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Candidate surname <i>StemUp Model Solution</i>		Other names
Centre Number	Candidate Number	

Pearson Edexcel Level 3 GCE

Thursday 22 May 2025

Morning (Time: 1 hour 30 minutes)

Paper reference **8BN0/02**

Biology A (Salters Nuffield)

Advanced Subsidiary

PAPER 2: Development, Plants and the Environment

You must have:
Scientific calculator, HB pencil, ruler

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 80.
- 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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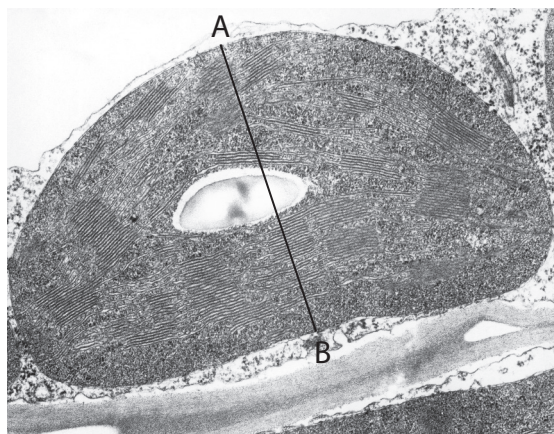


Answer ALL questions. Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 All living organisms are made of cells.

(a) The image shows an electronmicrograph of an organelle found only in eukaryotic cells.



(Source: © Omikron/SCIENCE PHOTO LIBRARY)

magnification $\times 44\,000$

(i) This organelle is not found in prokaryotic cells.

Explain why this type of organelle is present only in eukaryotic cells and **not** in prokaryotic cells.

(2)

It is a chloroplast, which is a membrane-bound organelle.

Prokaryotic cells do not have membrane-bound organelles; only eukaryotic cells have membrane-bound organelles.

(ii) Calculate the width of this organelle from A to B, as shown in the image.

Give your answer in micrometres (μm) to two significant figures.

(2)

length A to B on image = 40 mm

actual width = image size $\div$ magnification = $40 \div 44\,000$

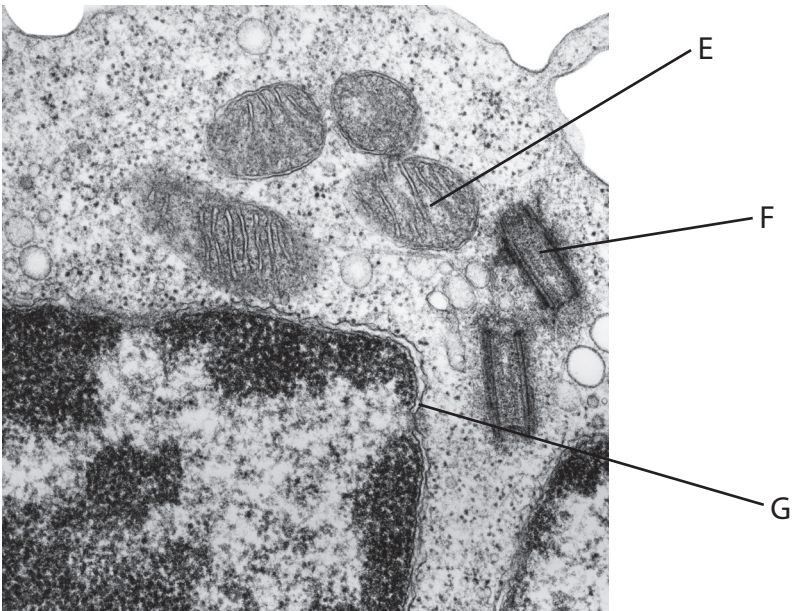
= 0.000909 mm = 0.909 μm

0.91

μm



(b) The image shows an electronmicrograph of part of a eukaryotic cell.



(Source: © Don Fawcett/SCIENCE PHOTO LIBRARY)

(i) Which row in the table identifies structures E, F and G? (1)

	Structure E	Structure F	Structure G
☐ A	chloroplast	centriole	nucleus
☐ B	chloroplast	Golgi apparatus	nuclear membrane
☒ C	mitochondrion	centriole	nuclear membrane
☐ D	mitochondrion	Golgi apparatus	nucleus

(ii) Which row of the table shows the processes that involve structures E and F? (1)

	Structure E	Structure F
☐ A	photosynthesis	mitosis
☐ B	photosynthesis	protein synthesis
☒ C	respiration	mitosis
☐ D	respiration	photosynthesis

(Total for Question 1 = 6 marks)



- 2 The photograph shows a Pyrenean desman, a mammal that is endemic to fast-flowing mountain streams in Spain.



