Write your name here

Surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | | | | | |

Candidate Number | | | | |

Biology A (Salters-Nuffield)

Advanced

Unit 3: General and Practical Applications in Biology

Monday 26 June 2017 – Morning
Time: 2 hours

Paper Reference
9BN0/03

Candidates must have:
Calculator, HB pencil, ruler and a copy of the scientific article adapted from *The Energy of Life* (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.

Turn over ▶

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Pearson

Answer ALL questions.

Write your answers in the spaces provided.

1 Plant fibres and oil-based plastics have both been used to make ropes.

(a) Describe one advantage and one disadvantage of using ropes made from plant fibres rather than ropes made from oil-based plastics.

(2)

(b) Ropes used in climbing need to have high tensile strength.

State what is meant by the term **tensile strength**.

(1)

(c) Climbing ropes can be made from manila (a plant fibre) or nylon (an oil-based plastic). Various factors affect the tensile strength of these ropes, including diameter and storage conditions.

The table shows the effect of rope diameter on tensile strength.

Diameter of rope / mm	Tensile strength / kN	
	Manila rope	Nylon rope
6	2.4	7.5
8	4.2	12.1
10	5.7	16.3
12	10.6	28.4

It is claimed that the ideal storage conditions for rope are 18 °C and 60% relative humidity.

Devise a valid investigation to determine the effect of storage temperature on the tensile strength of manila rope and nylon rope.

(4)

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(d) Tissues that contain lignin provide strength to plant fibres.

Describe the positions in the stem of those tissues that contain lignin.

(2)

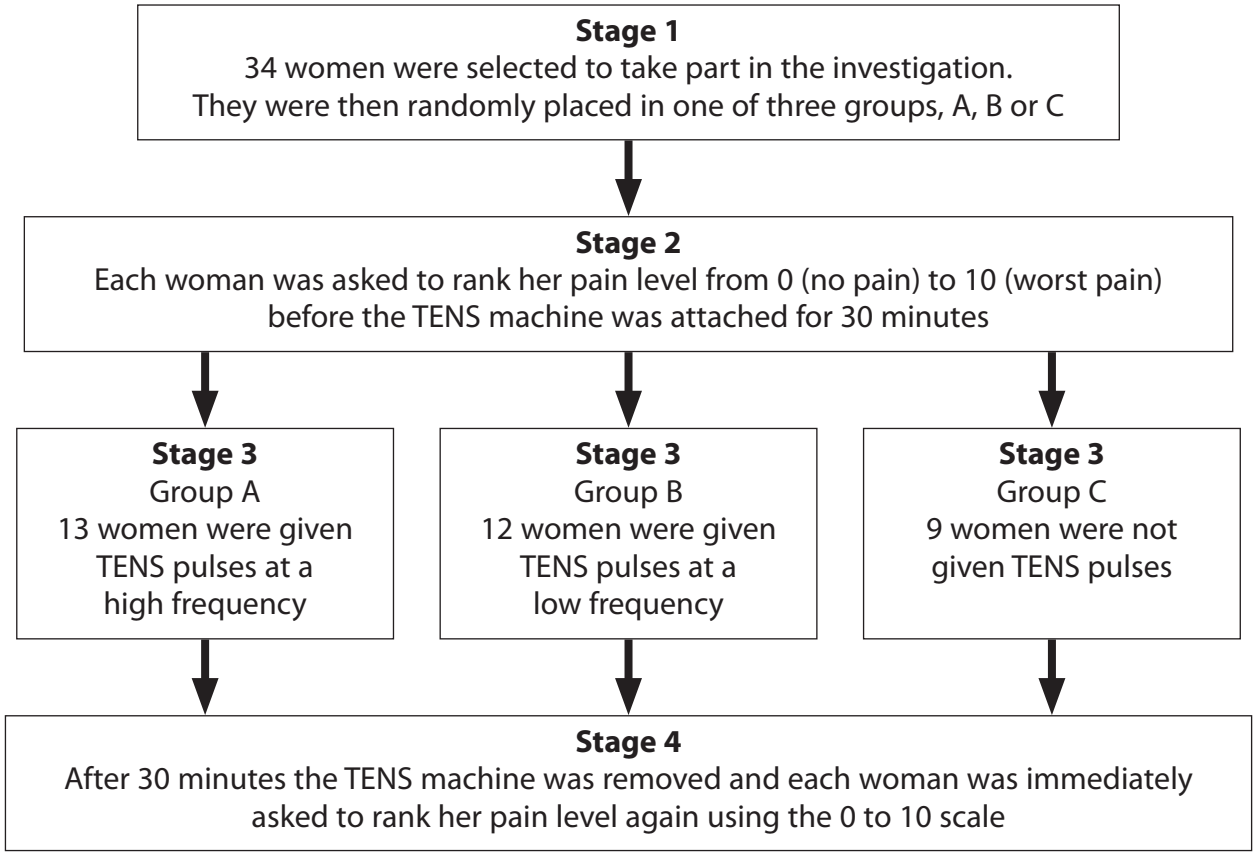
(Total for Question 1 = 9 marks)

