Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL

1400U40-1

S18-1400U40-1

BIOLOGY – A2 unit 4

Variation, Inheritance and Options

MONDAY, 11 JUNE 2018 – AFTERNOON

2 hours

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1.**	**13**	
	2.	**15**	
	3.	**15**	
	4.	**18**	
	5.	**9**	
Section B	**Option**	**20**	
	Total	**90**	

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ADDITIONAL MATERIALS

In addition to this paper, you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Write your answers in the spaces provided in this booklet. If you run out of space, use the continuation pages at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

This paper is in 2 sections, **A** and **B**.

Section **A**: 70 marks. Answer **all** questions. You are advised to spend about 1 hour 35 minutes on this section.

Section **B**: 20 marks; Options. Answer **one option only**. You are advised to spend 25 minutes on this section.

The number of marks is given in brackets at the end of each question or part-question.

The assessment of quality of extended response (QER) will take place in question **5**. The quality of written communication will affect the awarding of marks.

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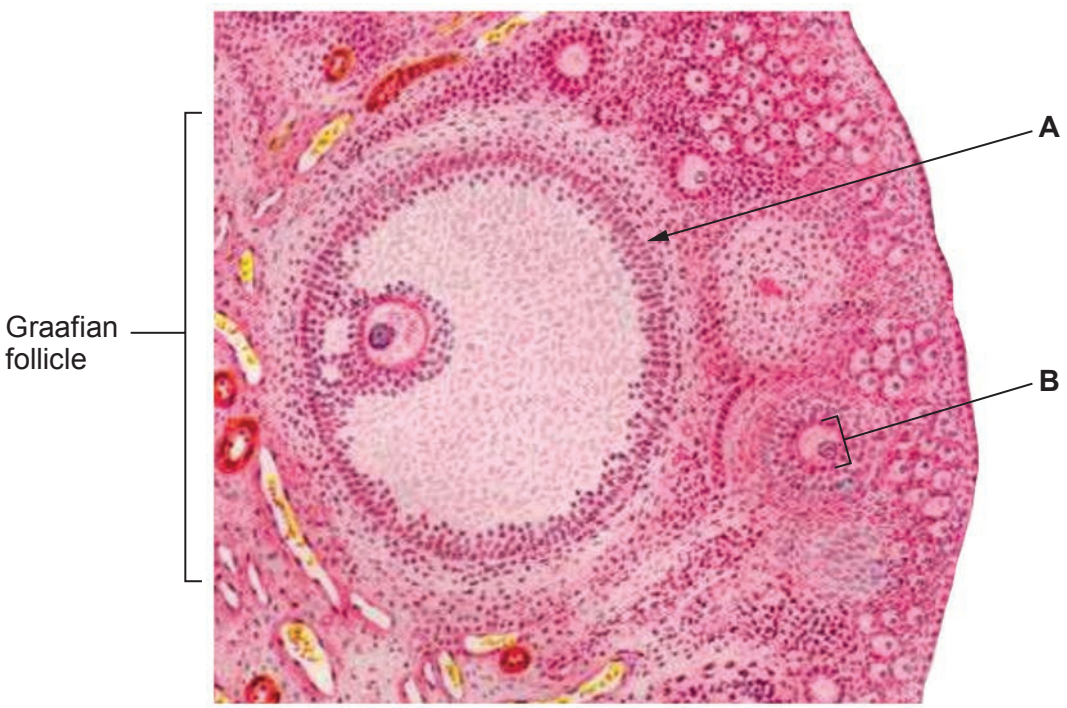
Answer **all** *questions.*

1. The photomicrograph below shows a section through part of a human ovary.



(a) (i) Name the structures **A** and **B**. [2]

A .....

B .....

(ii) The volume of a primary follicle is 0.00005 mm^3 and the volume of a mature Graafian follicle is 4.19×10^3 mm^3. By how many times is the volume of the Graafian follicle bigger than the volume of the primary follicle? Express your answer in standard form. [3]

Graafian follicle is ..... times bigger than the primary follicle

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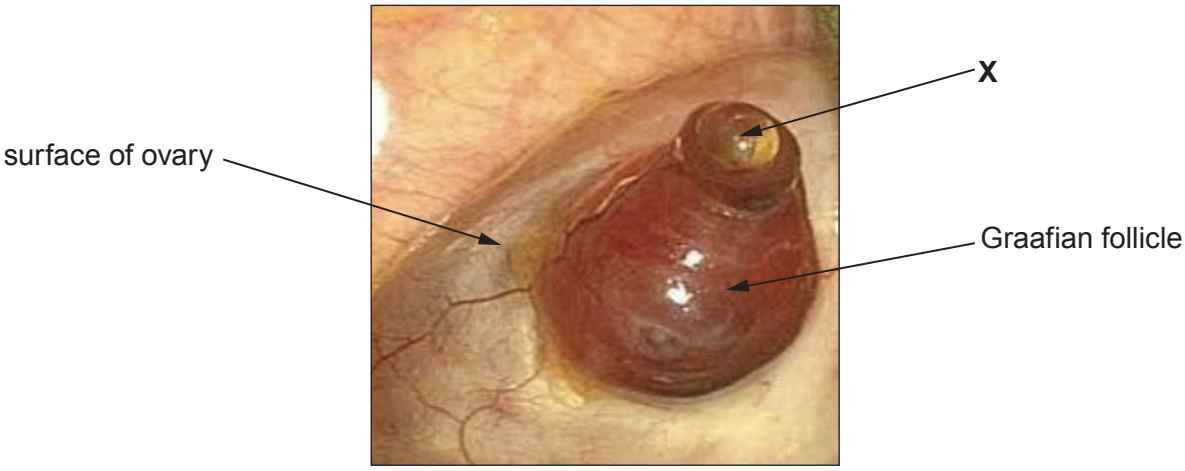
In the human female, the first half of the meiotic division takes place just before ovulation. The photograph below shows the surface of an ovary at ovulation.



