Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | Candidate Number

Monday 15 June 2020

Morning (Time: 2 hours) | Paper Reference **9BN0/03**

Biology A (Salters Nuffield)

Advanced

Paper 3: General and Practical Applications in Biology

You must have:
Calculator, HB pencil, ruler and a copy of the scientific article adapted from *Scientific American* (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.*

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.*
- 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.

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.

Turn over ▶

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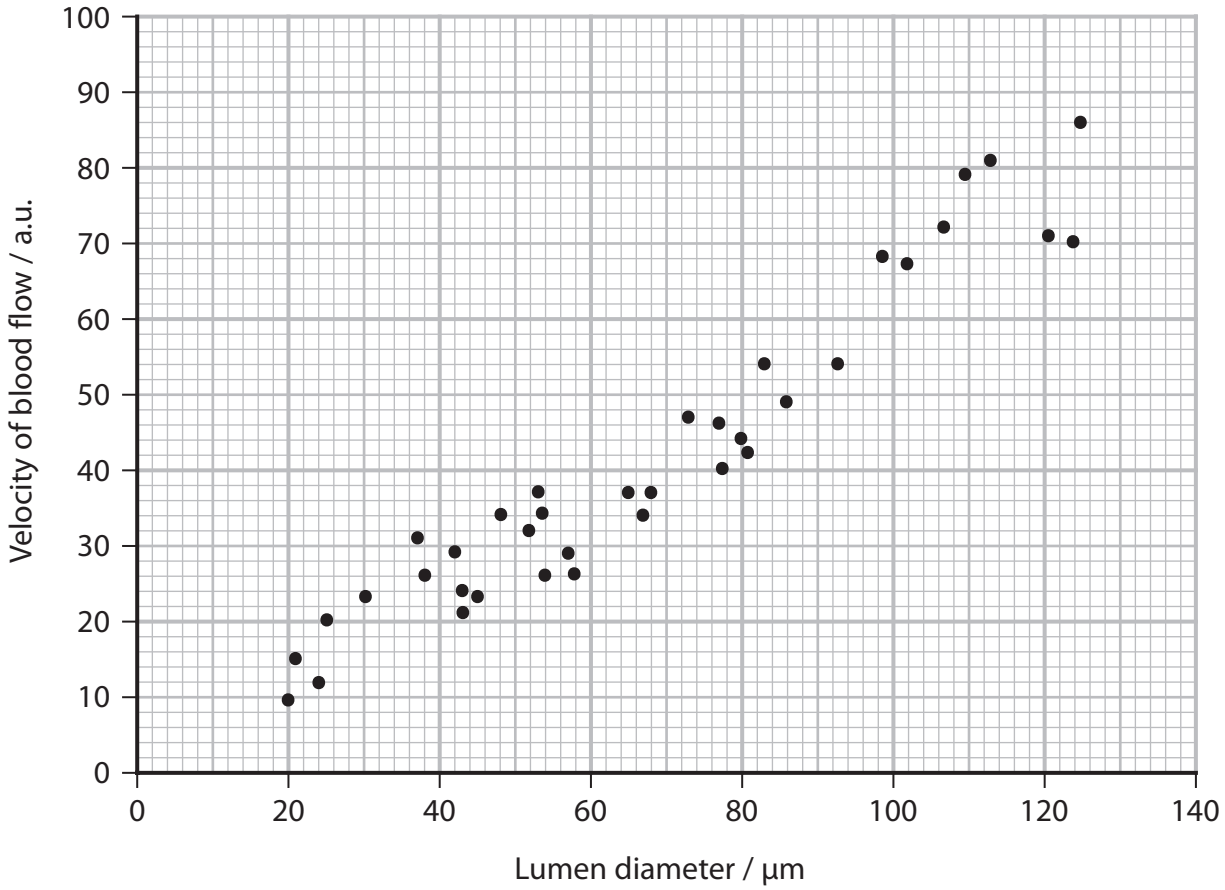
Pearson

Answer ALL questions.

Write your answers in the spaces provided.

1 The diameter of the inside of a blood vessel (lumen diameter) affects the speed of blood flow.

The graph shows the relationship between the lumen diameter of blood vessels and the velocity of blood flow.



(a) State the relationship shown in the graph.

(1)

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(b) (i) Explain how the development of cardiovascular disease (CVD) could affect the velocity of blood flow.

(2)

(ii) Explain why a change in the velocity of blood flow will affect the function of the heart muscle.

(2)

(c) Explain the importance of the relationship, shown in the graph, to capillary function.

