

Please check the examination details below before entering your candidate information

Candidate surname

StemUp Model Solution

Other names

Centre Number

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Candidate Number

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Pearson Edexcel Level 3 GCE

Time 1 hour 45 minutes

Paper
reference

9BI0/02

Biology B

Advanced

PAPER 2: Advanced Physiology, Evolution and Ecology

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.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You may use a scientific calculator.

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- In question(s) 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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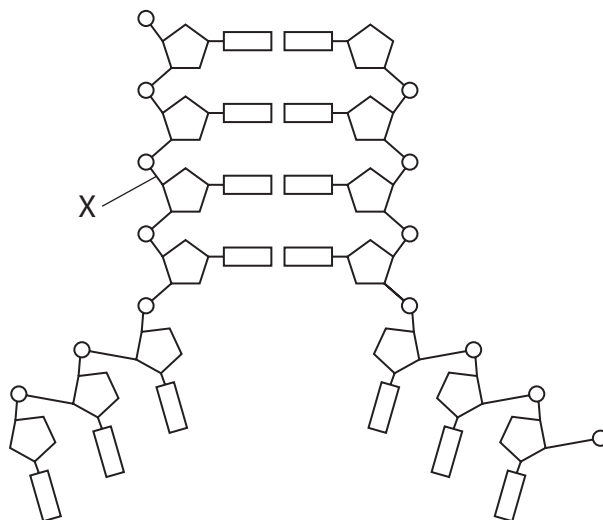


Pearson

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

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 The diagram shows DNA replication.



- (a) Which of the following is the name of the bond labelled X on the diagram?

(1)

- ☐ A ester
☐ B glycosidic
☐ C hydrogen
☒ D phosphodiester

- (b) Describe the roles of three named enzymes involved in DNA replication.

(3)

DNA helicase breaks the hydrogen bonds between the bases, unzipping the double helix and separating the two strands.

DNA polymerase joins adjacent nucleotides, forming phosphodiester bonds in the sugar phosphate backbone of the new strand.

DNA ligase joins the short fragments of DNA (Okazaki fragments) together.



(c) A section of double-stranded DNA has a total number of 10 000 nucleotides.

Adenine makes up 35% of the nucleotides in this section of double-stranded DNA.

Calculate the total number of cytosine nucleotides found in this section of DNA.

(2)

$$A = T = 35\%, \text{ so } G + C = 100 - 70 = 30\%$$

$$\text{cytosine} = 30 \div 2 = 15\%$$

$$15\% \text{ of } 10\,000 = 0.15 \times 10\,000 = 1500$$

Answer 1500

(Total for Question 1 = 6 marks)



2 Plant growth substances and phytochromes are chemicals that affect the growth of plants.

- (a) (i) Which row of the table shows the concentrations required for the fastest growth of lateral buds?

(1)

	Auxin concentration	Cytokinin concentration
☐ A	high	high
☐ B	high	low
☒ C	low	high
☐ D	low	low

- (ii) Some types of auxin affect the activity of cells in the same way as hormones such as oestrogen affect human cells.

These auxins pass through the cell membrane and affect the synthesis of enzymes.

Explain how these auxins affect the synthesis of enzymes.

(3)

The auxin passes through the membrane and binds to a receptor inside the cell (in the cytoplasm or nucleus), forming an auxin-receptor complex.

This activates a transcription factor (the complex acts as a transcription factor).

The transcription factor binds to the promoter region of the DNA and switches on transcription of the gene, so mRNA is produced and the enzyme is synthesised.



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P 6 7 0 8 8 A 0 5 3 6

(b) Phytochrome is involved in the germination of seeds.

The effect of red (R) light and far-red (FR) light on the germination of lettuce seeds was investigated.

A scientist exposed five groups of 50 seeds to red light for one minute.

The seeds were planted and the mean number that germinated was calculated.

Another five groups each of 50 seeds were then exposed to red light for one minute, followed by far-red light for four minutes.

These seeds were planted and the mean number that germinated was calculated.

The experiment was repeated with different combinations of red light and far-red light.

The results are shown in the table.

Sequence of red (R) and far-red (FR) light	Mean number of seeds that germinated	Standard deviation (SD)
R	45	± 4
R, FR	5	± 2
R, FR, R	45	± 5
R, FR, R, FR	10	± 4
R, FR, R, FR, R	40	± 9



Analyse the data to comment on the effect of red (R) and far-red (FR) light on the germination of lettuce seeds.

(4)

More seeds germinate when the last exposure is red light (40 to 45 seeds) than when the last exposure is far-red light (5 to 10 seeds).

The number of exposures makes no difference; only the colour of the final exposure matters.

The difference is significant when the last colours are different, as the standard deviations do not overlap; when the last colour is the same the SDs overlap, so there is no significant difference.

Red light converts P_R into P_{FR} , and far-red light converts P_{FR} back into P_R .