(Source: © BIOSPHOTO/Alamy Stock Photo)

- (a) Which of the following is the correct definition of the term **endemic**?

(1)

- ☐ A found in only one type of habitat
- ☒ B found in only one geographical location
- ☐ C lives in many different locations
- ☐ D occupies a single niche

- (b) The Pyrenean desman has a number of adaptations that allow it to survive in its habitat:

1. it feeds on insects
2. it has webbed feet to enable it to swim
3. it has a long snout that it can use to find food in between rocks
4. it has nostrils on the upper surface of the snout
5. it is nocturnal – feeding at night.

- (i) Which adaptations from the list are all **anatomical** adaptations?

(1)

- ☐ A 1, 2 and 3
- ☐ B 1, 3 and 4
- ☒ C 2, 3 and 4
- ☐ D 3, 4 and 5



- (ii) The Pyrenean desman is thought to have evolved from a land-living animal similar to a mole.

Explain how the Pyrenean desman could have evolved by natural selection from a land-living animal similar to a mole.

(5)

There was genetic variation in the population of the mole-like ancestor, caused by mutations producing new alleles.

There was a selection pressure, e.g. competition for food on land, so animals that could find food in streams had an advantage.

Some individuals had favourable characteristics, such as webbed feet for swimming, a long snout to find food between rocks and nostrils on the upper surface of the snout.

Those with the alleles for these favourable characteristics were more likely to survive and reproduce, while those without them were less likely to survive.

They passed on the advantageous alleles to their offspring.

Over many generations the frequency of the advantageous alleles increased in the population, until the desmans could no longer breed with the original species.

(Total for Question 2 = 7 marks)



P 7 8 6 8 8 A 0 5 2 8

- 3 The leaves of the pineapple plant provide long fibres that can be used in the production of textiles.

The photograph shows fibres being extracted from pineapple leaves.



(Source: © Jahangir Alam Onuchcha/Shutterstock)

- (a) Leaves are organs that contain tissues.

Give **one** difference between an organ and a tissue.

(1)

*An organ is made of more than one type of tissue (different tissues working together),
whereas a tissue is a group of similar cells.*

- (b) (i) The fibres extracted from pineapple leaves contain cellulose and lignin.

Which of the following tissues contain **lignin**?

(1)

- ☐ A only phloem
- ☐ B only sclerenchyma
- ☐ C only xylem
- ☒ D sclerenchyma and xylem

(ii) Explain how the features of xylem vessels are related to its functions.

(4)

Xylem vessels are hollow, with no cytoplasm and no end walls, so there is no resistance to the flow of water and the flow of water is uninterrupted.

Their cell walls contain lignin, which waterproofs the walls and provides support, so the xylem can withstand the pressure (tension) and does not collapse.

There are pits in the cell walls that allow the transfer of water (lateral movement) between vessels.

(c) Fibres for textiles can also be made from oil-based plastics.

Explain why the use of fibres from pineapple leaves is more sustainable than producing fibres from oil-based plastics.

(2)

Pineapple plants can be regrown, so they are a renewable resource that will not run out and is available for future generations.

Oil is a finite resource that will run out.

(Total for Question 3 = 8 marks)



- 4 Rockpools on the seashore contain seaweeds that provide habitats for other organisms.

The photograph shows *Fucus serratus*, a species of seaweed found in rockpools.



(Source: © NIGEL DOWNER/SCIENCE PHOTO LIBRARY)

- (a) State what is meant by the term **species**.

(2)

A group of organisms with similar characteristics (features)

that can interbreed (reproduce with one another) to produce fertile offspring.

- (b) The biodiversity of habitats can be measured and compared.

- (i) One measure of biodiversity is species richness.

Describe how species richness can be used to compare the biodiversity of two habitats.

(2)

Species richness measures the number of different species present, so count the number of species in each habitat.

Use the same size area (e.g. same number of quadrats) in each habitat. The habitat with the higher species richness has the greater biodiversity.



- (ii) Biodiversity can also be measured using an index of diversity.

The table shows data collected from one rockpool.