(b) Structure **X** contains the secondary oocyte. Name the **two** outer layers of structure **X**. [1]

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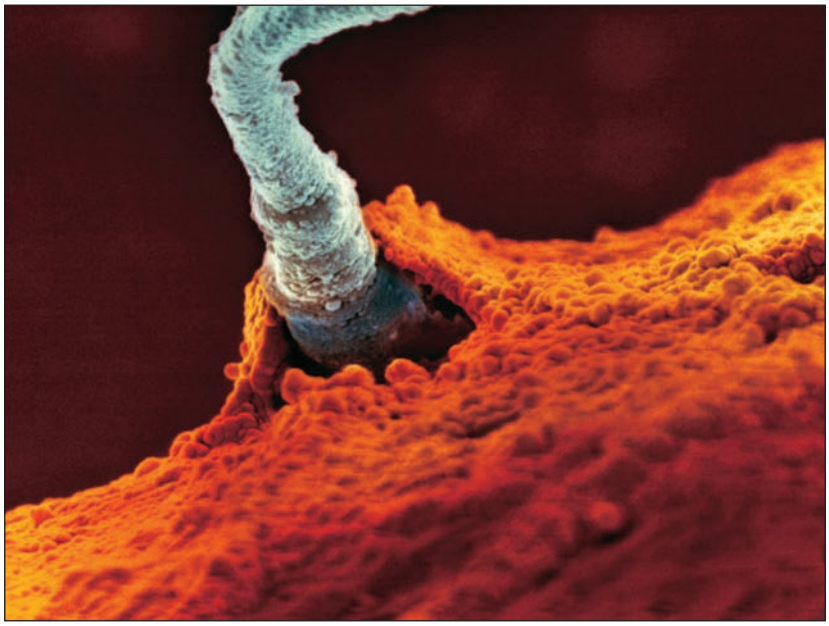
The scanning electron micrograph shows a sperm penetrating the surface of structure **X**.



(c) Describe how the sperm is able to penetrate the outer layers of this structure. [2]

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(d) In vitro fertilisation (IVF) is a technique available to help people with fertility problems. During IVF, secondary oocytes are removed from a woman's ovaries and are fertilised with sperm in a laboratory.

(i) There is a risk that during fertilisation more than one sperm enters the secondary oocyte. The risk is increased if the secondary oocyte is not fully mature. There is a 6% increased chance of more than one sperm entering the secondary oocyte with IVF.

State how the secondary oocyte usually prevents the entry of more than one sperm and suggest a reason why there is an increased risk with IVF. [2]

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(ii) The developing embryo is not transferred into the uterus until three days after IVF. Using your knowledge of fertilisation and implantation explain why this delay is needed. [3]

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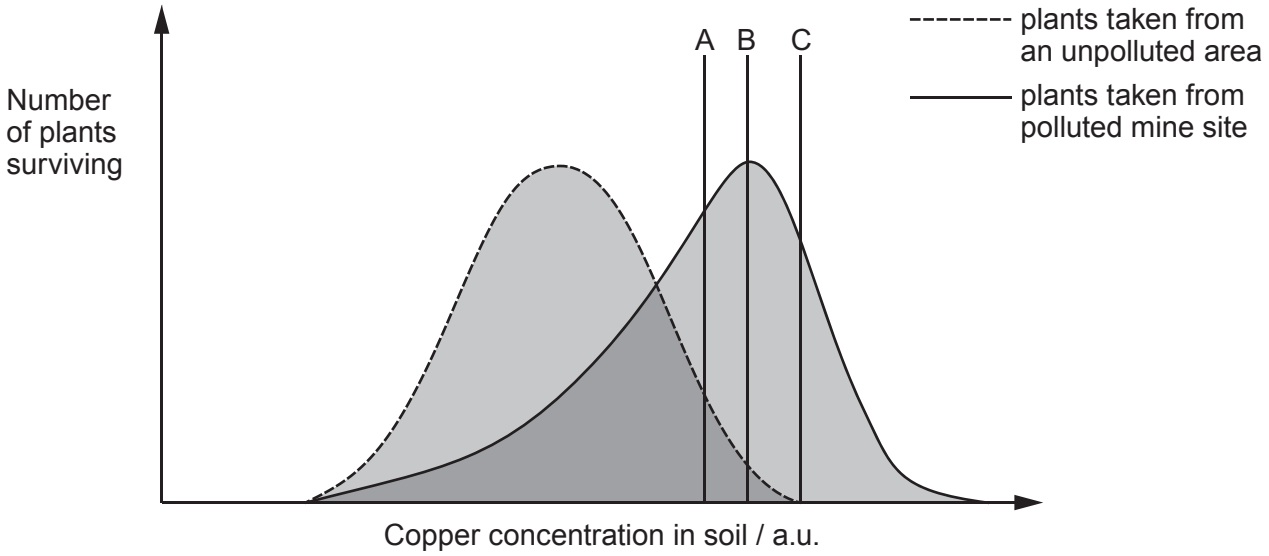
2. Plants, such as sweet vernal grass *(Anthoxanthum odoratum)*, require a range of mineral ions which are absorbed from the soil by the roots. Some ions are required in large amounts and others, such as copper, are required in smaller amounts but are toxic at high levels.

One population of sweet vernal grass was found growing in the soil of a derelict mine site in North Wales where copper concentrations reach highly toxic levels. An investigation was carried out to compare these with sweet vernal grass plants from an unpolluted area. Plants from both populations were then grown in soils containing different concentrations of copper. The graph below shows the number of plants from each population that survived at each concentration.



(a) (i) State the type of variation shown by the plants taken from the unpolluted soil. Explain your answer. [1]

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(ii) With reference to the graph, state which letter (**A**, **B** or **C**) identifies the mode for sweet vernal grass taken from the mine site and state the difference between the terms *mean* value and *modal* value. [3]

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(b) One hundred years ago the sweet vernal grass was unable to survive on the mine sites but now colonises them. Use your understanding of natural selection to explain this observation. [4]

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(c) Sweet vernal grass plants which are tolerant to high copper concentration in the soil flower at a different time of year from the non-tolerant plants in adjacent areas. Explain why it is predicted that this could lead to the formation of two different species. [4]

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(d) (i) Another species of grass, common bent *(Agrostis tenuis)*, is also copper tolerant and is found growing in polluted mine sites together with sweet vernal grass. The frequency of common bent was seen to be higher than sweet vernal grass. State the type of competition involved and **two** factors for which the plants compete. [2]

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(ii) State and explain whether high copper concentrations act in a density dependent or density independent way. [1]

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3. The image below shows sweet peas which can be a number of different colours including white and purple.

Pollen was transferred from the anthers of white flowers onto the stigmas of purple flowers. In the F1, some plants produced purple flowers and some produced white flowers.

Two hypotheses have been suggested to explain this result.

(a) The **first hypothesis** is that the purple variety is caused by a dominant allele of a single gene.

(i) Construct a genetic diagram to show the genotypes and phenotypes of the parents of this cross. Use the letters **A** and **a** to represent the alleles of this gene. [2]

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(ii) Based on the first hypothesis, the F1 would be expected to contain equal numbers of plants producing purple flowers compared to white flowers. When the cross was carried out, the resulting seeds were planted and 32 plants produced white flowers and 18 produced purple flowers.

State the null hypothesis and complete the table below. [4]

Null hypothesis

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Phenotype	Observed numbers *(O)*	Expected numbers *(E)*	*O-E*	$(O-E)^2$	$\frac{(O-E)^2}{E}$
White	32				
Purple	18				

Use the formula below to calculate the value of chi-squared (χ^2).

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

χ^2 = ...