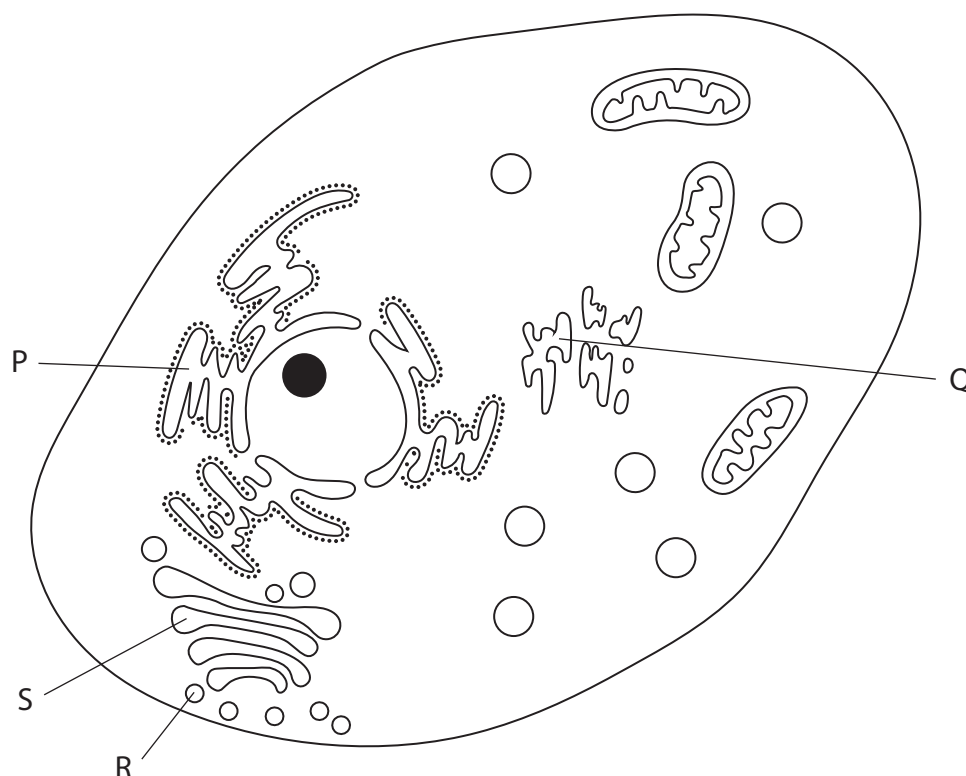
P_{FR} stimulates germination (e.g. gibberellin release, activating amylase), so a high $P_{FR} : P_R$ ratio after red light causes germination.

(Total for Question 2 = 8 marks)



P 6 7 0 8 8 A 0 7 3 6

3 The diagram shows the structure of an animal cell.



(a) (i) Which of the following is the name of the structure labelled Q?

(1)

- ☐ A centriole
- ☐ B nucleus
- ☐ C rough endoplasmic reticulum
- ☒ D smooth endoplasmic reticulum

(ii) These cells were cultured in radioactively-labelled amino acids.

In which sequence would the cell structures in the diagram become radioactive during protein synthesis?

(1)

- ☐ A Q S R
- ☐ B S P R
- ☐ C P R Q
- ☒ D P S R



(iii) Explain one function of lysosomes.

(2)

Lysosomes contain hydrolytic (digestive) enzymes, e.g. lysozyme and proteases.

*These hydrolyse pathogens such as bacteria that have been engulfed by phagocytosis,
and digest old, worn-out organelles.*

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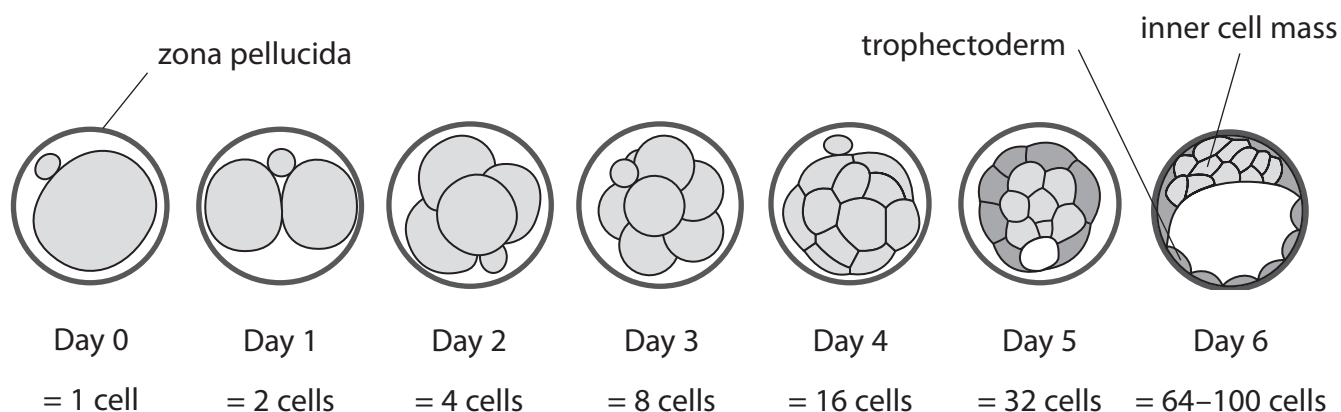
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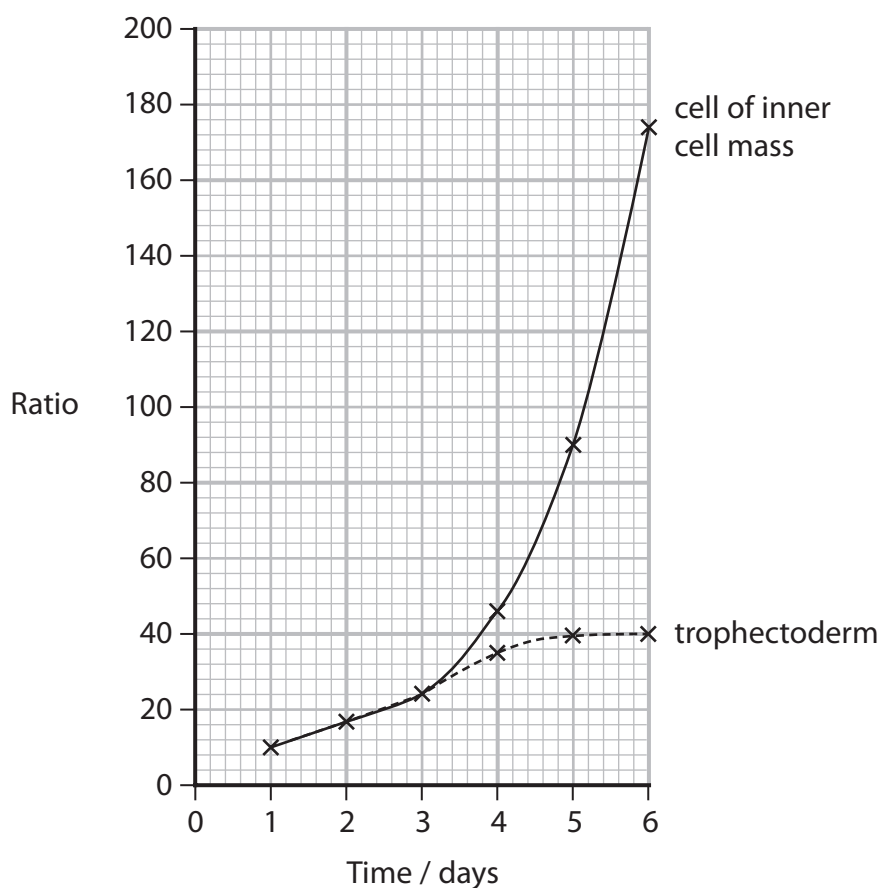


