* flies could be genetically modified to produce one form of the human TAU protein.

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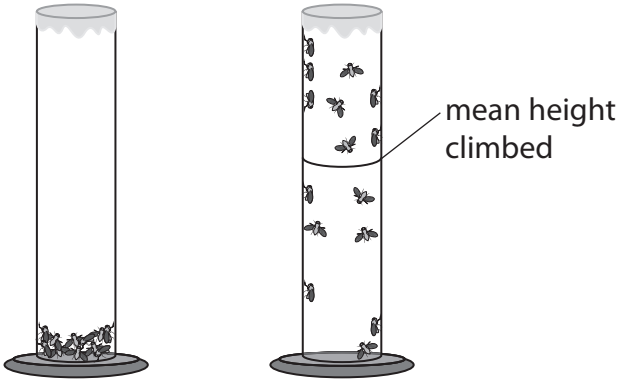
(b) In one investigation, the effect of ageing on *Drosophila* making different human TAU proteins was studied.

Flies making different forms of human TAU protein were tested in a climbing test.

- Fifteen one-day-old *Drosophila* flies were placed at the bottom of a measuring cylinder.
- A video recording was carried out and paused at 10 seconds. The height climbed by each fly was recorded.
- The test was repeated for flies of different ages.




time = 0 seconds  time = 10 seconds

The table shows the results of this investigation.

| Age of flies / days | Mean height climbed at 10 seconds / mm | | |
|---|---|---|---|
| | Control (no human TAU protein) | 0N3R TAU protein | 0N4R TAU protein |
| 1 | 60 ± 6 | 52 ± 5 | 54 ± 5 |
| 7 | 61 ± 4 | 43 ± 1 | 50 ± 4 |
| 14 | 53 ± 3 | 18 ± 2 | 28 ± 8 |
| 21 | 45 ± 9 | 12 ± 4 | 18 ± 5 |
| 28 | 32± 8 | 10 ± 5 | 19 ± 1 |
| 35 | 26 ± 9 | 3 ± 1 | 11 ± 1 |
| 42 | 15 ± 3 | 1 ± 1 | 3 ± 1 |

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Comment on the effect of TAU proteins on the ability of *Drosophila* flies to climb.

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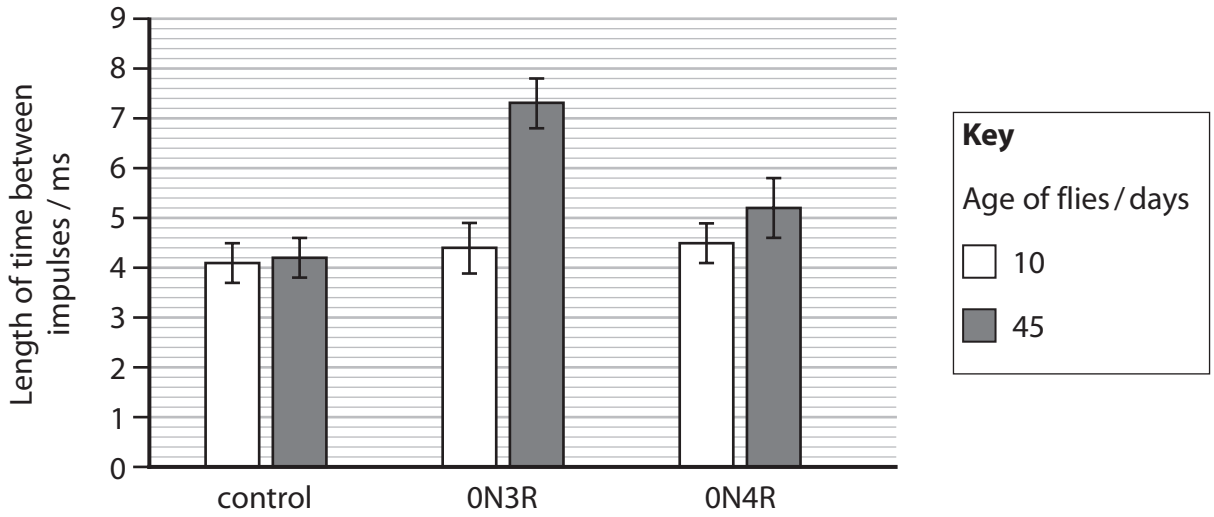
(c) In another investigation, the effect of these TAU proteins and age on the conduction of nerve impulses along the axon of neurones was studied.

The length of time between impulses was measured for *Drosophila* flies of different ages.

The results are shown in the graph.




Determine the effect of these TAU proteins on the maximum frequency at which nerve impulses can be conducted along the axon of the neurone.

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**(Total for Question 6 = 11 marks)**

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***7** Humans are complex multicellular organisms.

Cell division is involved in:

- the production of gametes
- the development of tissues
- the development of tumours
- the response to infection in humans.

The figure summarises some information about the organisation of cells in a human.

More than $3.7 \times 10^{13}$ cells in one human

↓

More than 200 different cell types

↓

Four main tissue types (each with many 'sub-types')

↓

At least 79 different organs

↓

Eleven different organ systems

The typical cell cycle for a human cell is about 24 hours. However, some cells can divide every eight minutes and others do not divide at all.

The table summarises some information about human genetics and cancers.

| | |
|---|---|
| Number of protein coding genes | Approximately 20 000 |
| Number of different genetic disorders | Approximately 2200 |
| Proportion of cancers caused by an inherited genetic defect | 5 to 10% |

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Evaluate the role of cell division in processes affecting human health and disease.

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**(Total for Question 7 = 9 marks)**

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

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

(a) Explain how two populations of mosquito could be shown to belong to different species (paragraph 4).

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(b) Explain why scientists believe CRISPR could be used to prevent AIDS developing in people infected with HIV (paragraph 7).

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(c) Describe how plant biologists could demonstrate the effect of deleting genes that attract pests to crops (paragraph 8).

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(d) Explain why the editing of the germ line of a human embryo would result in the changes being inherited by the next generation (paragraph 9).

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(e) Explain why an RNA guide can be used to identify the precise nucleotides that Cas9 has been sent to cut (paragraph 12).

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(f) Gene drives can be used to 'force almost any genetic trait through a population' (paragraph 16).

Multiple genetic crosses were carried out between individuals homozygous for a recessive allele and individuals heterozygous for the same gene.

Describe how the outcome of these crosses would be affected if a gene drive was used with the recessive allele.

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(g) Dengue is a disease caused by a virus carried by *Aedes aegypti*.

Using CRISPR and a gene drive, it may be possible to stop the reproduction of *Aedes aegypti* mosquitoes (paragraphs 20 and 21).

Explain why stopping the reproduction of this species of mosquito might not stop the spread of this disease.

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(h) Deduce how PERVs present in pig tissues could infect human cells (paragraph 25).

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(i) Explain why some pig genes can cause reactions in the human immune system (paragraph 27).

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(j) Explain how a vaccine developed against human plague can provide lifelong immunity to sylvatic plague in the black-footed ferret (paragraph 33).

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(k) State what is meant by the term endemic (paragraph 35).

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(l) Deduce the pattern of inheritance for Tay-Sachs disease (paragraph 39).

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**(Total for Question 8 = 29 marks)**

**TOTAL FOR PAPER = 100 MARKS**

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