Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE A LEVEL

A400U20-1

S23-A400U20-1

FRIDAY, 16 JUNE 2023 – MORNING

BIOLOGY – A level component 2

Continuity of Life

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**6**	
2.	**6**	
3.	**13**	
4.	**22**	
5.	**12**	
6.	**14**	
7.	**18**	
8.	**9**	
Total	**100**	

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01

ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

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

You may use a pencil for graphs and diagrams only.

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

Answer **all** questions.

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

INFORMATION FOR CANDIDATES

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

The assessment of the quality of extended response (QER) will take place in question **8**.

The quality of written communication will affect the awarding of marks.

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Answer **all** questions.

1. (a) Restriction endonucleases are found in bacterial cells. They are used by these cells to cut the DNA of viruses that infect the bacteria. These viruses are called bacteriophages.

(i) State the name given to enzymes which work inside cells. [1]

Intracellular enzymes.

(ii) The cutting of the viral DNA prevents the bacteriophage viral proteins being synthesised in the bacterium.

Apart from enzymes, state which other part of the virus is formed of protein. [1]

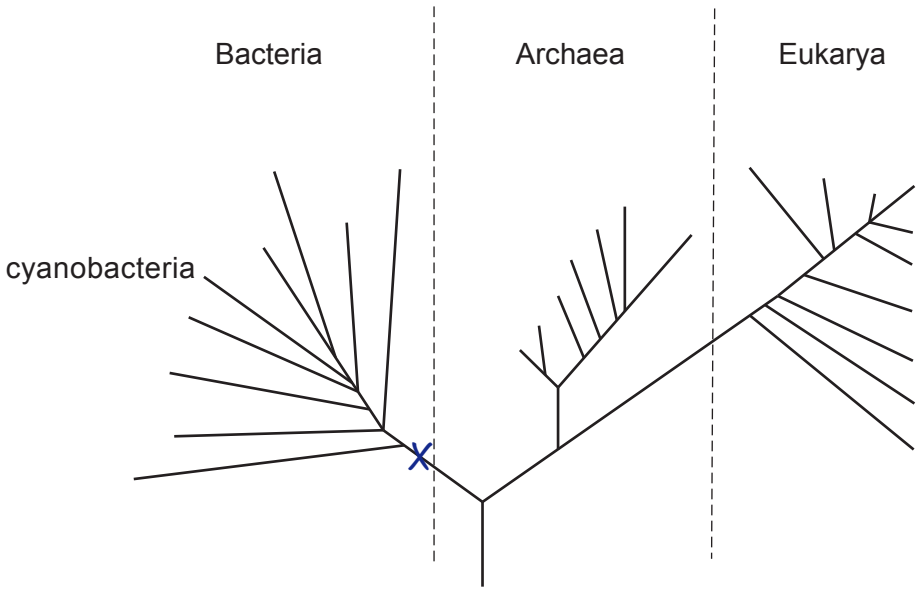
The capsid (protein coat made of capsomeres).

The Three Domain system, developed by Carl Woese in 1990, is a system for classifying biological organisms. It replaced the Five Kingdom classification system.

The phylogenetic tree in **Image 1.1** is a simplified version of his work.

Image 1.1

Phylogenetic Tree of Life



(iii) One type of endonuclease is Cas9. It has not yet been found in any of the Archaea.
Using this information, **write a letter X** on the tree in **Image 1.1** to show the most recent common ancestor of organisms containing Cas9. [1]