2 Some women need to have surgery to aid childbirth. This can lead to pain after surgery.

A TENS (transcutaneous electrical nerve stimulation) machine releases regular pulses of electricity onto the skin surface and can be used in pain relief.

An investigation was carried out to study whether the frequency of the pulses from a TENS machine could help these women with their pain relief.

The diagram shows how the investigation was carried out.



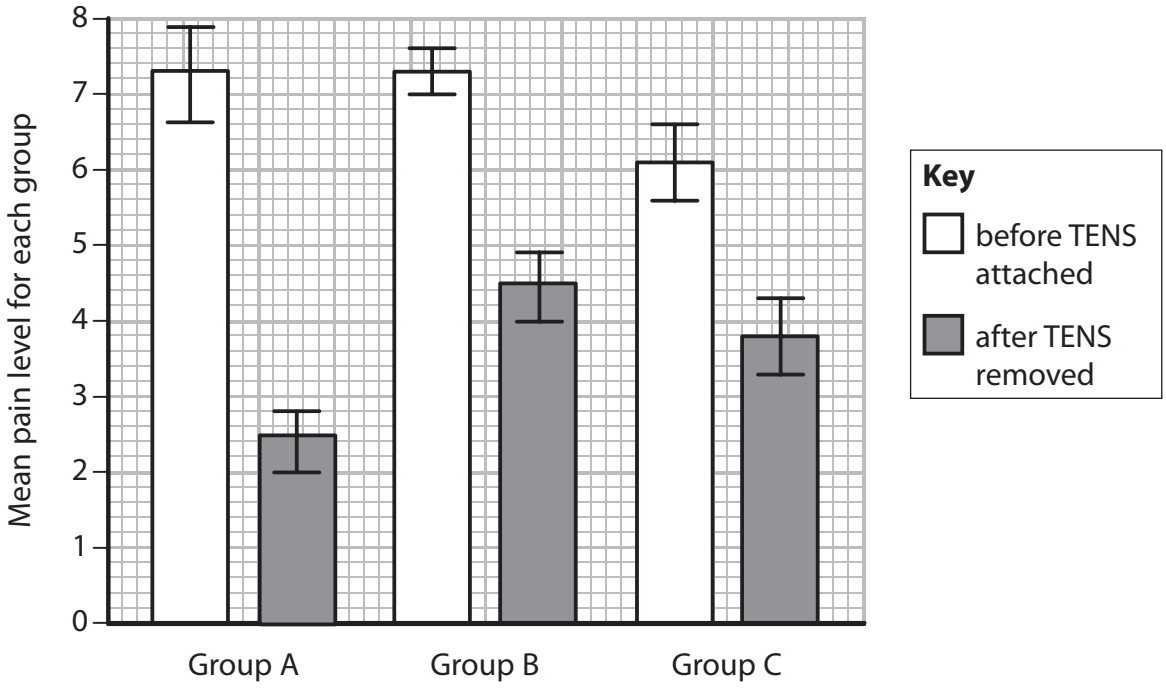
(a) Describe how the 34 women were selected in stage 1 to ensure that this investigation was valid.

(2)

(b) Explain why group C was included in this investigation.

(2)

(c) The results and range of data for the investigation are shown in the graph.



Determine the effectiveness of the use of a TENS machine in relieving pain following surgery.

(4)

(d) This investigation used only one 30-minute session of TENS pulses. This was done to reduce the risk of habituation.

Describe the process that occurs at a synapse that leads to habituation.

(4)

(Total for Question 2 = 12 marks)

3 Studies have provided evidence for a link between heart rate when a person is at rest and various medical conditions.

(a) In one study, the relationships between resting heart rate and the percentage incidence of coronary heart disease and cancer were investigated.

The results are shown in the table.