P 6 7 0 8 8 A 0 9 3 6

(b) The diagram shows the development of a zygote into a blastocyst.



The graph shows how the ratio of the volume of the nucleus to the volume of the cytoplasm of each embryonic cell changes as the blastocyst develops.



- (i) The ratio shown in the graph can be calculated using the formula

$$\text{ratio} = \frac{\text{volume of nucleus}}{\text{total volume of cell} - \text{volume of nucleus}}$$

On day 2, the volume of the cell nucleus was $900 \mu\text{m}^3$.

Calculate the total volume of this cell on day 2.

Give your answer to two significant figures.

(3)

ratio on day 2 from graph = 17

$17 = 900 \div (\text{total volume} - 900)$

$\text{total volume} - 900 = 900 \div 17 = 52.94$

$\text{total volume} = 952.94 \mu\text{m}^3$

Answer 950 μm^3

- (ii) Comment on the changes in the ratios as the zygote develops into a blastocyst.

(3)

The ratio increases for both cell types up to day 3 (at a steady rate).

After day 3 to 4 the ratio increases much more steeply for the inner cell mass cells, whereas for the trophectoderm cells it levels off (at about 40) after day 4.

As the ratio increases, the volume of cytoplasm (cell volume) decreases, because the cells divide without growing in between.

This shows the cells are differentiating; the inner cell mass cells divide faster than the trophectoderm cells.

(Total for Question 3 = 10 marks)



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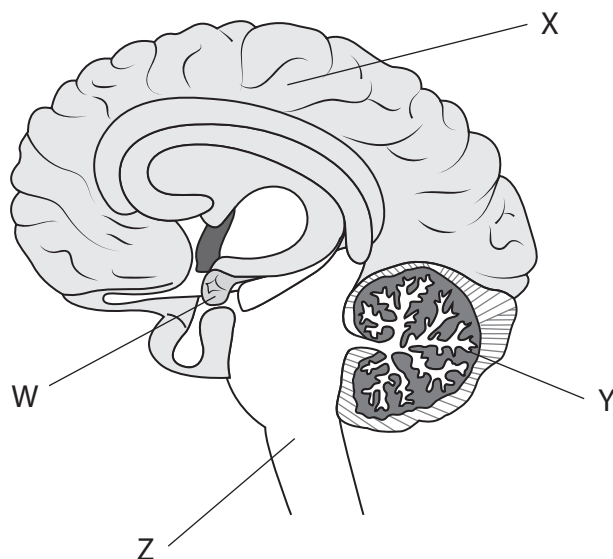
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4 The autonomic nervous system controls the heart rate.

(a) The diagram shows a human brain.



(i) Which region of the brain controls the heart rate?

(1)

- ☐ A W
- ☐ B X
- ☐ C Y
- ☒ D Z

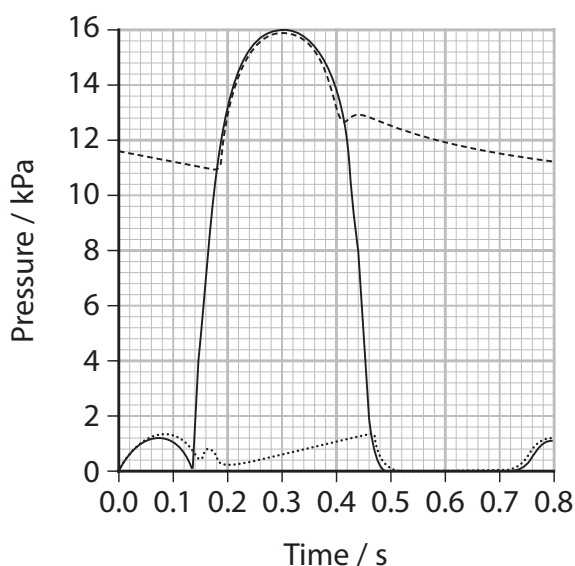
(ii) Which one of the following would lead to an increase in heart rate?

(1)

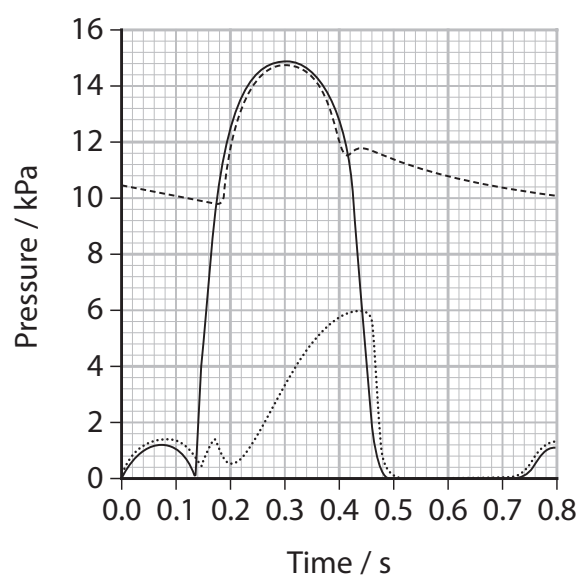
- ☐ A release of acetylcholine by the sympathetic nervous system
- ☐ B release of acetylcholine by the parasympathetic nervous system
- ☒ C release of noradrenaline by the sympathetic nervous system
- ☐ D release of noradrenaline by the parasympathetic nervous system



- (b) The graphs show the pressure changes that occur in a healthy heart and the pressure changes that occur in a heart with an atrioventricular valve that leaks.