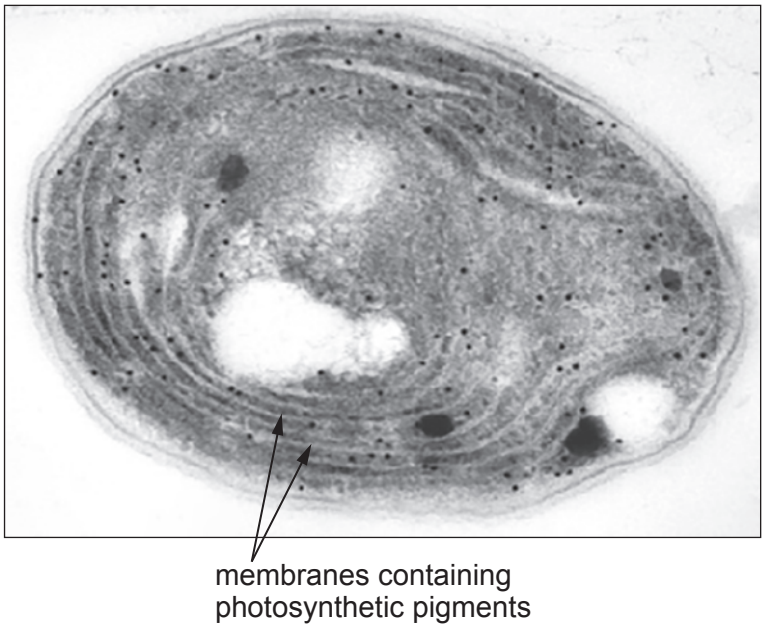
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(b) A labelled branch on **Image 1.1** represents a group called the cyanobacteria. **Image 1.2** shows one of these organisms.

Image 1.2



Some bacteria contain an enzyme called nitrogenase. This enzyme is used in nitrogen fixation. It does not function in the presence of oxygen.

(i) Describe and explain the evidence from **Image 1.2** that shows that nitrogen fixation is not taking place in this cyanobacterium. [2]

The cell contains membranes with photosynthetic pigments, so photosynthesis is taking place. Photosynthesis produces oxygen, and oxygen inhibits nitrogenase, so nitrogen fixation cannot occur.

(ii) Scientists used to classify cyanobacteria in the Kingdom Protoctista. With reference to their cell structure, suggest why they have been reclassified as bacteria. [1]

They have no nucleus, no mitochondria and no chloroplasts, smaller 70S ribosomes and a peptidoglycan (murein) cell wall.

6

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2. Scientists studied the changes associated with growth occurring in the root tip region of wheat plants. They measured the dry mass of cells and the volume of cells at different distances from the root tip.

The results are shown in **Table 2.1**.

Table 2.1

Distance from end of root tip / mm	Mean dry mass of cells / pg	Mean volume of cells / μm^3
1	2.5	20
2	2.5	25
3	2.5	35
4	3.5	45
5	4.5	55
6	5.5	65

(a) Suggest why there is an increase in the volume of the cells between 1 and 3 mm from the end of the root tip, even though the dry mass remains constant. [2]

Water entered the cells by osmosis (into the vacuole). Water adds volume but no dry mass, so the cells expand while their dry mass stays the same.

(b) A student made a root tip squash to observe mitosis. They used hydrochloric acid to separate the cells by breaking down the chemicals which bind cells together.

The instructions they followed then stated:

'Make sure that the slide is on a flat surface and squash down on the coverslip with a strong vertical pressure using your thumb. Do not twist or roll the thumb from side to side.'

(i) Explain why the student is told to 'squash down with strong vertical pressure' **and** not to 'twist or roll the thumb from side to side'. [2]

Strong vertical pressure spreads the cells into a single layer, allowing light to pass through so individual cells and chromosomes can be seen.

Twisting or rolling would make cells move over each other into several layers and would damage or distort the cells.