(2)

(Total for Question 1 = 7 marks)

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2 The banded snail *Cepaea nemoralis* occupies many habitats.

The thrush is a major predator of the banded snail.

The thrush and the banded snail, shown in the photograph, occupy different niches.

Source: © Dave Watts/Alamy

(a) Describe the difference between the terms niche and habitat.

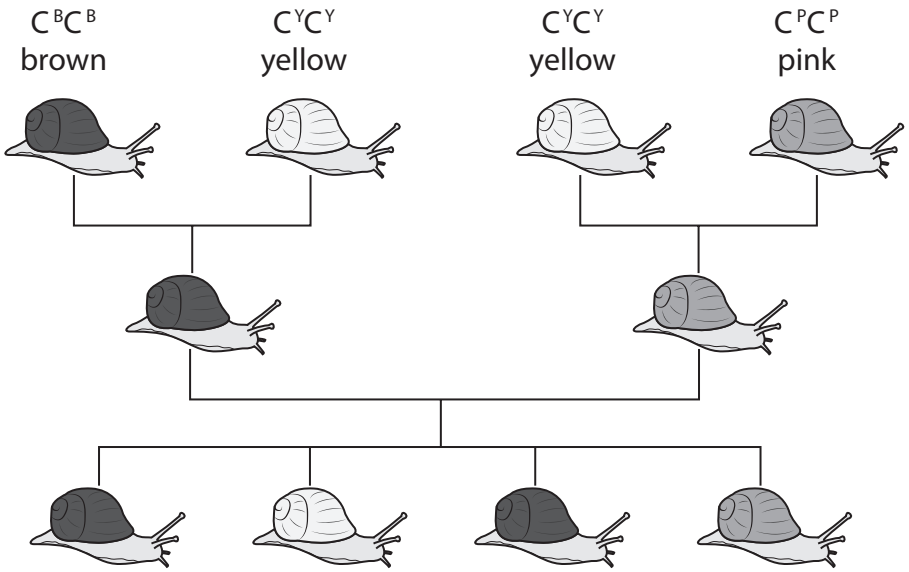
(2)

(b) The shell colour of the banded snail can be yellow, pink or brown.

A single gene controls shell colour in the banded snail.

There are three alleles for this gene, C^Y, C^P, and C^B.

The effects of these alleles on shell colour is shown in the genetic pedigree diagram.



Deduce the dominance of the alleles for shell colour.

(2)

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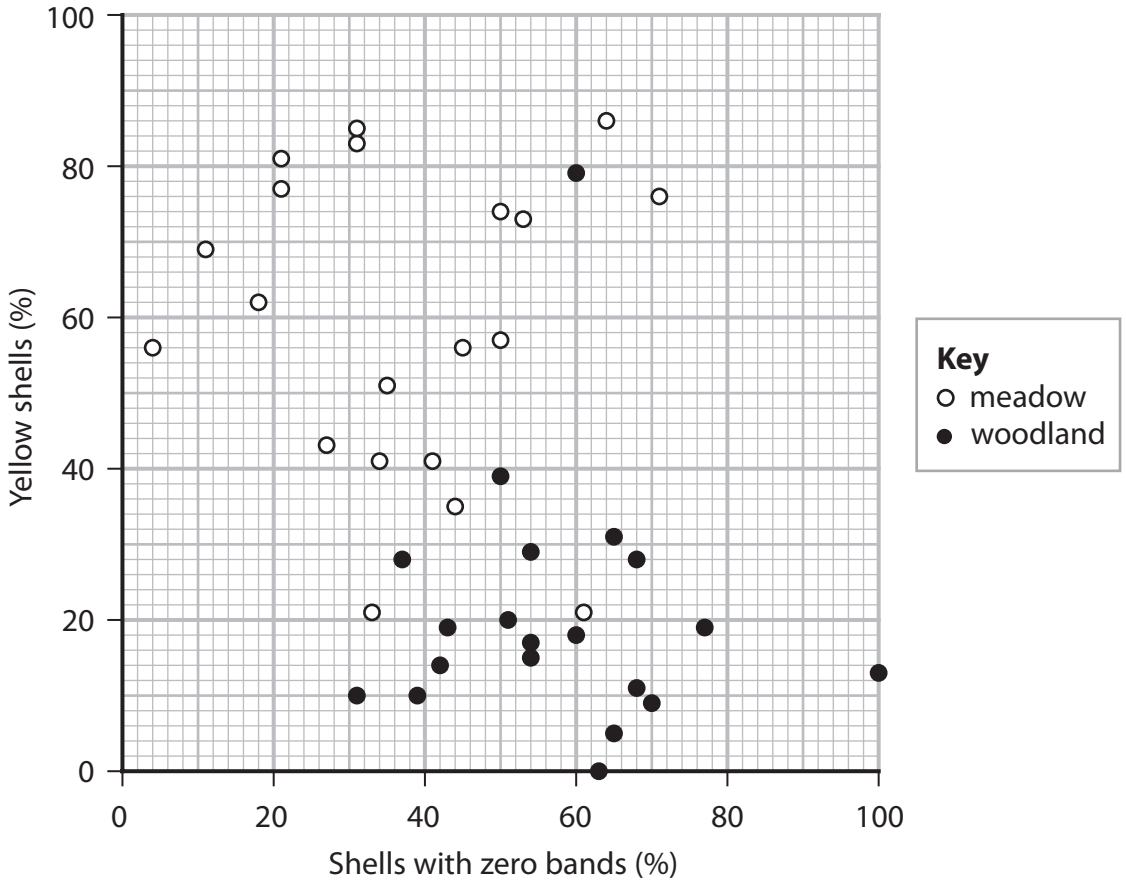
(c) The shells of the banded snail can have from zero to five black bands.