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(iii) Use the table of chi-squared values below to state whether you would accept or reject the null hypothesis stated in *(a)*(ii). Explain your answer. [4]

Degrees of freedom	Probability								
	0.9	0.8	0.7	0.5	0.2	0.1	0.05	0.02	0.01
1	0.016	0.064	0.15	0.46	1.64	2.71	3.84	5.41	6.64
2	0.21	0.45	0.71	1.39	3.22	4.60	5.99	7.82	9.21
3	0.58	1.00	1.42	2.37	4.64	6.25	7.82	9.84	11.34
4	1.06	1.65	2.20	3.36	5.99	7.78	9.49	11.67	13.28

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(b) The **second hypothesis** is that the purple variety is produced by an interaction between two unlinked genes **A** and **B**. The presence of at least one dominant allele for both genes results in purple flowers. If the plant is homozygous recessive for either gene, the phenotype will be white.

(i) Complete the Punnett square to determine the phenotype ratios expected on the basis of this second hypothesis, given that the genotype of the purple flower is **AaBb** and the genotype of the white flower is **aaBb**. The gametes for the white flowering plant have been done for you. [3]

aB				
ab				

Phenotype ratio .....

(ii) The value of chi-squared for the second hypothesis was calculated as 0.044. Using the data conclude which hypothesis is more likely to be correct, the first or the second. Explain your answer. [1]

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(c) Explain how a cross between two white flowered parents which produced purple flowered offspring would confirm that hypothesis 2 is correct. [1]

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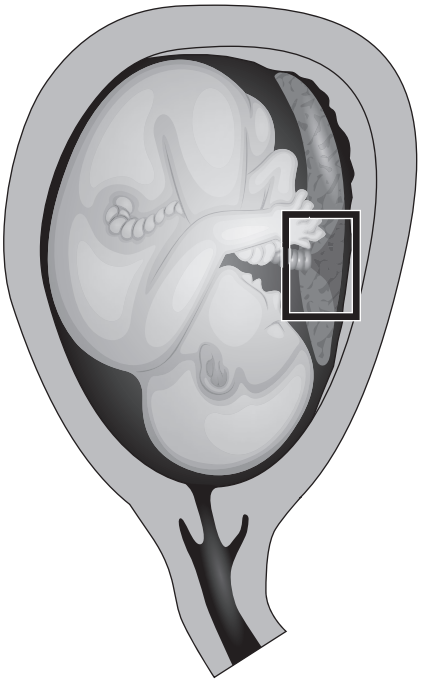
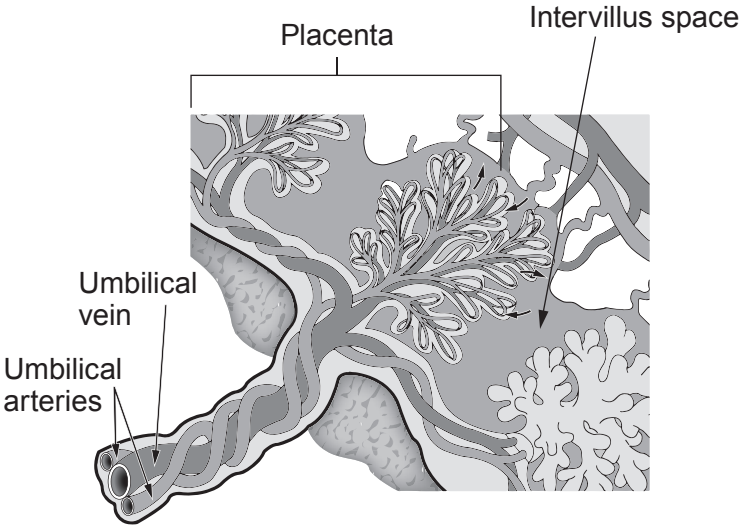
4. The diagram below shows the structure of a human placenta.





(a) State **four** differences between the composition of the blood in the umbilical arteries and the umbilical vein. [2]

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(b) Give **two** reasons why there must be a barrier between foetal and maternal blood systems. [2]

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(c) Suggest how the following features of the placenta enable it to carry out its function.

(i) The arterial blood flow to the placenta is high (700 $cm^3 min^{-1}$) and the blood in the intervillus space is exchanged three times per minute. [1]

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(ii) The pressure in the uterine arteries is ten times greater than the pressure in the intervillus space. [1]

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(iii) The length of the capillaries in the placenta is about 320 km. [1]

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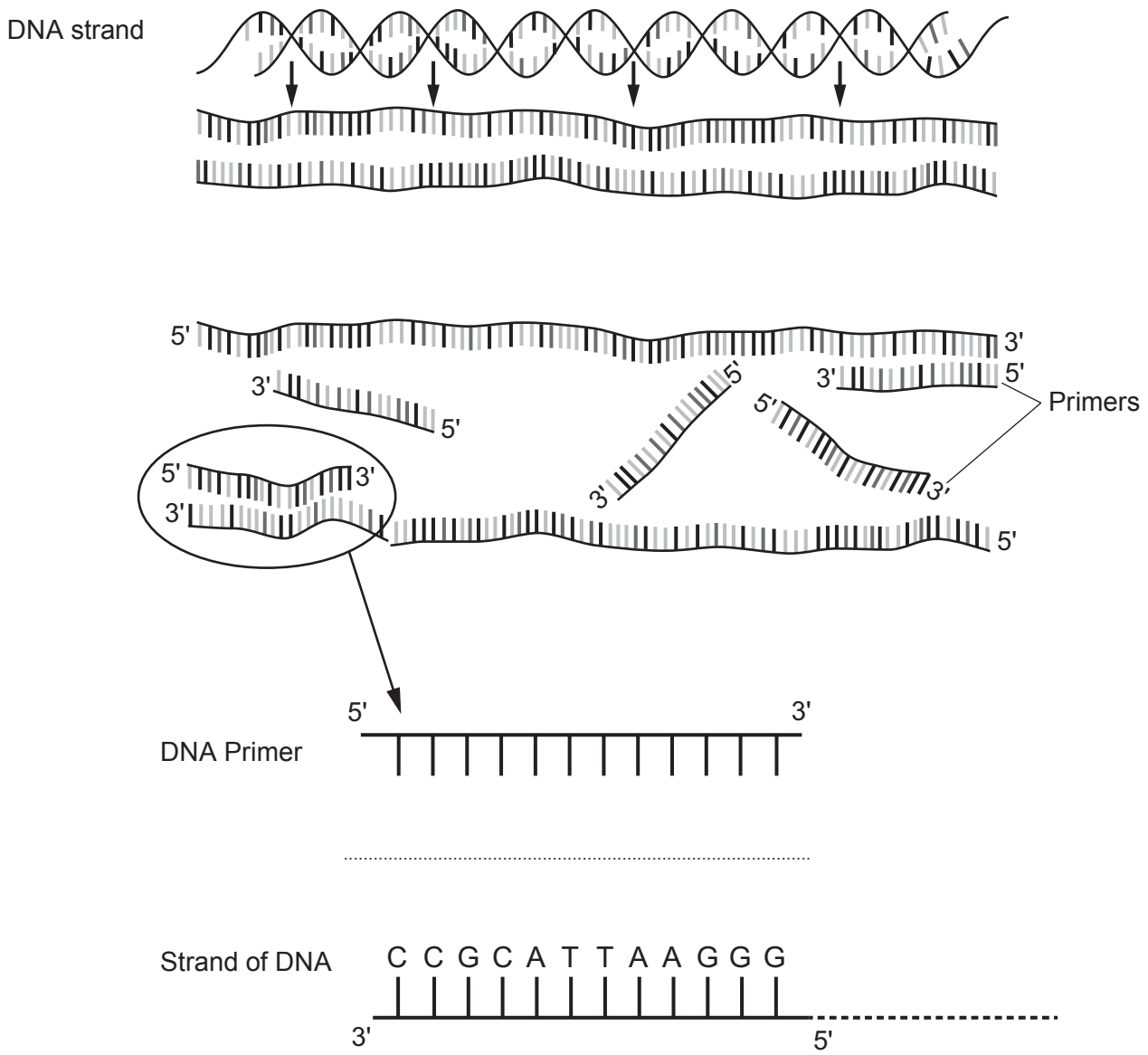
(d) During pregnancy, foetal cells die and release many different fragments of DNA into the mother's blood. A blood sample can be taken from the mother and foetal DNA fragments isolated and replicated (amplified) using the polymerase chain reaction (PCR). Many chromosomal abnormalities can be identified using this DNA, by a technique called non-invasive prenatal diagnosis.