Range of resting heart rate / beats per min	Number of individuals in each range	Percentage incidence of condition (%)	
		Coronary heart disease	Cancer
< 59	961	4.2	1.0
60–69	2277	6.0	1.5
70–79	2120	7.5	2.0
80–89	1202	8.0	2.5
90–99	576	8.2	4.0
> 99	379	7.9	3.8

(i) Comment on the evidence for a link between resting heart rate and the percentage incidence of coronary heart disease and cancer.

(5)

(ii) Give two reasons why there were different numbers of people in each resting heart rate group.

(2)

(iii) Give two reasons why the number of people in each resting heart rate group did not affect the validity of this investigation.

(2)

(b) Cancer can be due to body cells continuing to undergo mitosis and cell division. Prophase is one stage of mitosis.

Describe the events that occur during prophase in an animal cell.

(3)

(Total for Question 3 = 12 marks)

4 A student investigated the effect of salt concentration on the growth of one species of brine shrimp.

The student placed 100 shrimp eggs in a beaker containing 1dm^3 of 3% salt solution. Three days after the eggs hatched, 10 shrimps were collected and their lengths measured. Seven days after hatching, another 10 shrimps were collected and their lengths measured.

The procedure was repeated using a 5% salt solution. All other variables were kept constant.

The results are shown in the table.

Specimen number	Length of specimen in 3% salt solution / mm		Length of specimen in 5% salt solution / mm	
	3 days after hatching	7 days after hatching	3 days after hatching	7 days after hatching
1	0.75	1.00	0.75	0.98
2	0.78	1.25	0.73	0.95
3	0.66	1.10	0.61	0.93
4	0.73	1.03	0.63	0.83
5	0.85	1.15	0.53	0.98
6	0.78	1.08	0.60	1.08
7	0.90	1.13	0.52	0.95
8	0.90	1.05	0.81	1.03
9	0.80	1.18	0.58	0.88
10	0.85	1.05	0.68	0.88
Mean	0.800	1.102		0.949

(a) (i) Calculate the mean length of shrimp three days after hatching in the 5% salt solution. Give your answer to an appropriate number of significant figures.

(1)

Answer ..... mm

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(ii) Explain how these data can be used to show the effect of salt concentration on the rate of growth of brine shrimps.

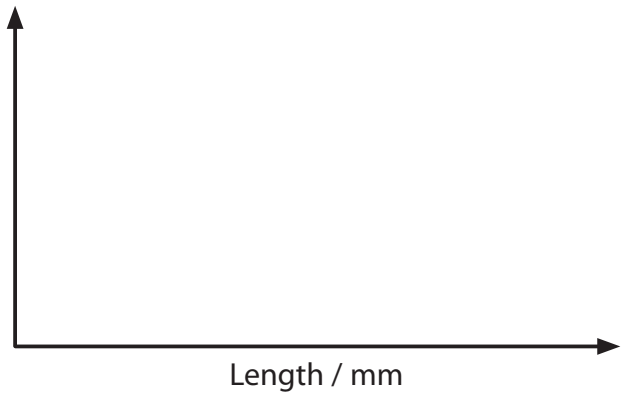
(2)

(b) The student carried out a statistical test to see if there was a significant difference between the mean lengths of brine shrimps in these two salt solutions. The student used the 7 days after hatching data.

The student selected the *t*-test because the data are normally distributed.

(i) Draw a line on the graph to show a normal distribution for a population of brine shrimp.

(1)



(ii) Complete the table by filling in the missing value for specimen 7 and then calculate the value for Σx_1^2.

(1)

Specimen number (n)	3% salt solution		5% salt solution	
	Length of specimen (x_1)	Square of length of specimen (x_1^2)	Length of specimen (x_2)	Square of length of specimen (x_2^2)
1	1.00	1.000	0.98	0.960
2	1.25	1.563	0.95	0.903
3	1.10	1.210	0.93	0.865
4	1.03	1.061	0.83	0.689
5	1.15	1.323	0.98	0.960
6	1.08	1.166	1.08	1.166
7	1.13	.....	0.95	0.903
8	1.05	1.103	1.03	1.061
9	1.18	1.392	0.88	0.774
10	1.05	1.103	0.88	0.774
Sum ($\sum$)	$\sum x_1 = 11.020$	$\sum x_1^2$ = ...	$\sum x_2 = 9.490$	$\sum x_2^2 = 9.055$
Mean	$\bar{x}_1 = 1.102$		$\bar{x}_2 = 0.949$	

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(iii) The variances are used in the calculation of a *t*-value.

The variance for the 3% salt solution $S_1^2 = 0.0059$.