Healthy heart



Heart with an atrioventricular valve that leaks

Key

- left ventricle
- aorta
- left atrium

- (i) An atrioventricular valve in the healthy heart has a surface area of 3.5 cm^2 .

Determine the force that is applied to this atrioventricular valve when it closes.

Use the formula

$$\text{Pressure in kPa} = \frac{\text{Force in newtons}}{\text{Area in m}^2}$$

(3)

pressure when the AV valve closes = 0.8 kPa

area = $3.5 \text{ cm}^2 = 3.5 \times 10^{-4} \text{ m}^2$

force = pressure $\times$ area

= $0.8 \times 3.5 \times 10^{-4} = 2.8 \times 10^{-4} \text{ N}$

Answer 2.8×10^{-4} newtons



- (ii) Explain why people with an atrioventricular valve that leaks find exercise difficult.

(4)

In the leaking heart the pressure in the left atrium rises when the ventricle contracts (during ventricular systole).

This is because blood is flowing back from the ventricle into the atrium through the leaking valve.

So there is a lower pressure in the ventricle and the aorta, and less blood enters the systemic circulation.

Therefore less oxygenated blood flows to the muscles, so oxygen is delivered more slowly.

So there is less aerobic respiration in the muscles, less ATP is produced and more anaerobic respiration occurs, so exercise is difficult.

(Total for Question 4 = 9 marks)



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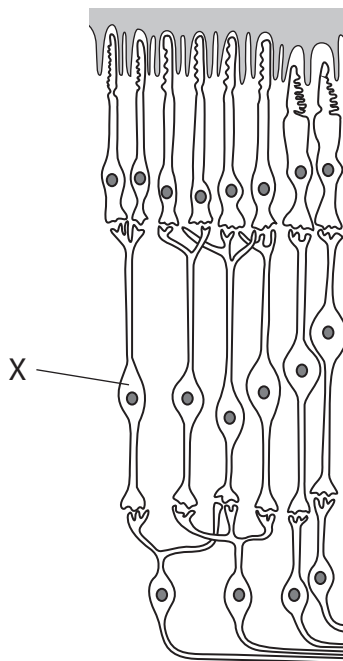
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5 The diagram shows a section of a human retina.



(a) Which of the following is the name of the cell labelled X?

(1)

- ☒ **A** bipolar neurone
☐ **B** ganglion neurone
☐ **C** motor neurone
☐ **D** optic neurone

(b) Explain the role of rhodopsin in the generation of a nerve impulse in cell X when light falls on the retina.

(3)

When light falls on the rod cell, rhodopsin breaks down into opsin and trans retinal (cis retinal is converted to trans retinal).

This causes the sodium ion channels in the rod cell membrane to close, so sodium ions stop moving into the cell and the rod cell hyperpolarises.

So less inhibitory transmitter (glutamate) is released onto cell X, so cell X depolarises and an impulse is generated.

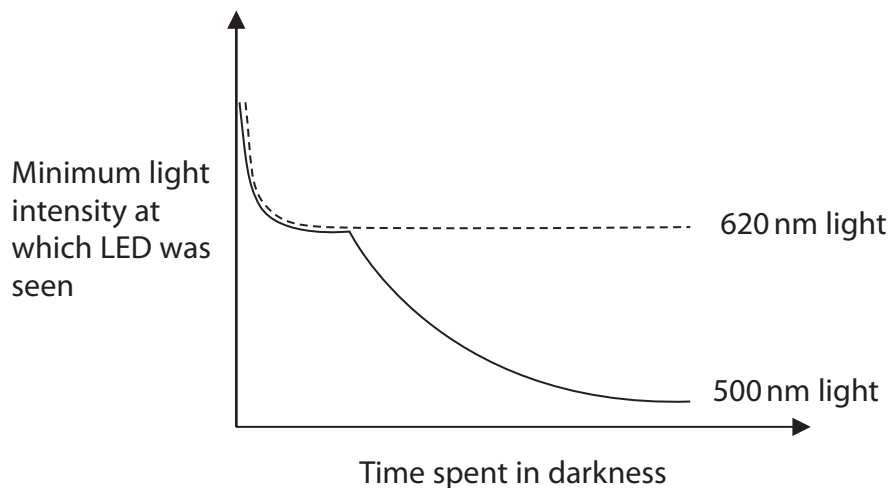


- *(c) A scientist investigated the effect of how the length of time a volunteer spent in darkness affected the sensitivity of their retina to light.