Two different primers are needed in the polymerase chain reaction as shown in the diagram below.



(i) **On the diagram above complete** the nucleotide sequence of **the DNA primer** complementary to the strand of DNA. [1]

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(ii) Explain why two different DNA primers are required. [1]

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(iii) A sample of blood from a pregnant woman is taken. Primers specific to a gene on chromosome 21 are used to replicate it. Primers specific to another gene on a different chromosome are used at the same time. These act as a control. Both primers have fluorescent markers attached.

Suggest why it is important to use primers which are specific to a certain gene on each chromosome. [1]

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(iv) After the PCR, the DNA fragments are separated using gel electrophoresis and the level of fluorescence for each gene is measured. The level of fluorescence corresponds to the quantity of that gene.
The quantity of both genes is expressed in the form of a ratio as shown below.

Quantity of gene from chromosome 21 : Quantity of gene from control chromosome.

Suggest why it is necessary to express the quantity of the genes as a ratio. [2]

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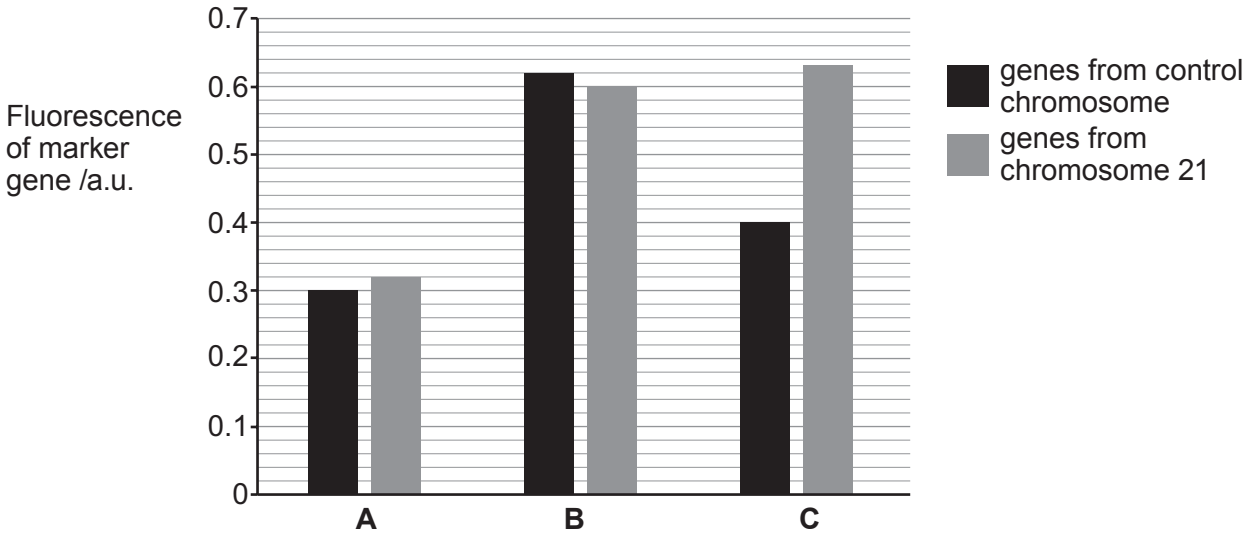
(v) The diagram below shows the quantity of genes from chromosome 21 and the quantity of the control gene following PCR in three pregnant women **A**, **B** and **C**.



With reference to the ratio of the genes, state and explain the conclusions you can make from the results for **A**, **B** and **C**. [4]

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(e) Suggest **two** concerns that some people may have about the ethics of prenatal diagnosis. [2]

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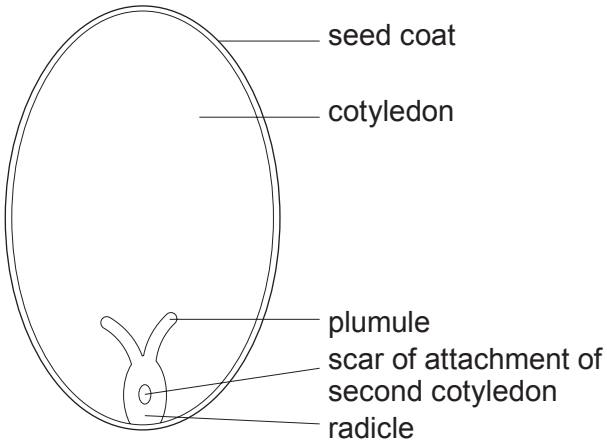
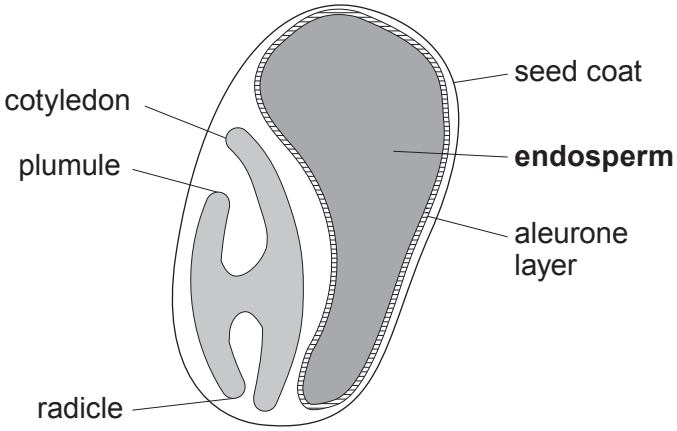
5. The diagrams below show a peanut seed *(Arachis hypogaea)* and a barley seed *(Hordeum vulgare)*.