The populations of banded snails in 20 meadow habitats and 20 woodland habitats were investigated.

At each location the percentage of snails with yellow shells was recorded. The percentage of snails with shells with zero bands was also recorded.



(i) Explain the importance of the different shell patterns in these two habitats.

(3)

(ii) Explain how a statistical test could be used to determine if the number of shells with zero bands is significantly different in these two habitats.

(2)

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(Total for Question 2 = 9 marks)

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3 Photosynthesis in green plants involves light-dependent reactions and the Calvin cycle.

(a) The Calvin cycle uses the products of the light-dependent reactions.

(i) State the location of the Calvin cycle.

(1)

(ii) Describe the roles of the products of the light-dependent reactions in the Calvin cycle.

(3)

(b) Photosynthesis contributes to the productivity of ecosystems.

(i) State what is meant by the term ecosystem.

(1)

(ii) The table shows information about two types of ecosystem.

Ecosystem	Gross productivity / g m^{-2} day^{-1}	Net productivity / g m^{-2} day^{-1}	Percentage of gross productivity used in respiration (%)	Total surface area of Earth occupied / km^2
Tropical rainforest	16.7	5.5	67.1	510×10^6
Salt marsh	10.5		34.3	5.5×10^4

Calculate the net productivity of the salt marsh ecosystem.

(2)

..... g m^{-2} day^{-1}

(iii) Comment on the impact of these different types of ecosystem on global warming.

(3)

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(c) Explain the importance of RUBISCO to the productivity of an ecosystem.

(2)

(Total for Question 3 = 12 marks)

4 Global warming can affect abiotic factors that determine the distribution of organisms.

The presence of sodium chloride in soil is an abiotic factor that affects the germination of seeds.

The effects of sodium chloride solution and gibberellin on the germination of rice seeds have been investigated.

Gibberellin regulates developmental processes in plants.

Fifty seeds were placed in each of three Petri dishes containing different solutions.

The seeds were incubated for 96 hours and the number that germinated in each Petri dish was counted.

Treatment	Solution	Number of seeds germinating
Control	Distilled water	48
Sodium chloride	120 mmol dm^{-3} of sodium chloride	33
Sodium chloride and gibberellin	120 mmol dm^{-3} sodium chloride and 50 µmol dm^{-3} gibberellin	45

(a) (i) Give a null hypothesis for this experiment.

(1)

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(ii) Calculate the chi-squared (χ^2) value for these results, using the formula provided.

(3)

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

Answer .....

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(iii) In a second experiment, using the same three treatments, the chi-squared (χ^2) value was found to be 6.635.

The table gives the critical values for the chi-squared (χ^2) test at different probability levels.

Degrees of freedom	Probability level		
	0.05	0.01	0.001
1	3.841	6.635	10.83
2	5.991	9.210	13.82
3	7.815	11.34	16.27
4	9.488	13.28	18.47

Deduce the statistical significance of the results of the second experiment.

(2)

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(b) Gibberellins can activate the gene for amylase in rice seeds.

Amylase is an enzyme that hydrolyses starch in the rice seeds.

Devise an investigation to demonstrate the effect of gibberellin on amylase activity in rice seeds treated with sodium chloride.