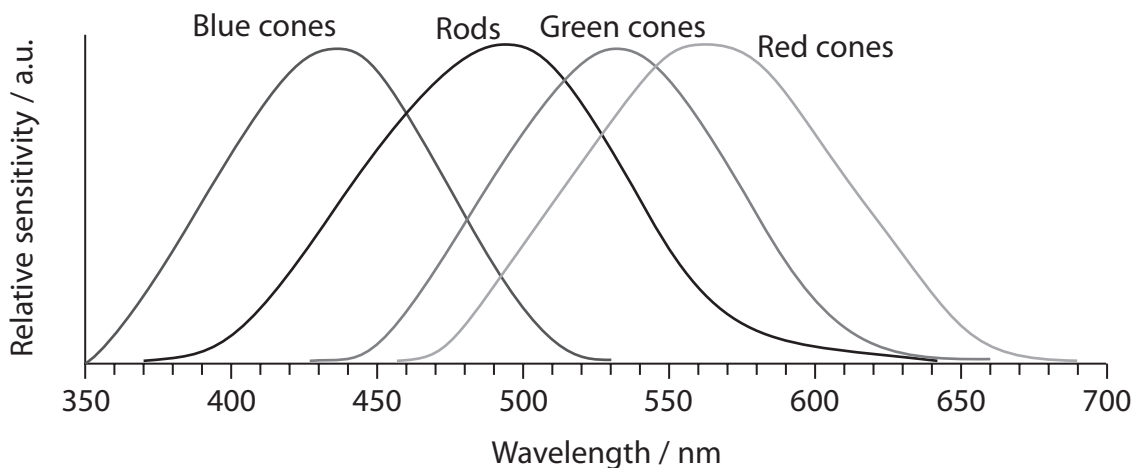
This is the method used:

- the volunteer sat in a room illuminated with white light for twenty minutes
- the lights were switched off and the room was placed into total darkness for one minute
- an LED emitting light of wavelength 500 nm at low light intensity was switched on
- the light intensity was gradually increased until the volunteer was able to see the LED and this minimum light intensity was recorded
- this was repeated with increasing lengths of time that the volunteer was kept in total darkness
- the investigation was then repeated with an LED that emitted red light with a wavelength of 620 nm.

The graph shows the results of this investigation.



The graph shows the relative sensitivity of rods and three types of cone to light of different wavelengths.



Analyse the graphs to explain the results of this investigation.

(6)

The longer the volunteer spends in the dark, the lower the minimum light intensity at which the LED is seen, so the retina becomes more sensitive. The retina is more sensitive to 500 nm light than to 620 nm light: with 620 nm light the minimum intensity falls quickly then levels off, while with 500 nm light it continues to fall for longer.

The sensitivity graph shows 620 nm light stimulates only cones (mainly red cones) but not rods, whereas 500 nm light stimulates rod cells (their peak) and cones.

In white light, rhodopsin in rods and iodopsin in cones are bleached (broken down into opsin and trans retinal). In the dark, trans retinal is converted back to cis retinal, which binds to opsin, so rhodopsin and iodopsin are resynthesised.

Cone cells dark adapt faster than rod cells, as iodopsin is reformed quickly, which explains the first rapid fall for both wavelengths. Rhodopsin takes longer to be reconverted from opsin and retinal, so the 500 nm curve keeps falling after the 620 nm curve has levelled off.

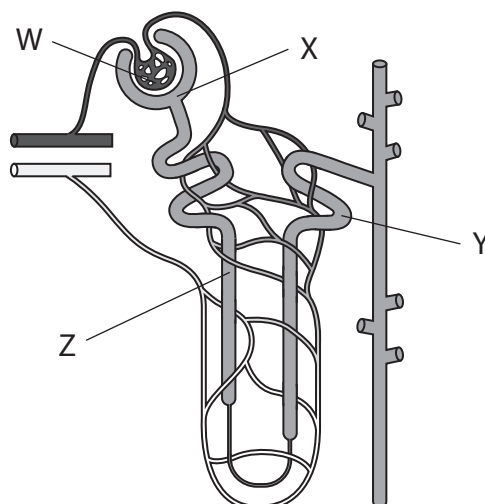
Rhodopsin is more sensitive than iodopsin, and rod cells show retinal convergence: several rods synapse with one bipolar cell, so spatial summation lets several rods together overcome the threshold and generate an action potential at a lower light intensity.

So the levelling off with 620 nm light shows that cone cells are less sensitive than rod cells.

(Total for Question 5 = 10 marks)



6 The diagram shows a nephron.



(a) Which labelled parts of this nephron would normally contain glucose?

(1)

- ☐ A W only
- ☒ B W and X
- ☐ C W, X, and Y
- ☐ D W, X, Y, and Z

(b) Oedema is an accumulation of tissue fluid. This is due to less tissue fluid being returned to the blood capillaries.

(i) Explain how tissue fluid is returned to capillaries.

(3)

There is more protein in the plasma than in tissue fluid, because plasma proteins are too large to pass out of the capillary.

The plasma proteins generate an oncotic pressure (lower water potential in the blood).

At the venous end, hydrostatic pressure is lower, so the oncotic (osmotic) pressure is greater than the hydrostatic pressure and tissue fluid moves back into the capillary by osmosis.



- (ii) Furosemides are drugs that are used to reduce oedema. They are diuretics that increase urine production.

Furosemides reduce the active transport of sodium ions by the loop of Henle.

Explain how furosemides cause an increase in urine production.

(4)

With less active transport, sodium ions are not removed from the ascending limb of the loop of Henle into the medulla.

So the water potential of the medullary tissue fluid is higher (less negative), and the water potential gradient is lower.

Therefore less water is removed by osmosis from the descending limb, and less water is reabsorbed from the collecting duct (and distal tubule).

So a higher volume of dilute urine is produced.

(Total for Question 6 = 8 marks)



- 7 The photograph shows a tawny owl. These owls live in areas close to the Arctic Circle.