Peanut seed *(Arachis hypogaea)*



Barley seed *(Hordeum vulgare)*

State and explain the conditions required for germination to take place. Describe the germination of the peanut and barley seeds shown above. [9 QER]

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SECTION B: OPTIONAL TOPICS

Option A: **Immunology and Disease** ☐

Option B: **Human Musculoskeletal Anatomy** ☐

Option C: **Neurobiology and Behaviour** ☐

Answer the question on **one topic only**.

Place a tick (✓) in one of the boxes above, to show which topic you are answering.

You are advised to spend about 25 minutes on this section.

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Option A: Immunology and Disease

6. *(a)* In 2010, an earthquake hit the country of Haiti in the Caribbean, causing devastation and severe damage to the water supplies and sewage treatment facilities. United Nations peace keepers from Nepal came to the country to help with the disaster. An epidemic of cholera broke out 10 months after the earthquake affecting hundreds of thousands of people. Cholera was not endemic to Haiti. Cholera is caused by the gram negative bacteria *Vibrio cholerae* and causes severe dehydration due to diarrhoea.

(i) Define the terms *endemic* and *epidemic*. [2]

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(ii) Explain how cholera spread in Haiti. [2]

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(iii) Conclude what could have been the original source of the cholera epidemic, explain your answer. [1]

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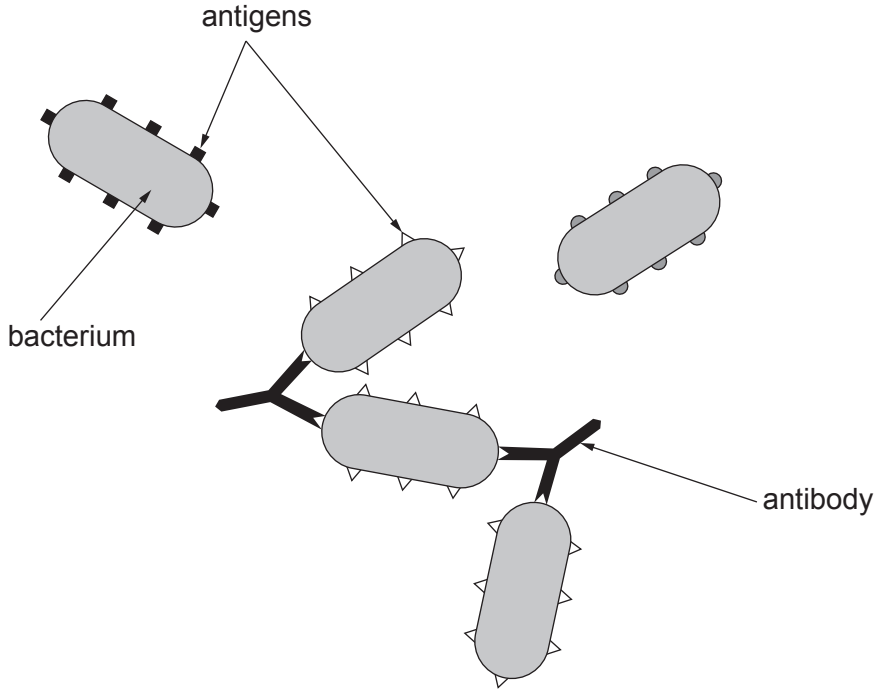
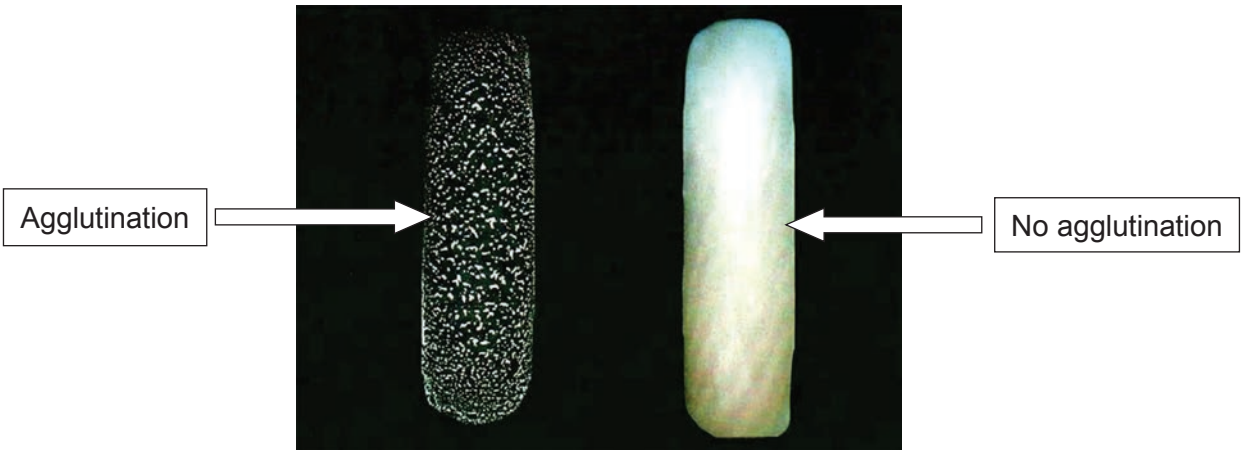
(b) Cholera is caused by the production of cholera toxin by 2 strains of *V. cholerae*, O1 and O139. An agglutination test can be carried out to test for the presence of O antigens on the bacterial surface. Agglutination is when clumping takes place between antibodies and antigens. A different agglutination test can be carried out to test for each of the strains.



Samples were taken from patients for testing to confirm the strain of bacteria and determine the source of the outbreak.



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(i) Explain why an agglutination test would be able to distinguish between the two strains of cholera bacteria. [3]

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(ii) How would the scientists be able to confirm the source of the outbreak? [2]

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(iii) Suggest why some patients with severe symptoms are given antibiotic tablets, but antibiotics alone are not a cure for the disease. [3]

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(iv) Treatment for severe dehydration caused by Cholera is by intravenous rehydration. Patients are given 200 cm^3 of fluid per kg of body mass in a 24 hour period. Calculate the volume of liquid per hour to be given to a patient weighing 70 kg. [2]

Volume of liquid per hour = ... cm^3

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(c) Oral cholera vaccines can be used to prevent the disease if there is a risk of an epidemic. Two doses of the vaccine are required. Shancol is a vaccine which has been used successfully in areas of endemic cholera but was not used during the Haiti epidemic as it had not then been authorised for use by the United Nations/World Health Organisation (UN/WHO).