Calculate the variance for the 5% salt solution (S_2^2) using the formula

$$S_2^2 = \frac{\sum x_2^2 - \frac{(\sum x_2)^2}{n}}{n-1}$$

n = the number of specimens

(2)

S_2^2 .....

(iv) Calculate the *t*-value using the formula.

Give your answer to an appropriate number of significant figures.

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

(3)

t = ...

(v) The calculated *t*-value is greater than the critical value at $p = 0.05$.

Describe what this result indicates about the effect of salt concentration on the length of brine shrimp.

(2)

(Total for Question 4 = 12 marks)

5 The pigment content of mountain plants can be affected by various environmental factors. These factors include altitude (height up a mountain), exposure to ultraviolet radiation (UV-B) and temperature.

These pigments include chlorophyll, found in chloroplasts, and flavonoids that are found in sap vacuoles.

Flavonoids can protect plants from ultraviolet radiation (UV-B) that can damage DNA.

(a) State the location of chlorophyll in a chloroplast.

(1)

(b) The altitude at which a plant grows on a mountain affects its flavonoid content.

Devise a procedure to show that an increase in altitude increases the flavonoid content of one species of plant found growing on a mountain.

(5)

(c) Scientists have investigated the effect of UV-B on both chlorophyll and flavonoid content.

A group of plants was exposed to UV-B for 20 minutes per day for one month. The chlorophyll and flavonoid content of each plant were then determined and the means calculated.

This was repeated for three more groups of plants. Each group was exposed to UV-B for different lengths of time. All other variables were kept constant.

The results are shown in the table.

Length of time exposed to UV-B / minutes	Mean chlorophyll content / arbitrary units	Mean flavonoid content / arbitrary units
0	32	25
20	30	24
40	27	39
60	24	40

(i) Compare and contrast the effect of length of exposure to UV-B on the chlorophyll and flavonoid content of these plants.

(3)

(ii) As altitude increases on a mountain, the temperature decreases and the UV-B radiation increases.

Scientists have found that a rise in temperature decreases flavonoid gene expression in plants.

Analyse the data to discuss why altitude can affect plant growth.

(5)

(Total for Question 5 = 14 marks)

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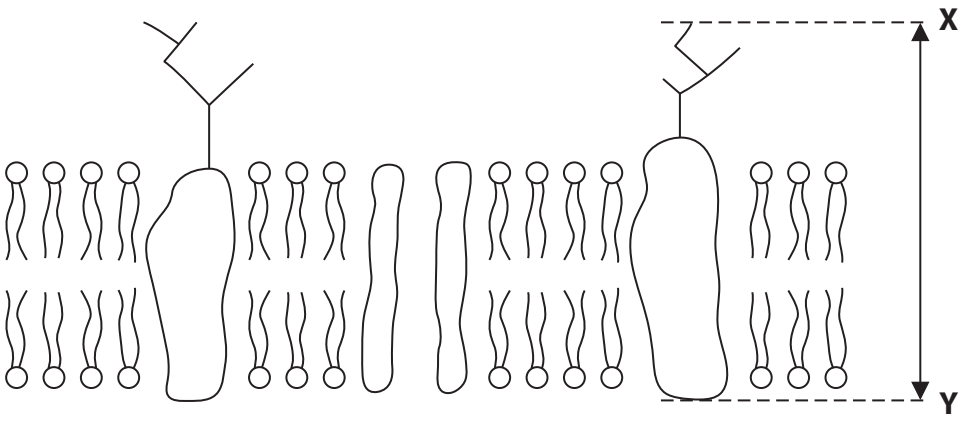
6 The structure of the cell surface membrane can be explained using the fluid mosaic model.

This model suggests that there are a variety of different proteins and glycoproteins present in a phospholipid bilayer.

(a) The drawing shows the cell surface membrane of a liver cell. The drawing has a magnification of 5×10^6.



Calculate the actual length of the glycoprotein between points **X** and **Y**.
Give your answer with an appropriate unit.

(2)

Answer .....

*(b) The ratio of lipid to protein in a cell surface membrane is approximately 1:1.