Species of seaweed	Number of individuals (n)	n(n – 1)
<i>Chondrus crispus</i>	5	20
<i>Cladophora rupestris</i>	5	20
<i>Corallina officinalis</i>	11	110
<i>Fucus serratus</i>	4	12
<i>Fucus spiralis</i>	9	72
<i>Ulva lactuca</i>	8	56
Total number of individuals (N)	42	

Calculate the index of diversity for this rockpool using the formula:

$$D = \frac{N(N - 1)}{\sum n(n - 1)}$$

Give your answer to two decimal places.

(2)

$$N(N - 1) = 42 \times 41 = 1722$$

$$\sum n(n - 1) = 20 + 20 + 110 + 12 + 72 + 56 = 290$$

$$D = 1722 \div 290 = 5.9379$$

Answer 5.94



(iii) Explain why an index of diversity is more useful than species richness for determining biodiversity.

(2)

Species richness only gives the number of species in an area.

However, the index of diversity also takes into account the population sizes (abundance) of each species, i.e. species evenness.

(Total for Question 4 = 8 marks)

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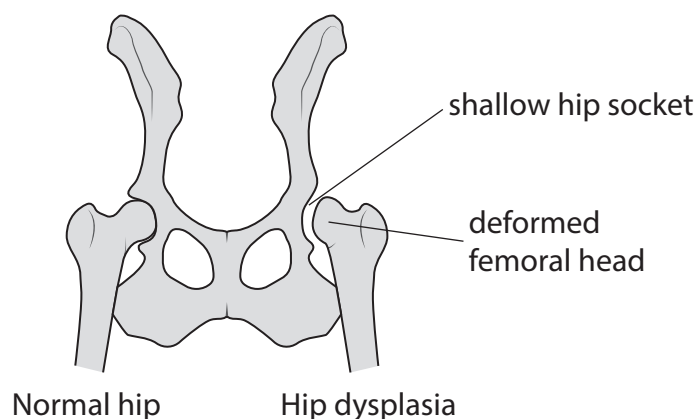
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5 Canine hip dysplasia is a polygenic disorder that affects dogs.

The diagram shows the effect of this disorder on the hip joint of a dog.



(a) Canine hip dysplasia is a polygenic disorder showing continuous variation.

(i) Describe what is meant by the term **continuous variation**.

(2)

A characteristic showing a range of differences along a spectrum of values (e.g. height), which are measurable and not distinct categories.

(ii) Explain how **polygenic inheritance** can give rise to continuous variation in characteristics such as eye colour in humans.

(4)

Polygenic means many genes (more than one gene) are involved in the characteristic, and these genes are at different loci.

Each gene (allele) has a small effect on the phenotype, so the genes have a cumulative (additive) effect.

Therefore there is a range within the characteristic, e.g. eye colour ranges from pale blue to dark brown, depending on the number of alleles for dark pigment in the genotype.

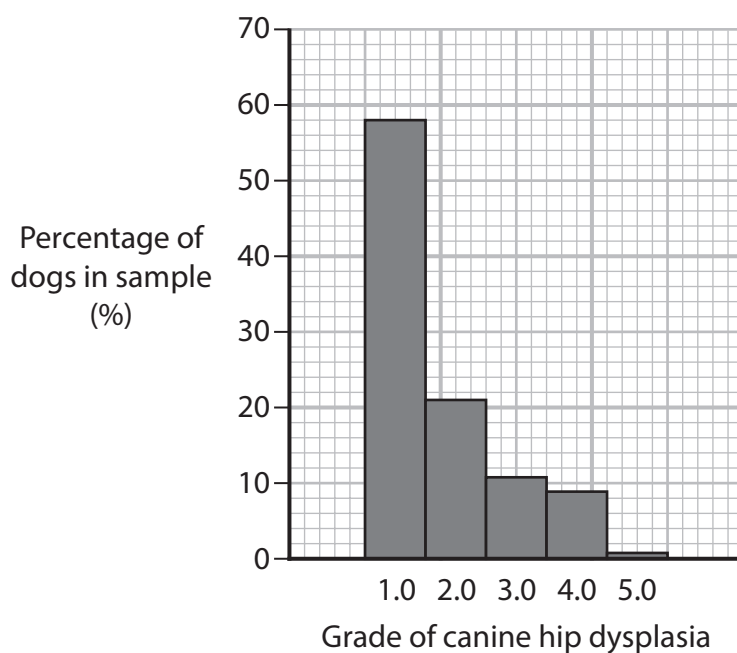
- (b) Canine hip dysplasia affects the hip joint of dogs causing pain and difficulty walking. Canine hip dysplasia is more common in larger dogs.