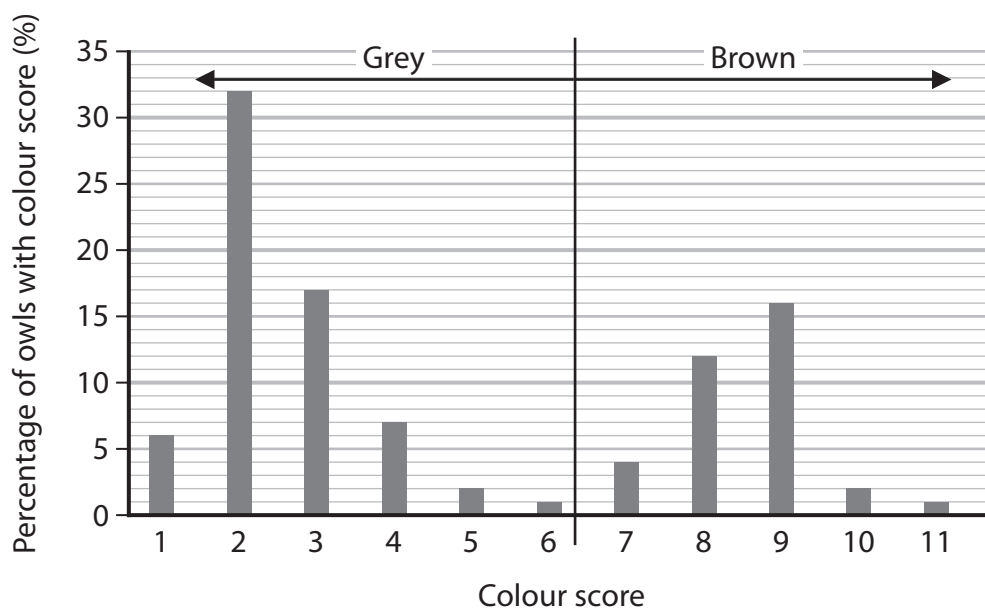
(Source: © LINDA WRIGHT/SCIENCE PHOTO LIBRARY)

Scientists investigated the feather colours of a population of tawny owls. Feather colours of the owls were scored on a scale of 1 to 11, according to how grey or brown they were.

Grey feathered owls were given a score between 1 and 6, with 1 being the most grey.

Brown feathered owls were given a score between 7 and 11, with 11 being the most brown.

The graph shows the percentages of owls in the population with each of the colour scores.



- (a) The scientists concluded that feather colour in owls is controlled by a single genetic locus. The brown allele is dominant to the grey allele.

(i) State what is meant by a dominant allele.

(1)

An allele where only one copy is needed to affect the phenotype; it is expressed in heterozygotes.



- (ii) Explain the range of feather colours, shown in the graph, in this population of owls.

(2)

There are two main peaks because there are only two alleles; grey owls are homozygous recessive and brown owls have a dominant allele.

The intermediate scores are due to the environment (e.g. diet) affecting feather colour, and the peak for grey is larger as grey owls have a survival advantage.

- (iii) In this population of 120 owls, 84 of them were grey.

Calculate the number of owls that are heterozygous for feather colour.

Use the Hardy-Weinberg equation

$$p^2 + 2pq + q^2 = 1$$

(3)

$$q^2 = 84 \div 120 = 0.7$$

$$q = \sqrt{0.7} = 0.84$$

$$p = 1 - 0.84 = 0.16$$

$$2pq = 2 \times 0.16 \times 0.84 = 0.27$$

$$\text{heterozygotes} = 0.273 \times 120 = 32.8$$

Answer 33



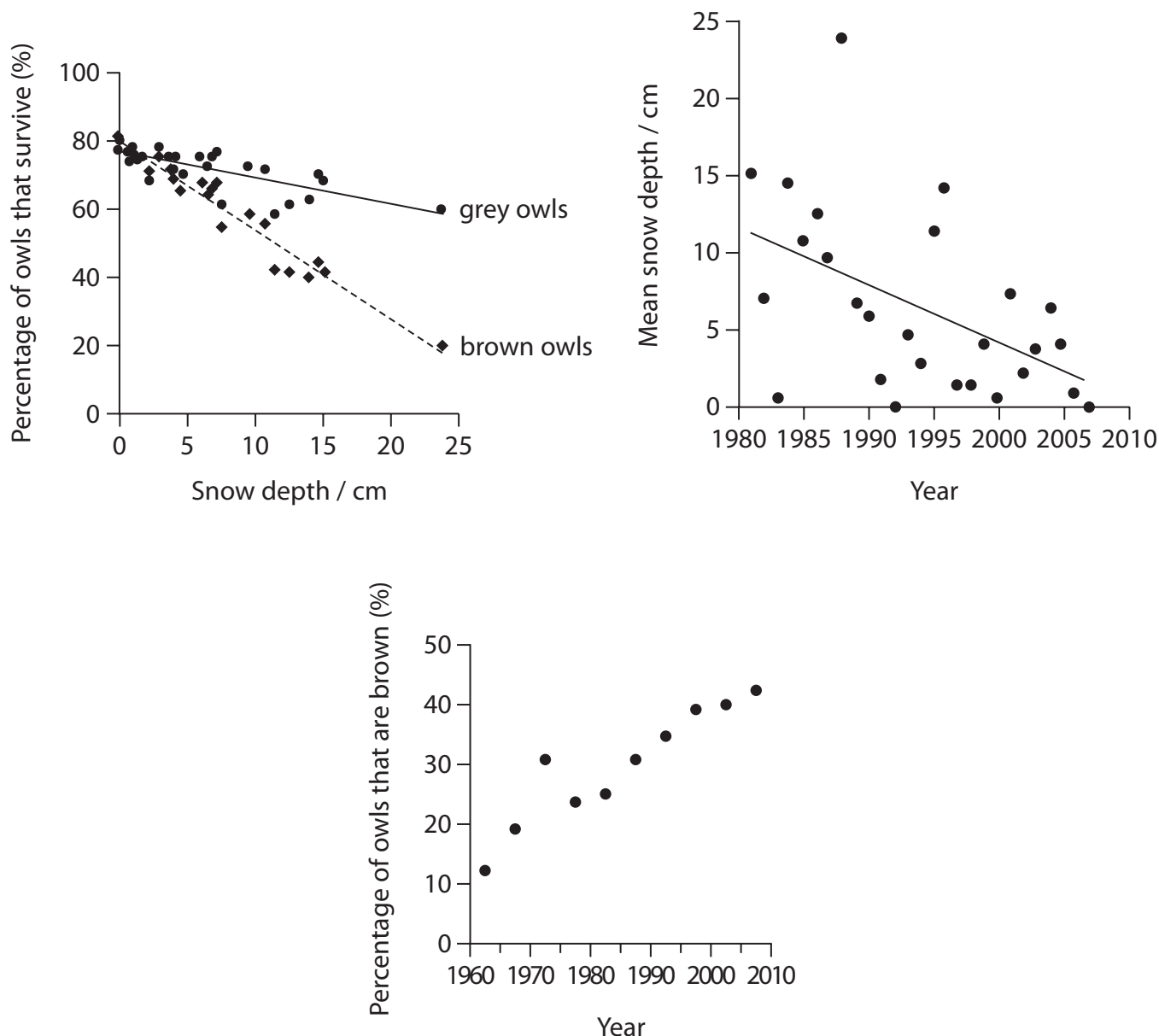
- *(b) The scientists investigated the effect of climate change on the frequencies of these two alleles for feather colour in populations of tawny owls.