(4)

(Total for Question 4 = 10 marks)

5 Blood clotting is a process that is affected by genes.

Some people are at an increased risk of a condition called deep vein thrombosis (DVT). Blood clots form in the veins of people with DVT.

There are two alleles in a population, a wild type allele and G20210A.

(a) The table shows the risk of DVT for people with different genotypes in this population.

Genotype	Risk of DVT / number of people with DVT per 1000 individuals
Homozygous wild type	1.0
Heterozygous for G20210A	2.5
Homozygous for G20210A	20.0

(i) Determine the effect of the allele G20210A on the risk of an individual developing DVT in this population.

(2)

(ii) The frequency of the G20210A allele in a population of 10 000 individuals was investigated.

In this population, 50 individuals were homozygous for G20210A.

Calculate the number of individuals in the population who were heterozygous for the G20210A allele, using the Hardy-Weinberg equation:

$$p^2 + 2pq + q^2 = 1.0$$

(3)

Answer .....

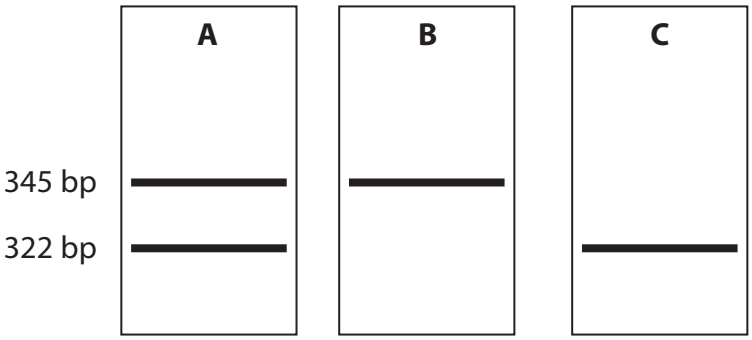
(b) Individuals with a family history of DVT may be offered a genetic test for the G20210A allele.

In this test, a sequence of 345 base pairs (bp) from this gene is amplified using the polymerase chain reaction (PCR).

A specific restriction enzyme is then added to the amplified DNA.

The DNA fragments produced are then separated using gel electrophoresis.

The diagram shows the results of gel electrophoresis for three individuals, A, B and C.



Key
DNA sample from:
A heterozygous individual
B individual homozygous for wild type allele
C individual homozygous for G20210A

(i) Explain the role of DNA primers in the production of the amplified 345bp sequence.

(2)

(ii) Explain why the amplified DNA fragments for the G20210A allele and the wild type allele are different.

(3)

(iii) Devise an investigation to determine the optimum number of cycles for the polymerase chain reaction used to amplify the DNA for this test.

(4)

(Total for Question 5 = 14 marks)

6 Cells use ions in many different processes.

(a) Explain why ions can dissolve in blood.

(2)

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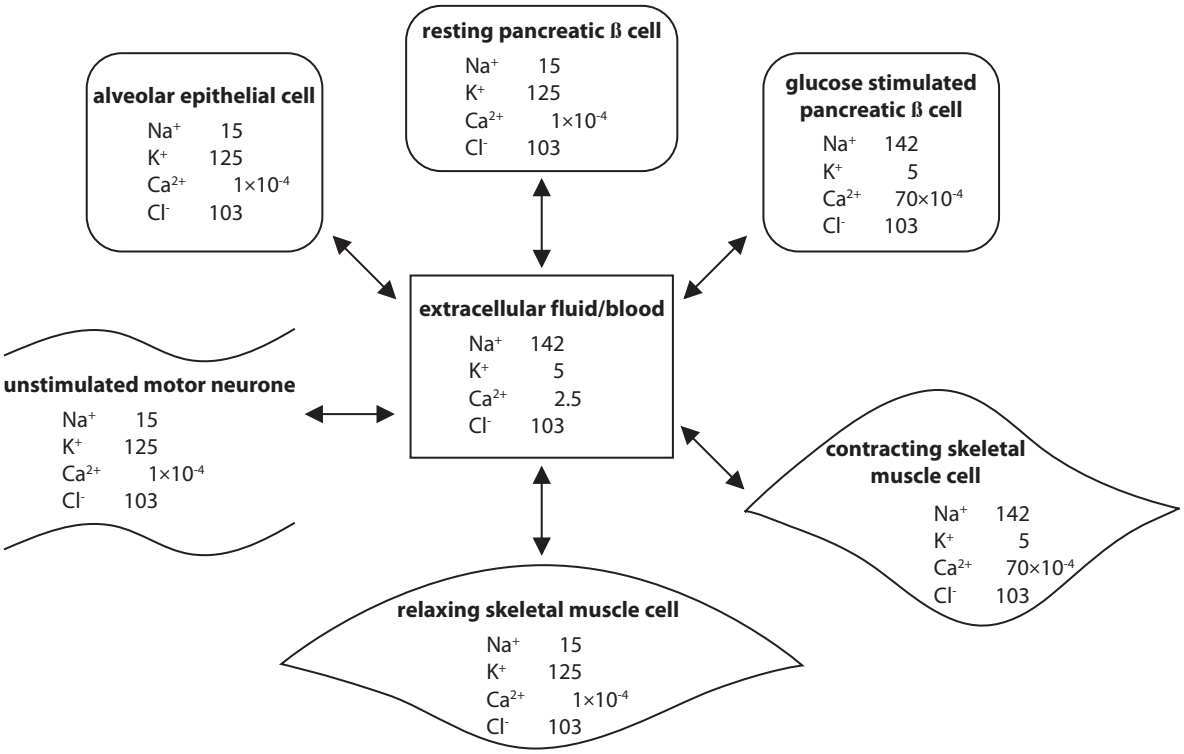
*(b) Ion transport across cell membranes is a fundamental property of all living cells.