A study of the incidence of this disorder in dogs was carried out.

The table shows how the severity of this disorder is graded.

Grade of severity	Description
1.0	Normal hip joint
2.0	Borderline dysplasia
3.0	Mild dysplasia
4.0	Moderate dysplasia
5.0	Severe dysplasia

The graph shows the percentage of Labrador dogs with canine hip dysplasia of different grades.



Identify the evidence that canine hip dysplasia is a polygenic condition and not one caused by environmental factors.

Use the information provided and your own knowledge to answer the question.

(4)

Canine hip dysplasia shows different grades of severity (1.0 to 5.0), so it shows continuous variation.

This suggests that dogs inherit different alleles at multiple loci (several genes are responsible for the condition).

So the more disadvantageous (dysplasia) alleles a dog has in its genotype, the more severe the condition, which accounts for the range of severity.

As 42% of the dogs in the sample had dysplasia (only 58% had normal hip joints), the adverse alleles are relatively common in the gene pool.

The alleles for dysplasia may be recessive, so they can be carried by unaffected dogs and passed on.

(Total for Question 5 = 10 marks)



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6 The phenotype of an organism can be affected by its genotype and the environment.

(a) (i) Which of the following is the definition of the term **phenotype**?

(1)

- ☐ A the alleles inherited by an organism
- ☒ B the characteristics shown by an organism
- ☐ C the genes inherited by an organism
- ☐ D the physical environment of an organism

(ii) The photograph shows a Siamese cat.



(Source: © DK IMAGES/SCIENCE PHOTO LIBRARY)

This breed of cat has darker fur on the face, tail and feet.

If a Siamese cat spends more time outdoors, it may grow darker fur in other places on its body.

Which factors are most likely to affect the pattern of fur colour of Siamese cats?

(1)

- ☐ A body temperature only
- ☐ B environmental temperature only
- ☒ C genotype and environmental temperature
- ☐ D genotype only

- (b) An armadillo is a mammal that can produce litters of four genetically identical offspring.

The photograph shows an armadillo with a litter of four offspring.



(Source: © Keystone Press/Alamy Stock Photo)

- (i) Which of the following describes how these four genetically identical offspring are produced?

(1)

- ☐ **A** a fertilised egg divides by meiosis to produce four embryos
- ☒ **B** a fertilised egg divides by mitosis to produce four embryos
- ☐ **C** an egg cell divides by mitosis and is then fertilised by four sperm cells
- ☐ **D** four egg cells are fertilised by four sperm cells

- (ii) Deduce why armadillos have been used to investigate the effects of the environment on phenotype.

(2)

Several individuals with the same genotype can be tested, so the genotype is controlled.

Any differences in phenotype between them when placed in different environments

would be due to the environment and not to genotype.

- (c) Epigenetic factors, such as DNA methylation, can affect the phenotype of an organism.

Explain how DNA methylation can affect the activation of a gene.

(3)

Methyl groups attach to the DNA of the gene (to cytosine at CpG sites).

This causes the DNA to coil more tightly around the histones,

so RNA polymerase and transcription factors cannot bind to the promoter region of the gene.

This prevents transcription of the gene, so the gene is deactivated (switched off).

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(d) In mice, fur colour is determined by genetic and by epigenetic factors.

The photograph shows a litter of mice.



(Source: © Floris Slooff/Shutterstock)

All these mice

- have a gene that produces brown fur and this gene is always switched on
- have the agouti gene that can produce yellow fur.

In an investigation, female agouti mice with yellow fur were placed in two groups, A and B. The mice were fed different diets.

The table shows the features of their offspring.

Group	Diet	Features of offspring produced	
		Fur colour	Health
A	Rich in sources of methyl groups	Most had brown fur	Most had good health
B	Low in sources of methyl groups	Most had yellow fur	Most had poor health



- (i) Deduce the effect of methyl groups in the diet on the features of the offspring of these mice.

(3)

Mothers given a diet rich in methyl groups had offspring with brown fur, while a diet

low in methyl groups gave offspring with yellow fur.

This is because DNA methylation deactivates the agouti gene, so only the brown gene is expressed.