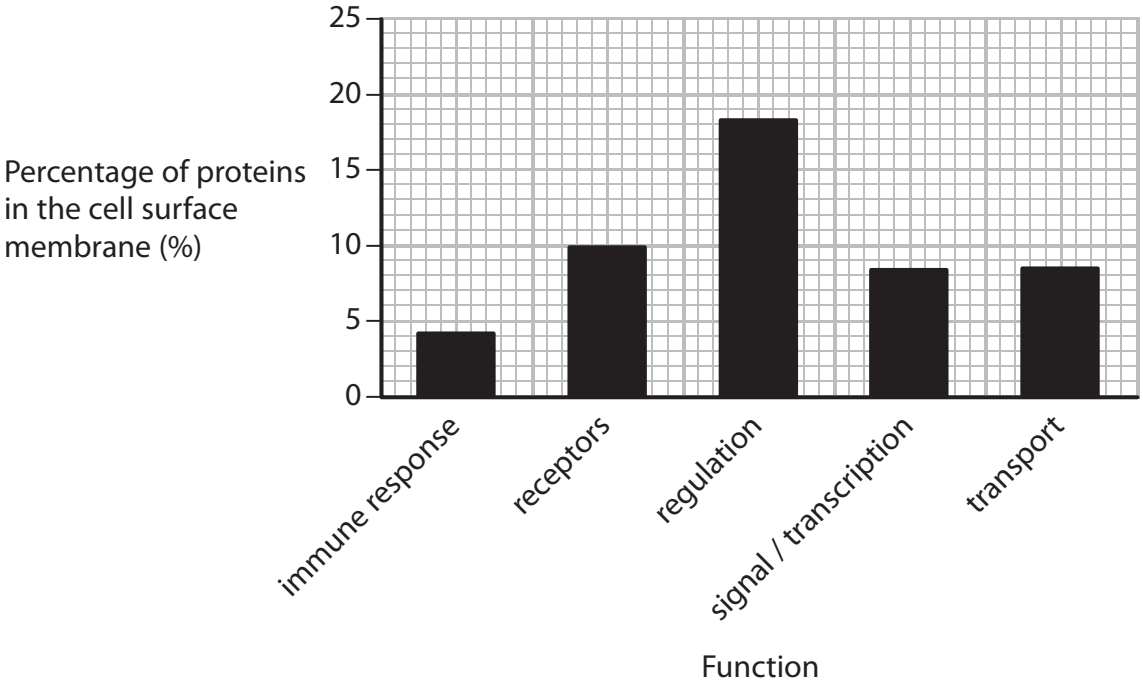
Scientists have studied the proteins present within human cells. Proteins in a cell are found in several locations.

The table shows the percentage of protein found in some locations in a cell.

Location within a cell	Percentage of total protein present (%)
cell surface membrane	68.2
cytoplasm	1.4
endoplasmic reticulum / Golgi apparatus	1.4
nucleus	14.5
other	14.5

The proteins within the cell surface membrane were further analysed for their function.

The graph shows some of the results of this analysis.



Analyse the data to evaluate the following statement.

'The variety of different proteins present in the cell surface membrane makes them more important than the phospholipid bilayer to the functioning of that cell.'

(9)

(Total for Question 6 = 11 marks)

7 The scientific article you have studied is adapted from an article from '*The Scientist*'.

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

(a) Explain why the 'anaerobic oxidation of methane' could be a 'key climate regulator' (paragraph 2).

(3)

(b) Give reasons why 'humble microbes', such as bacteria, are considered less complex than eukaryotes (paragraph 4).

(2)

(c) State what is meant by the phrase 'fix carbon into biomass' (paragraph 4).

(2)

(d) Humans have a 'requirement for oxygen' (paragraph 5).

Explain the role of oxygen in human respiration.

(4)

(e) Explain how the unfolding of the enzymes in *E. coli* makes them 'become ineffective at 60 °C' (paragraph 12).

(3)

(f) State what is meant by the genome of a thermophile (paragraph 14).

(1)

(g) Explain how cyanobacteria evolved to 'handle high temperatures' (paragraphs 14 and 15).

(5)

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(h) Describe the structure of the 'protein-synthesis machinery' in bacteria (paragraph 20).

(2)

(i) Explain how the production of antibiotics by *Streptomyces* species can reduce interspecific competition (paragraph 20).

(3)

(j) Pyruvate is one of the products of glycolysis (paragraph 20).

State one difference between the structure of pyruvate and the structure of the acetyl group in acetyl CoA.

(1)

(k) *Bacillus subtilis* 'initiate a hibernation protocol' (paragraph 25).

Mycobacterium tuberculosis can also become dormant for long periods of time.

Compare and contrast the dormancy of these two species of bacteria.

(4)

(Total for Question 7 = 30 marks)

TOTAL FOR PAPER = 100 MARKS

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