The diagram shows some typical ion concentrations in healthy human cells and in the extracellular fluid.

All values are in mmol dm^{-3}.



The tables show information about the human genome and types of transport channel in humans.

Some information about the human genome	
Number of genes in the human genome	approximately 20 000
Number of genes coding for membrane proteins	approximately 5 400
Number of genes coding for proteins involved in the transport of ions across cell membranes	more than 350
Number of diseases associated with mutations in genes involved in the transport of ions across cell membranes	more than 28
Organs and systems in which ion channel mutations cause disease	central nervous system, heart, lungs, pancreas and skeletal muscle

Type of transport channel	Number of each type of transport channel
Voltage gated ion channels	147
Chloride channels	17
Active transport	81

Discuss the importance of ion transport across membranes in human health and disease.

(9)

(Total for Question 6 = 11 marks)

7 The scientific article you have studied is from *Scientific American*.

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

(a) Describe how 'eyes relay visual information' to the brain (paragraph 2).

(5)

(b) 'Most drugs cannot easily penetrate the brain' (paragraph 3).

Explain how the treatment of Parkinson's disease overcomes the difficulty of drugs passing from the blood into the brain.

(2)

(c) 'Innate immunity initiates the inflammatory response, in which white blood cells swarm the site of infection' (paragraph 5).

Explain how white blood cells 'swarm' to accumulate at the site of inflammation.

(4)

(d) The protein $\alpha 4\beta 1$ integrin projects out from the cell surface membrane of white blood cells.

Deduce how molecules such as $\alpha 4\beta 1$ integrin help immune cells cross the blood-brain barrier (paragraph 8).

(2)

(e) The immune system plays a role in recovery following spinal cord injuries.

Give **two** ethical arguments to support the use of rats and mice with spinal cord injuries in these experiments (paragraph 10).

(2)

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2 .....

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(f) 'The lymphatic vessels also ferry antigens—substances capable of inducing an immune response—from the tissues into tissue-draining lymph nodes, where they are presented to immune cells' (paragraph 15).

Describe how these antigens are presented to immune cells.

(3)

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(g) 'A cytokine produced by immune cells in the meninges can change the activity of neurons, thereby altering the function of the circuit' (paragraph 20).

Cytokine has been found to affect neurotransmitter systems in the brain.

Explain how a cytokine could modify the activity of a neural circuit.

(4)

(h) Compare and contrast the structure of a sensory neurone and a motor neurone (paragraph 21).

(4)

(i) Sight is a sense that develops during a critical period, 'providing a basis on which the brain can compute the activity needed for self-preservation.' (paragraph 22).

Describe what is meant by a critical period.

(2)

(j) It has been suggested that there is a critical period for the development of the hard wiring of the immune response into the brain (paragraphs 22 and 23).

Explain how this critical period could be investigated using animal experiments.

(2)

(k) Describe how bacteria can be genetically modified to produce a cytokine for the treatment of neurological and mental disorders (paragraph 24).

(4)

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(l) An immune system that interacts adversely with the CNS might be described as 'flawed' (paragraph 24).

Explain why a bone marrow transplant can be used to replace a flawed immune system.

(3)

(Total for Question 7 = 37 marks)

TOTAL FOR PAPER = 100 MARKS

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