Methylation of the agouti gene also affects health, and a diet low in methyl groups might alter the methylation of other genes apart from the agouti gene, causing poor health.

- (ii) Epigenetic changes to the DNA of the offspring happen during their development inside the mother.

Explain how the results of this investigation support this statement.

(2)

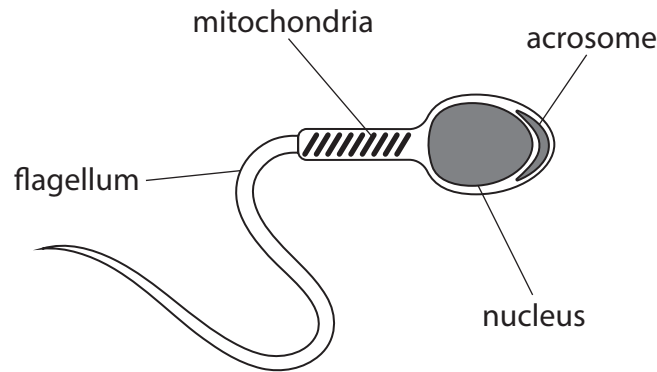
The mother mice all had yellow fur and the only difference between the groups was their diet.

The mothers given a diet low in methyl groups had offspring with yellow fur, because the agouti gene was activated in the offspring (it was deactivated in the brown offspring), so methylation happened while they developed inside the mother.

(Total for Question 6 = 13 marks)

7 Sperm cells are gametes produced by animals.

The diagram shows the structure of a sperm cell.



- (a) Describe how the structure of the sperm cell allows it to reach the surface membrane of an egg cell.

(3)

The flagellum moves (lashes) to propel the sperm, so the sperm can swim towards the egg cell.

The many mitochondria provide ATP (energy) for the movement of the flagellum.

The acrosome contains enzymes (acrosin) that digest the zona pellucida, allowing the sperm to reach the surface membrane of the egg cell.

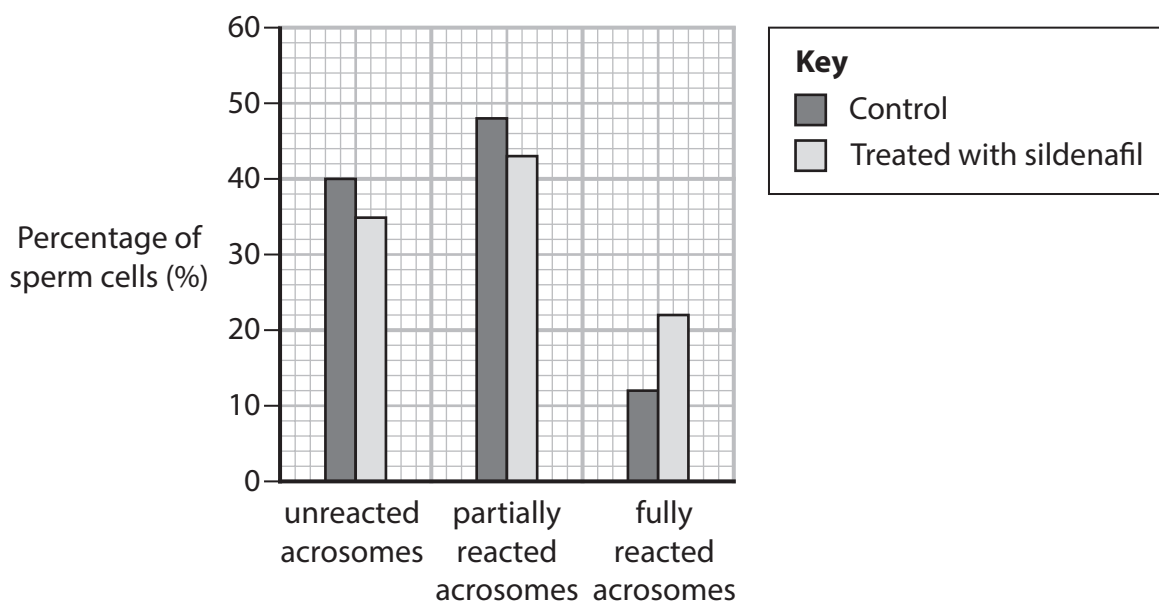


(b) The effect of the drug sildenafil on sperm cells was investigated.