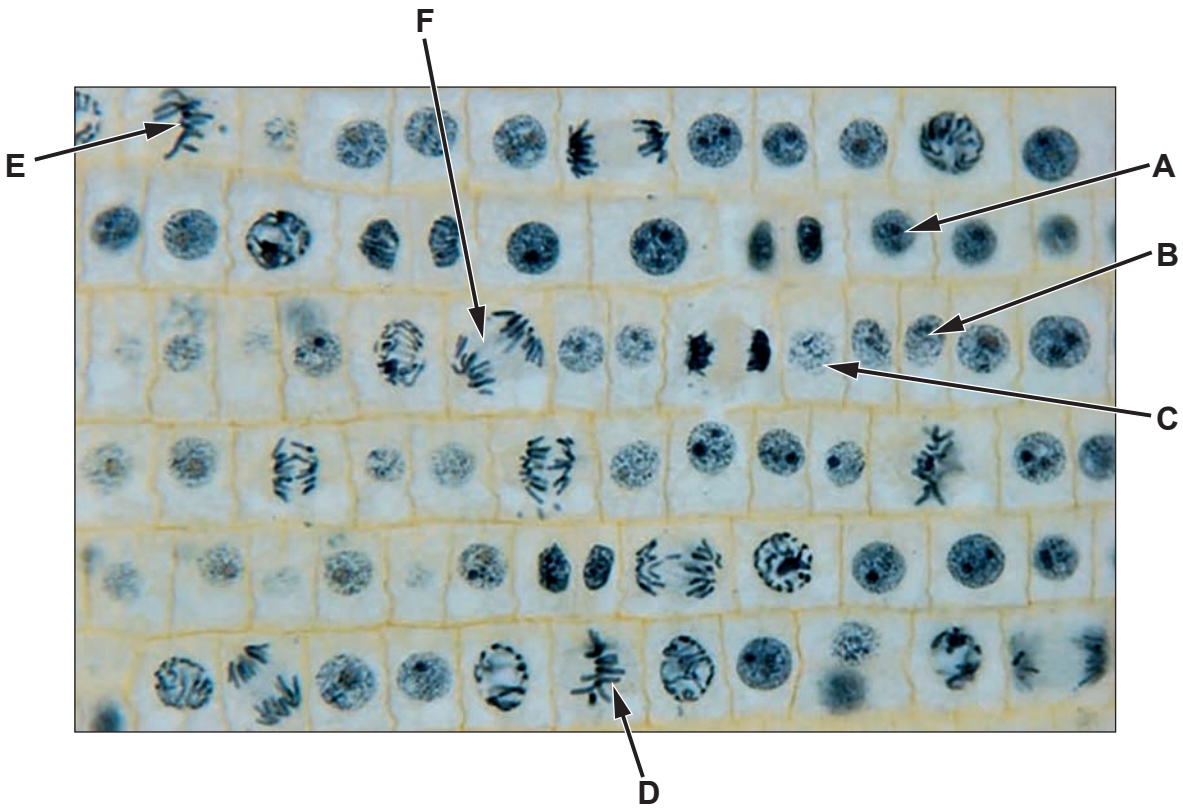
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The photograph in **Image 2.2** has been taken from the root tip.

Image 2.2



(ii) Use **Image 2.2** to describe the evidence that interphase is the longest stage of the cell cycle. [1]

Most of the cells in Image 2.2 are in interphase (no visible chromosomes); far fewer cells are in mitosis.

(iii) State which of the cells **A** to **F** contains spindle fibres that are shortening. Explain your answer. [1]

F, because it is in anaphase; the shortening spindle fibres are pulling the chromatids to opposite poles.

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3. *Colchicum autumnale* is a flowering plant found in many countries.

(a) In the UK, *Colchicum autumnale* is known as autumn crocus, as well as meadow saffron or naked ladies. In India it is commonly known as 'gowri gedde'.

Use this information to explain why the binomial scientific name provides more reliable information to scientists than the common name. [2]

The binomial name is universal; it is the same in every country, whereas common names are localised and one species can have several common names. The genus name also shows which species it is closely related to (its evolutionary relatedness).

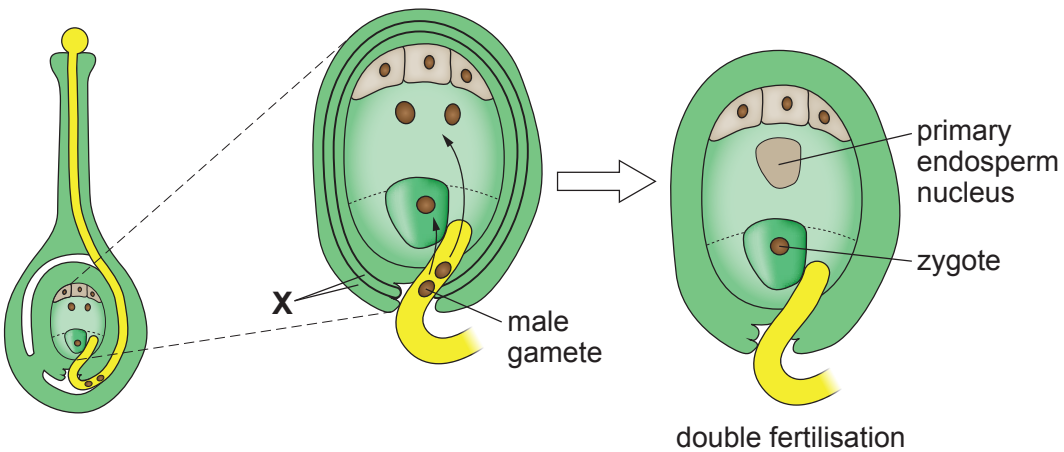
(b) **Image 3.1** shows specimens of *Colchicum autumnale*.