The percentage survival rates of both colours of owl were measured when there were different depths of snow.

The mean depth of snow was recorded each year between 1980 and 2007.

The percentage of owls that were coloured brown between 1960 and 2007 was also recorded.

The graphs show the results.



The scientists concluded that increased greenhouse gases from human activity are resulting in an increase in the frequency of the brown allele.

Analyse the data to evaluate this conclusion.

(6)

The data show that as snow depth increases, the survival of grey owls is higher than that of brown owls; fewer brown owls survive in deep snow. Mean snow depth has decreased between 1980 and 2007, and the percentage of brown owls has increased from about 12% in 1960 to over 40% in 2007.

Evidence for: increased greenhouse gases such as carbon dioxide absorb and re-radiate heat (enhanced greenhouse effect), causing warming and less snow. With less snow, more ground, twigs and trees are visible, so grey owls are more obvious to predators and prey and less camouflaged. Natural selection then favours brown owls, which survive and reproduce, so more brown alleles are passed on and fewer grey alleles.

Evidence against: there is no direct measure of greenhouse gases, temperature or fossil fuel emissions. The graphs only show correlations, not a causal link. The survival data are scattered with gaps, and the snow depth data are scattered with many anomalies (e.g. 24 cm in 1988), so the correlation is weak. The reduced snow may not be due to greenhouse gases, and other factors, such as food supply, prey or predators, could be affecting the owl population.

So the data partly support the conclusion, but it cannot be confirmed.

(Total for Question 7 = 12 marks)



- 8 The photograph shows a glacier that is melting. As the glacier gradually melts, it leaves behind bare rock.



melting glacier

(Source: © CHARLES D. WINTERS/SCIENCE PHOTO LIBRARY)

Scientists sampled the soil from areas that had been uncovered for different lengths of time after the glacier ice had melted.

The table shows the results from the samples.

Length of time since glacier melted / years	Soil depth / cm	Mass of nitrate in soil / mg m^{-2}	Mass of leaf litter that falls to ground each year / $\text{g m}^{-2} \text{yr}^{-1}$
5	5.2	3.8	1.5
15	6.4	4.1	1.7
40	7.0	5.3	12.8
100	9.2	21.8	277.0
150	10.8	35.4	335.0
200	15.1	53.3	277.0
250	16.2	61.4	261.0

- (a) Which of the following should be used to determine if there is an association between length of time since the glacial ice has melted and soil depth?

(1)

- ☐ A chi squared
- ☒ B correlation coefficient
- ☐ C standard deviation
- ☐ D t-test



(b) Explain how succession brings about the changes in the soil during this period of time.

(5)

After the glacier melts, pioneer species such as mosses and lichens colonise the bare rock.

When they die, decomposition increases the soil depth and the humus, mineral and nutrient content of the soil.

Therefore larger plants can grow, and animals arrive as there are more niches.

Leaf litter increases after 40 to 100 years (12.8 to $277 \text{ g m}^{-2} \text{ yr}^{-1}$) as more herbaceous plants, shrubs and trees are present.

There is a steep increase in nitrate after 40 to 100 years (5.3 to 21.8 mg m^{-2}) from more leaves, plants, animals and faeces decomposing.

Leaf litter falls from 150 to 250 years as a climax community has emerged, but nitrate continues to increase due to animals and their faeces.

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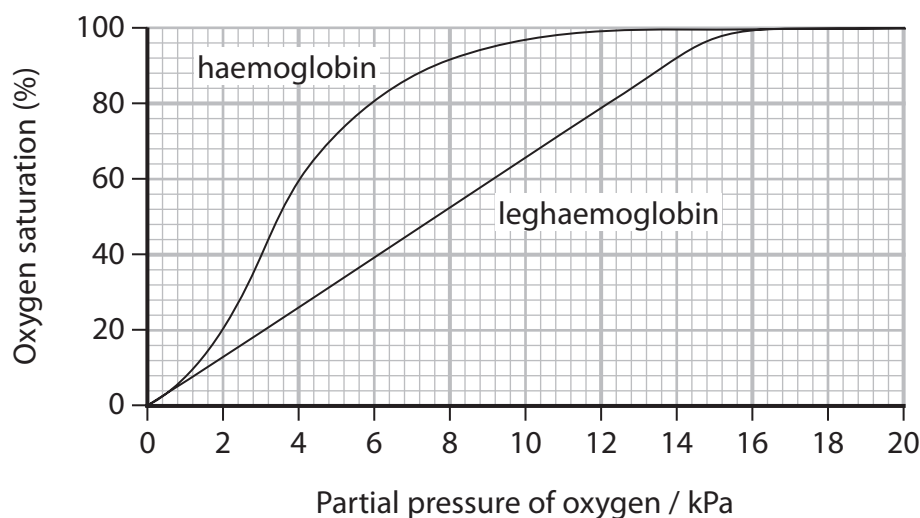
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- (c) The roots of some of the plants growing around the glacier were found to contain an oxygen binding protein called leghaemoglobin.