In one investigation, the state of the acrosome was observed after sperm cells were treated with sildenafil. Unreacted acrosomes had not fused with the sperm cell surface membrane. Partially or fully reacted acrosomes had fused with the sperm cell surface membrane.

The percentage of sperm cells with unreacted, partially reacted and fully reacted acrosomes was calculated. This was compared with sperm cells not treated with sildenafil.

The graph shows the results of this investigation.



Deduce how sildenafil could affect fertility.

(3)

Sildenafil reduces fertility.

It increases the number of sperm with fully reacted acrosomes: 22% compared with 12% in the control (10% more), and there are 5% fewer with unreacted acrosomes (35% compared with 40%).

So fewer sperm have an intact acrosome to break down the zona pellucida, and there is no acrosome reaction at the ovum surface, so the male nucleus cannot enter and there is no fertilisation.

- (c) In an investigation, the velocity of the sperm cells was measured from 0 to 90 minutes after being treated with sildenafil.

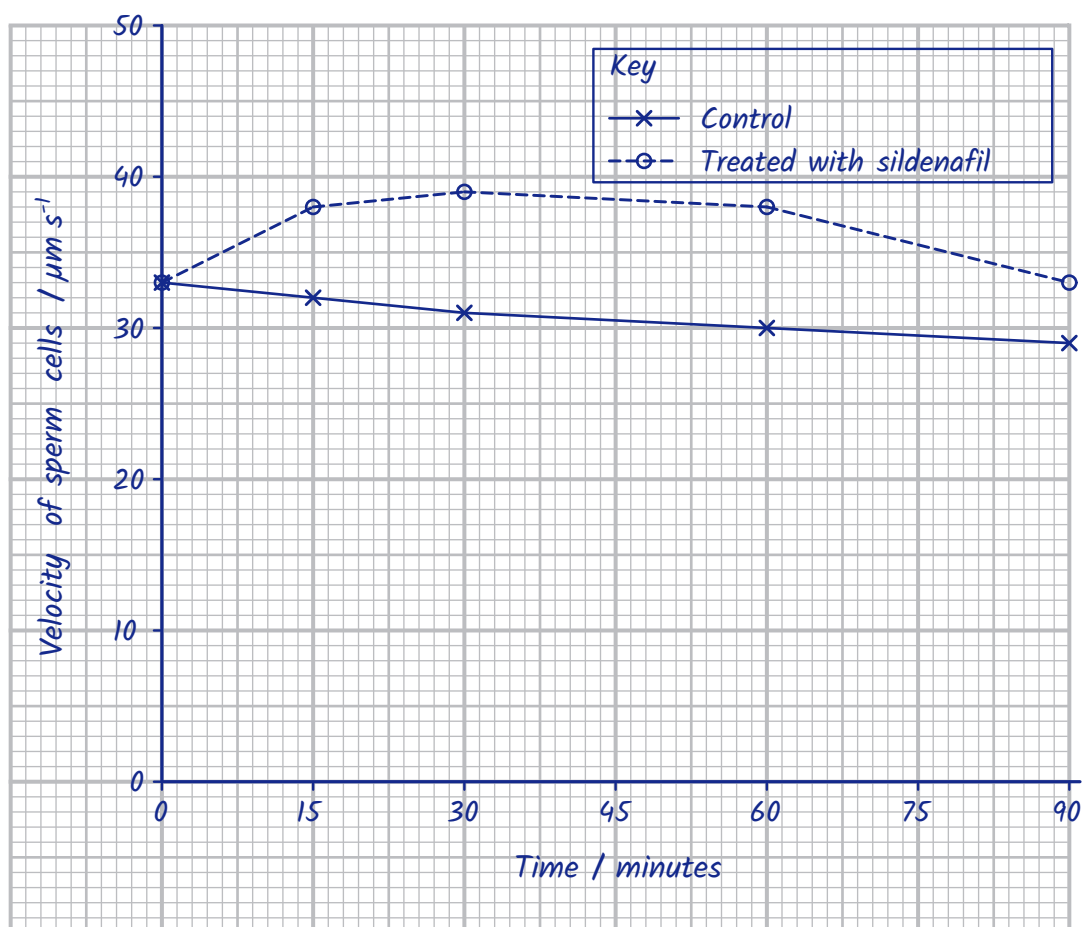
A control group was not given sildenafil.

The table shows the results of this investigation.