(i) Explain why the oral vaccine must be administered in two doses. [2]

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(ii) State **one** reason why a higher concentration of the vaccine must be used when given orally. [1]

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(iii) What considerations would need to be made by the UN/WHO before allowing the use of a vaccine in Haiti? [2]

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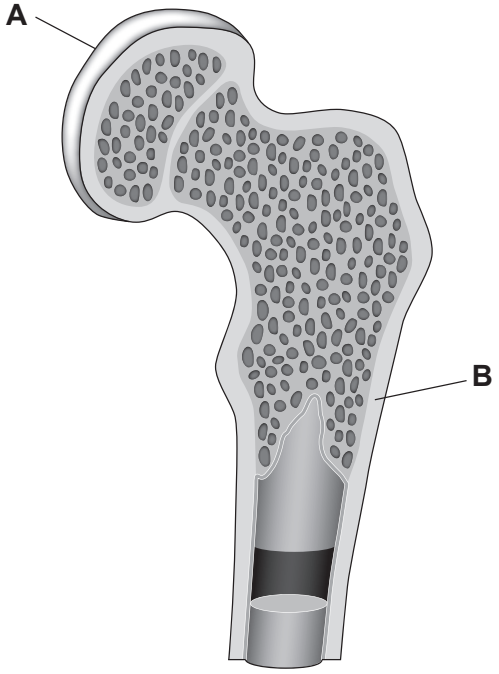
Option B: Human Musculoskeletal Anatomy

7. *(a)* The diagram below shows a longitudinal section through the head of the femur.



(i) Name the type of tissue at **A** and the cells which form it. [2]

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(ii) Bones are continually being remodelled for growth and repair, with calcium ions being both deposited and removed from the bone matrix. What is the name of the bone type **B** and the name of calcium compound found there in the highest proportion? [1]

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(b) Turners Syndrome (TS) is a condition which occurs in girls who have an incomplete or missing X chromosome. They produce less oestrogen than normal. This has an effect similar to the menopause on bone in reducing the level of calcium compounds, but at a much earlier age if left untreated. Oestrogen at normal levels reduces the number of osteoclasts and their activity.

(i) Describe the functions of osteoclasts and osteoblasts. [1]

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(ii) Explain why oestrogen treatment might be given to Turners Syndrome patients. [2]

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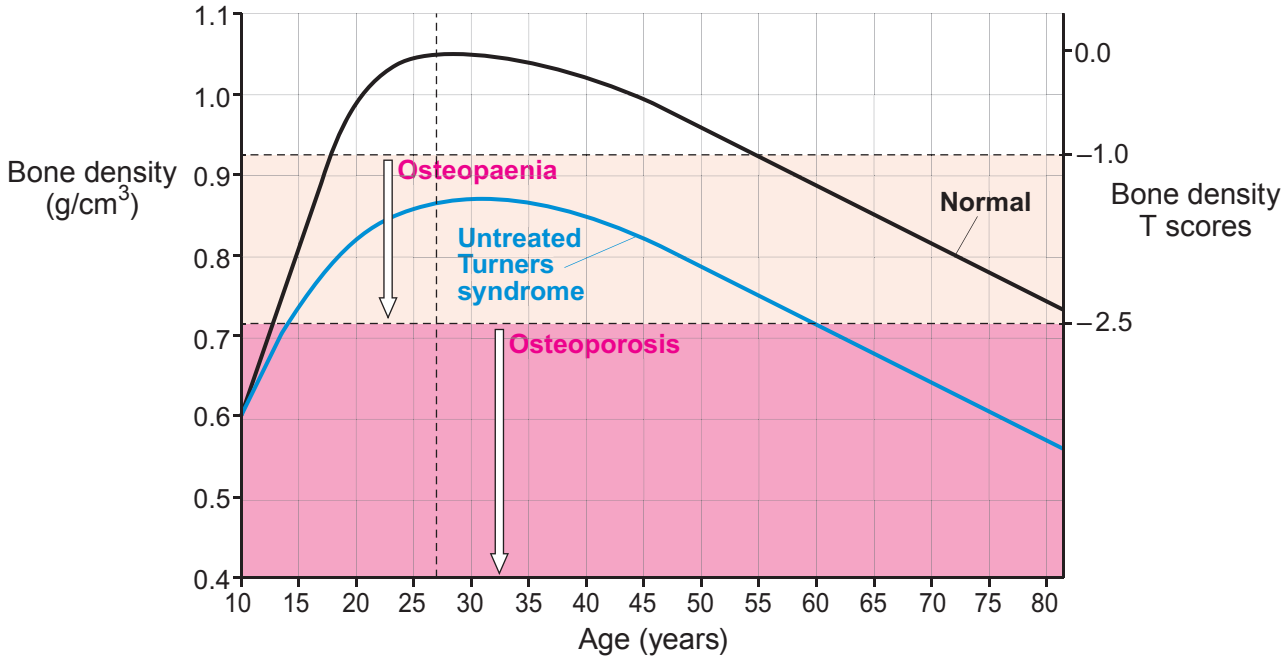
(iii) Turners Syndrome patients have a DEXA scan to assess Bone Mineral Density (BMD). The scan compares density to that of a healthy person of the same age. The difference is then calculated as a standard deviation called a T-score.



A TS patient has a Bone Mineral Density T-score of –2.56. Suggest a possible treatment for a patient which could be used alongside oestrogen and explain the effect of this treatment. [2]

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(iv) With reference to the graph, explain why is it difficult to confidently diagnose a 10-year-old girl with Turners Syndrome using the BMD test alone. [2]

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(v) Explain why a standard deviation is used for the BMD scan. [1]

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(vi) It is estimated that there is a 25% increase in the risk of fractures in Turners Syndrome patients, especially of the long bones of the forearm. What would be the course of treatment for a displaced fracture of the tibia? [1]

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(vii) Calcium is needed for the contraction of muscles. Explain how a lack of calcium could cause poor muscle contraction in patients. [4]

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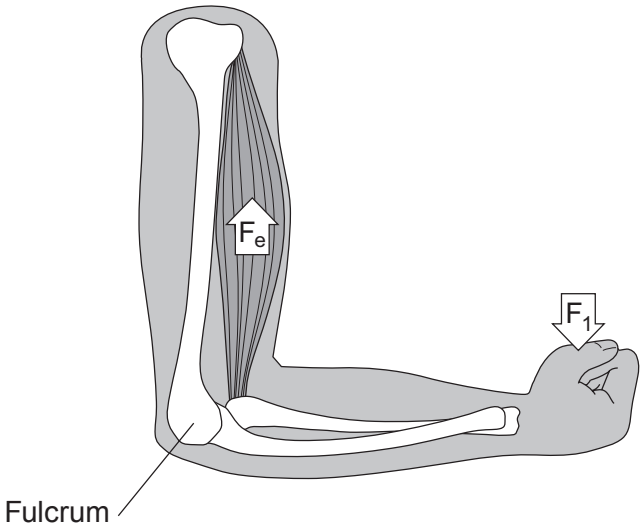
(c) TS patients have shorter bones than normal, and scientists investigated the effort needed to lift a 4kg hand weight using the biceps muscle.