The graph shows the oxygen dissociation curve for leghaemoglobin and the oxygen dissociation for haemoglobin.



- (i) Leghaemoglobin is a protein that is similar in structure to myoglobin. Both of these proteins have one subunit.

Explain how the oxygen dissociation curve shows that the structure of leghaemoglobin is more similar to myoglobin than to haemoglobin.

(3)

The leghaemoglobin curve is not S shaped; it is a straight line, like myoglobin, whereas haemoglobin is sigmoid.

This is because leghaemoglobin's affinity for oxygen does not change as oxygen binds, as there is no cooperative binding (no change in shape of subunits).

This is because it has only one subunit, so it binds to only one molecule of oxygen, whereas haemoglobin has four binding sites.



- (ii) Explain how leghaemoglobin enables these plants to grow in waterlogged and compact soils.

(3)

Waterlogged and compact soils have little oxygen.

Leghaemoglobin binds to and stores oxygen and provides it for aerobic respiration in the root cells.

This provides ATP which enables active uptake of mineral ions, such as nitrate to make amino acids, magnesium to make chlorophyll and calcium to make calcium pectate.

(Total for Question 8 = 12 marks)



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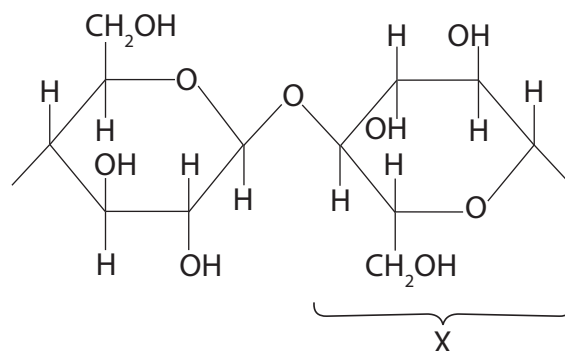


- 9 In Kenya, an in-situ conservation project has been set up to make paper from elephant dung.

This project aims to help conserve elephant populations, conserve biodiversity and help local communities.

- (a) Paper is produced from cellulose molecules present in elephant dung.

The diagram shows part of a cellulose molecule.



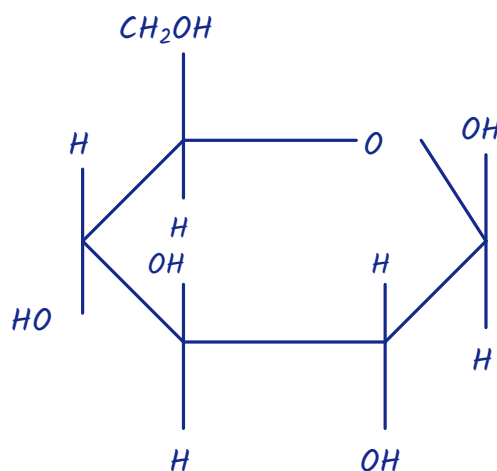
- (i) Which of the following is the name of the monomer labelled X on the diagram?

(1)

- ☐ A α glucose
- ☒ B β glucose
- ☐ C α ribose
- ☐ D β ribose

- (ii) Draw one of the products of the hydrolysis of this part of the cellulose molecule.

(2)



- (iii) Explain how the structure of cellulose is adapted for its function in plant cell walls.

(3)

Cellulose molecules are straight chains (not helical or coiled), with alternate β glucose molecules rotated 180° .

Many hydrogen bonds form between the parallel chains, holding them together into strong microfibrils.

This makes the cell wall strong to resist turgor pressure, preventing the cell bursting and maintaining turgidity, while water and minerals can still pass through.

- (b) Elephant conservation often involves the setting up of protected areas to stop poaching. Local people are banned from entering these areas.

This method of elephant conservation sometimes causes conflict with local people, as elephants can trample and eat crops in nearby farmland. Farmers sometimes burn areas of grassland and forest to stop elephants destroying their farmland.

The new paper conservation project encourages local people to make paper from elephant dung they collect from the conservation area. The paper they make is sold at a high price.

Conservationists measured the effect of the new paper project on the index of diversity of the area over two years. They also measured the effect of a protected conservation area where local people were banned from entering on the index of diversity. The results are shown in the table.

Area	Index of diversity	
	At start of project	After two years
Conservation area with paper project	2.8	3.6
Conservation area where local people are banned from entering	2.4	2.2



- (i) State why calculating an index of diversity is a better measure of biodiversity than counting the number of different species.

(1)

It takes into account the population (abundance) of each species, not just the number of species.

- (ii) Give two advantages of in-situ conservation of elephants compared with ex-situ conservation of elephants.

(2)

Other species in the ecosystem are also conserved and food webs are maintained.

The elephants' behaviour stays natural (they are not humanised) and less inbreeding occurs, so the gene pool is maintained.

- (iii) Explain the effect of the new paper project on biodiversity compared with the protected area where local people were banned.

(4)

Biodiversity increased in the paper project area (index of diversity 2.8 to 3.6) but went down in the area where people were banned (2.4 to 2.2).

This is because less grassland and forest is burnt by farmers and there is less poaching, as local people make money from selling the paper, so they have a vested interest in the elephants; if the elephants are not present they lose a source of income.

So more habitats are not destroyed and more niches are available, and the elephants transfer plant seeds in their dung.



- (c) Describe the limitations of CITES in the conservation of organisms such as elephants.

(2)

Signing the treaty is voluntary, so not all countries sign it, and many species such as elephants move across national boundaries.

CITES only prevents trade; monitoring is expensive and some countries are too large to monitor, and high financial rewards mean poaching continues.

(Total for Question 9 = 15 marks)

TOTAL FOR PAPER = 90 MARKS



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