Time / minutes	Velocity of sperm cells / $\mu\text{m s}^{-1}$	
	Control	Treated with sildenafil
0	33	33
15	32	38
30	31	39
60	30	38
90	29	33

- (i) Plot the data to show the results of this investigation in a suitable graphical form.

(4)



(ii) It has been stated that sildenafil improves the functioning of mitochondria.

Discuss how these results support this statement.

(4)

With sildenafil the velocity increased from 33 to $39 \mu\text{m s}^{-1}$ between 0 and 30 minutes, whereas in the control the velocity decreased steadily from 33 to $29 \mu\text{m s}^{-1}$ from 0 to 90 minutes.

The velocity was faster with sildenafil than in the control throughout (from 15 to 90 minutes).

Improved functioning of mitochondria would mean more ATP is produced by aerobic respiration, so more energy is available more quickly.

Therefore the flagellum has more energy for movement and propels the sperm faster, which supports the statement. However, the velocity falls back to $33 \mu\text{m s}^{-1}$ by 90 minutes, so the effect is only temporary.

(Total for Question 7 = 14 marks)

8 The conservation of plant species includes storing seeds in seedbanks.

(a) The photograph shows some seed samples prepared for storage.



(Source: © WLADIMIR BULGAR/SCIENCE PHOTO LIBRARY)

(i) Explain why seeds are dried before being stored.

(2)

Removing water prevents enzyme (metabolic) activity, so the seeds do not germinate.

Drying also prevents the growth of microbes (bacteria and fungi), so the seeds do not rot (decay).

(ii) The seeds of many plants are stored at very low temperatures.

Explain the effect of temperature on bacterial growth.

(3)

At low temperatures bacterial growth is slow (bacteria cannot grow), and as

temperature increases so does growth of bacteria,

because enzyme activity is reduced at lower temperatures, as the enzymes and substrates have less kinetic energy, so there are fewer enzyme-substrate complexes formed.

At high temperatures bacterial growth stops because the enzymes are denatured.

(b) Coffee beans are the seeds of the coffee plant.

The photograph shows seeds, leaves and fruits of the coffee plant.



(Source: © Subbotina Anna/Shutterstock)

In an investigation, extracts from different parts of the coffee plant were tested for antimicrobial properties.

Vibrio cholerae, a species of bacteria that causes the disease cholera, was used in this investigation.

The results of the investigation are shown in the table.

Extract from	Mean diameter of inhibition zone / mm $\pm$ SD
Seed	12.33 $\pm$ 0.58
Fruit	11.33 $\pm$ 4.04
Leaf	16.67 $\pm$ 1.15

Comment on the antimicrobial properties of the parts of the coffee plant tested.

(3)

The leaf extract has the most antimicrobial property, as its mean zone of inhibition is greatest (16.67 mm).

The leaf range (15.52 to 17.82 mm) does not overlap with the range for either the fruit or the seed, so this difference is significant.

The ranges overlap for the seed and the fruit (the fruit SD of 4.04 is large), so there is no significant difference in antimicrobial property between seed and fruit.

- *(c) It has been suggested that the antimicrobial properties of seeds are reduced during long periods of time in storage.

Devise an investigation to determine the effect of storage time on the antimicrobial properties of coffee seeds stored in a seed bank.

(6)

Independent variable: storage time. Take coffee seeds from one source (same variety, same harvest) stored in the seed bank for a range of times, e.g. 0, 1, 2, 4, 8 and 16 years (or test at intervals over months), with the same storage conditions (temperature and humidity).

Prepare an extract: surface sterilise the seeds to remove bacteria, grind the same mass of seeds with the same volume of the same solvent, so each extract has the same concentration.

*Using aseptic technique, spread the same volume of *Vibrio cholerae* culture (same species of bacteria) on agar plates. Soak filter paper discs of the same size in the same volume of each extract and place on the agar, with a disc soaked in solvent only as a control.*

Incubate all plates at the same temperature (e.g. 25 °C) for the same time (e.g. 48 hours). Dependent variable: measure the diameter of each zone of inhibition and calculate the area; a larger zone means greater antimicrobial activity.

Repeat with at least 5 plates per storage time and calculate the mean and SD. Use Spearman's rank correlation between storage time and size of inhibition zone to see if the correlation is significant.

(Total for Question 8 = 14 marks)

TOTAL FOR PAPER = 80 MARKS



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