(i) State the order of lever which is shown in the diagram above. [1]

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(ii) Calculate the force effort required to lift the 4 kg hand weight in a patient with TS where elbow to hand distance of 34 cm and elbow to biceps is 4 cm. Show your working.

[2]

Key

F_e = force exerted by the effort

F_1 = mass (kg) × 9.8 N

D_1 = distance from load to fulcrum

D_2 = distance from effort to fulcrum

1 kg = 9.8 Newtons (N)

Using the formula: $F_e = F_1 \times \frac{D_1}{D_2}$

Force effort = ... N

(iii) When testing patients, state the factor that would need to be taken into account to make a valid conclusion. [1]

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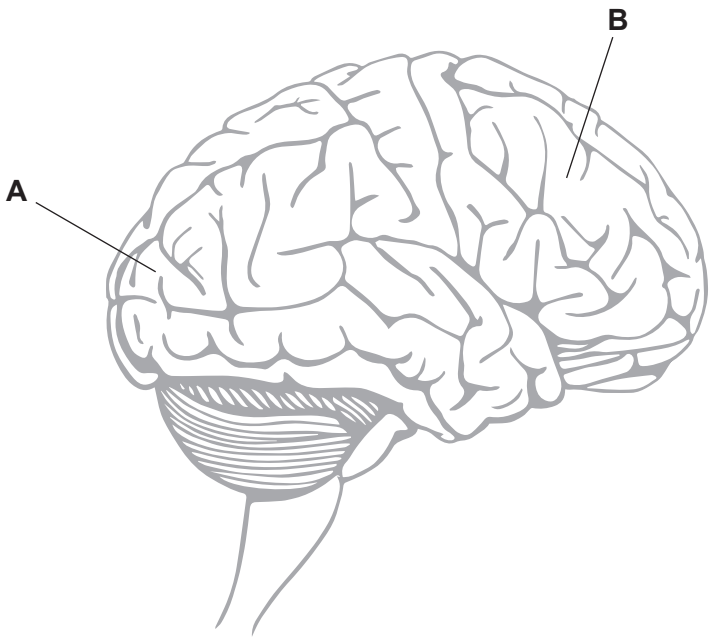
Option C: Neurobiology and Behaviour

8. *(a)* The image below shows the divisions of the human cerebral cortex into lobes.



(i) State the name and function of the lobes labelled **A** and **B** on the diagram above. [3]

	Name	Function
A		
B		

(ii) The brain can be studied in several ways. Outline the differences in the information provided by electroencephalography (EEG) and computerised tomography (CT). [2]

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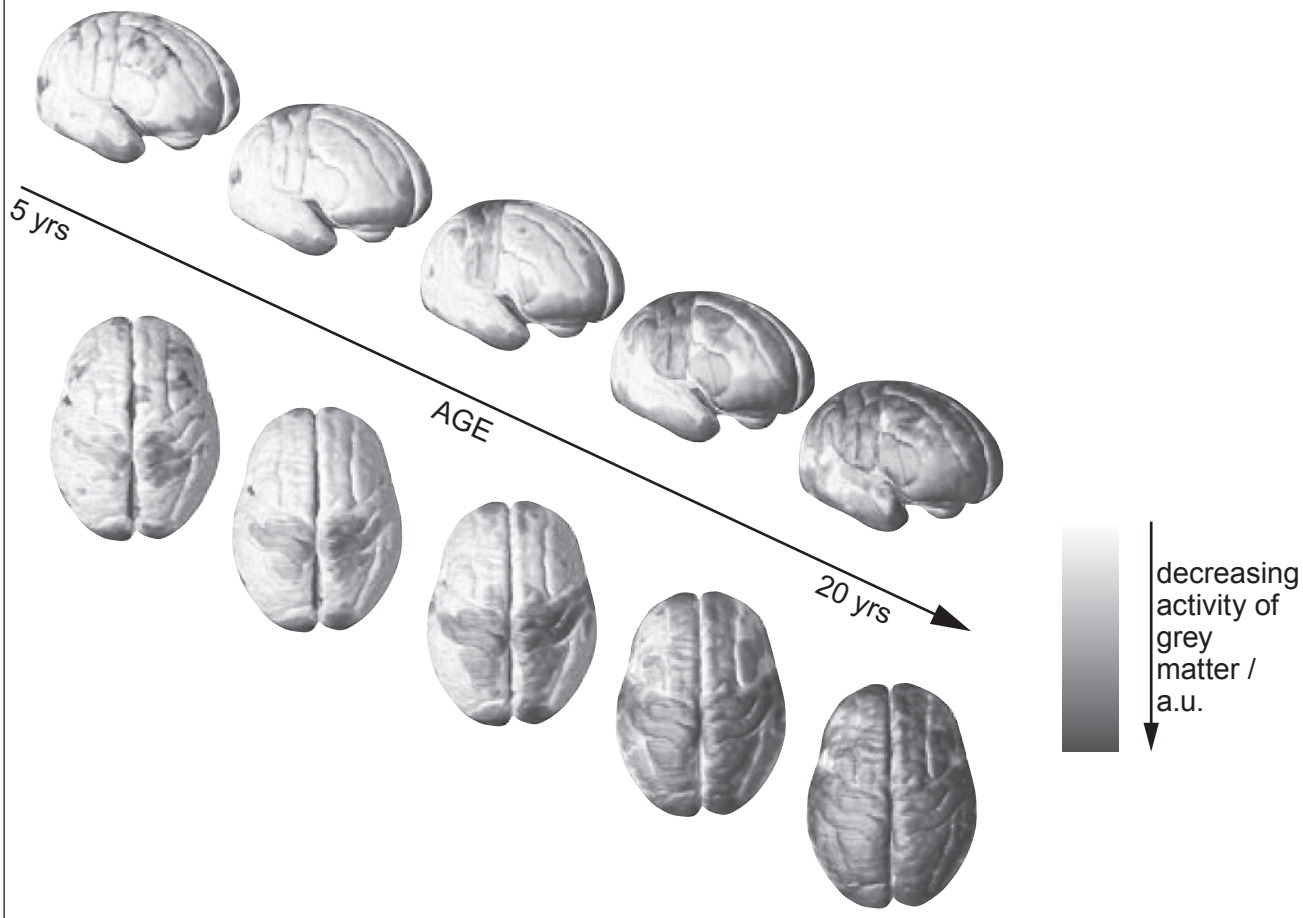
(b) Brain structure changes throughout life with most changes occurring in childhood. During childhood there are critical periods of development where synapses are strengthened in response to environmental stimuli. The critical period for the development of language is between 0-5 years.

Exposure to neglect or psychological trauma during these critical periods in childhood, can change the normal developmental pattern e.g. in 'feral' children.

Brain activity in children was measured using functional magnetic resonance imaging (fMRI) to show the level of activity in the grey matter. The diagram below shows how the level of activity of grey matter in the brain changes with age after this critical period in a person who had not been exposed to neglect or psychological trauma.



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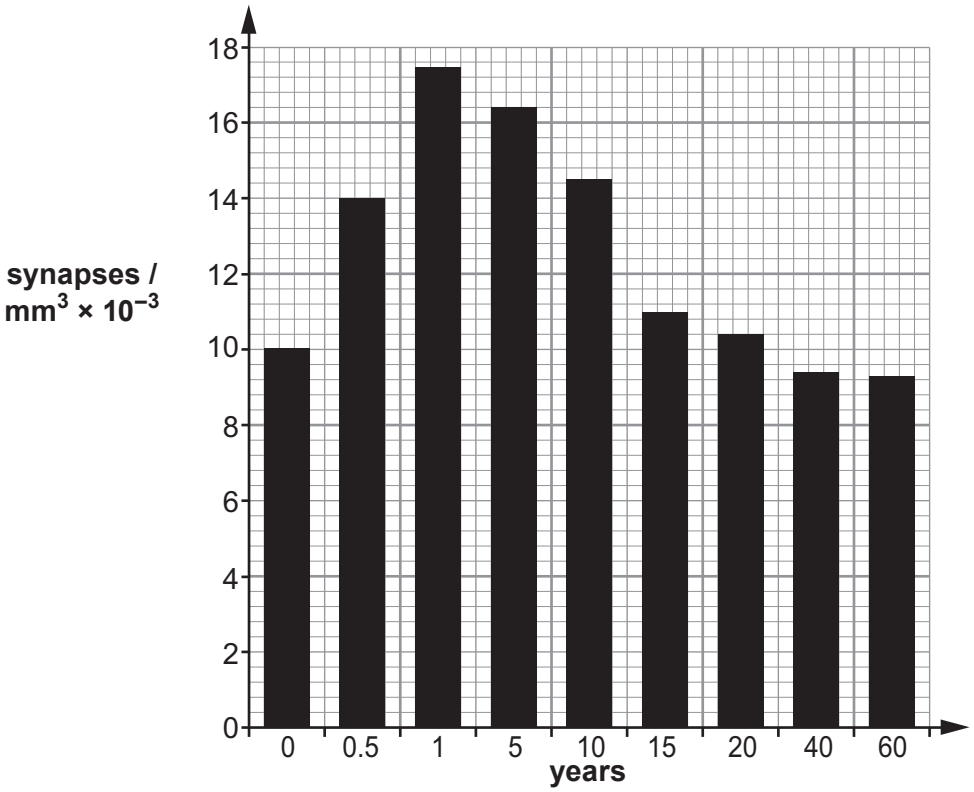
The graph shows the number of synapses present in the brain and the changes which normally occur as a child gets older.



(i) Suggest why children who are not exposed to language during the critical period are likely to never develop speech. [4]

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(ii) Suggest how the fMRI images and graph would differ for a feral child. [1]

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(iii) State **one** factor which could be involved in causing this effect in feral children or those exposed to psychological trauma at an early age. [1]

.....

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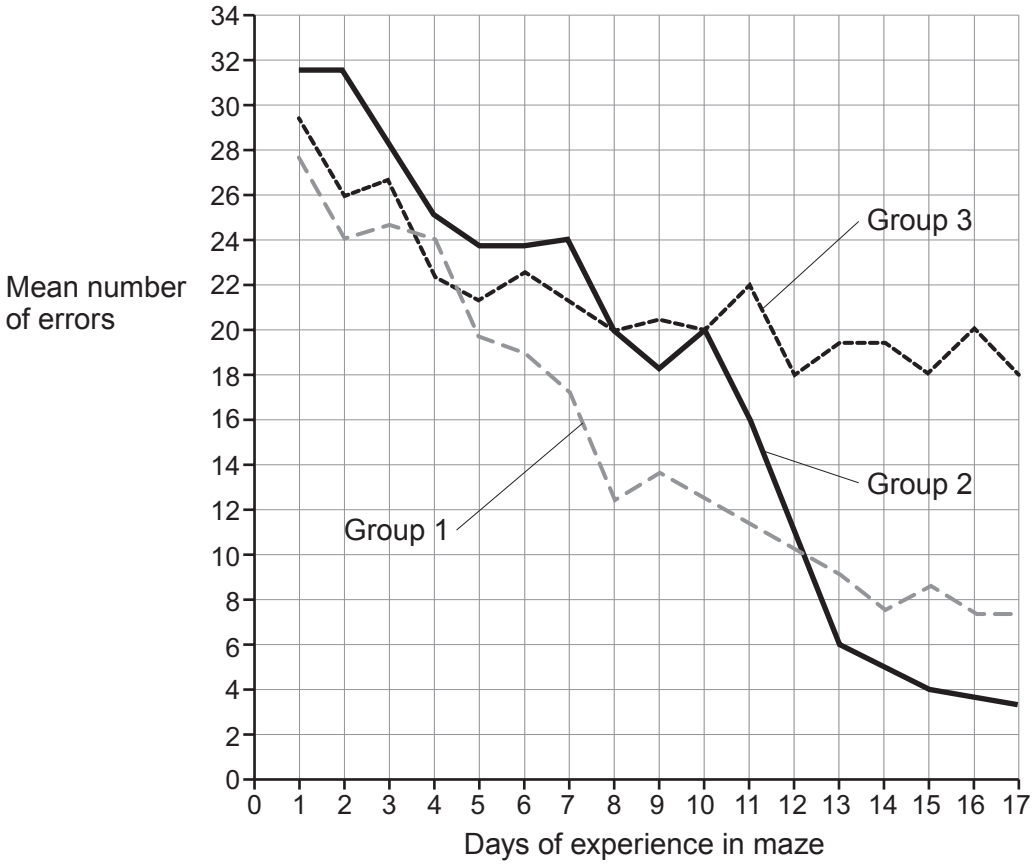
(c) In 1930, Tolman and Honzik investigated learning in rats. Thirty female rats were placed in three groups and the number of errors they made when going through the maze was recorded.

Group 1 – Rewarded every time they completed the maze
Group 2 – Placed in the maze every day and only rewarded from day 10 onwards
Group 3 – Never rewarded



(i) Which area of the brain is involved in learning? [1]

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(ii) Use the information provided to conclude the learning patterns exhibited by each group of rats. Explain your conclusions. [4]

Group 1 .....

.....

.....

Group 2 .....

.....

.....

Group 3 .....

.....

.....

(iii) Calculate the percentage change in the number of errors for group 2 between day 10 and day 13. [2]

Percentage change = ... %

(iv) State **two** factors which should have been controlled in this investigation. [2]

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