Image 3.1



Image 3.2 is a drawing of a section through a carpel of *Colchicum autumnale* undergoing double fertilisation. The diploid chromosome number of *Colchicum autumnale* is 16.

Image 3.2



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(i) Complete **Table 3.3** to state how many chromosomes are present in the following structures shown in **Image 3.2** and explain how the structures are formed. [6]

Table 3.3

Structure	Number of chromosomes	Explanation of how the structure is formed
male gamete	8	Formed by meiosis of the pollen mother cell, then the generative nucleus divides by mitosis.
primary endosperm nucleus	24	One haploid male gamete nucleus fuses with the two haploid polar nuclei (3 haploid nuclei).
zygote	16	Fusion of the haploid male gamete nucleus with the haploid female gamete (egg cell).

(ii) During development, the ovule is supplied with sugar by phloem sieve tubes. State how many chromosomes there would be in a phloem sieve tube element and explain your answer. [2]

None: 0 chromosomes.

Mature phloem sieve tube elements have no nucleus (it breaks down as they develop), so they contain no chromosomes.

(iii) Describe what happens to the structures labelled **X** in **Image 3.2** after fertilisation. [1]

The integuments (X) develop into the testa (seed coat).

(c) *Colchicum autumnale* plants release a chemical called colchicine into the soil. Colchicine inhibits the production of spindles in cells. Suggest an advantage to the plant of doing this. [2]

Colchicine stops spindles forming, so mitosis cannot occur in the roots of nearby plants and their growth is inhibited.

This reduces competition for water, mineral ions and light.

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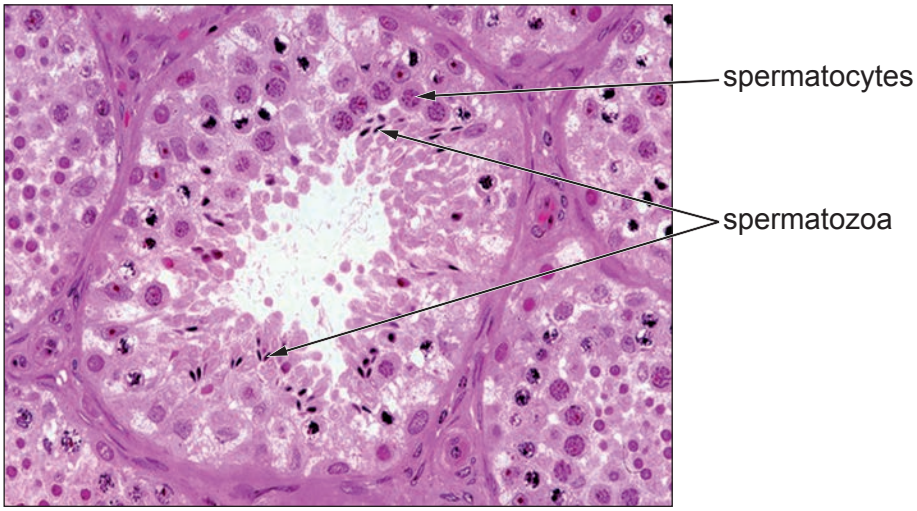
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4. The process of spermatogenesis takes place in the seminiferous tubules, as shown in **Image 4.1.**

Image 4.1



(a) (i) The heads of the spermatozoa are clustered around specific cells. Name the cells that the spermatozoa are clustered around and state their function. [2]

Sertoli cells.

They provide nourishment (nutrients) and protection for the developing spermatozoa.

(ii) Explain why both mitosis and meiosis are involved in the production of spermatozoa. [3]

Mitosis of the spermatogonia produces very large numbers of cells (primary spermatocytes).

Large numbers of spermatozoa are needed to increase the chance of fertilisation.

Meiosis halves the chromosome number, producing haploid spermatids (spermatozoa), so the diploid number is restored at fertilisation.

Meiosis also produces genetically different cells (genetic variation) by crossing over and independent assortment.

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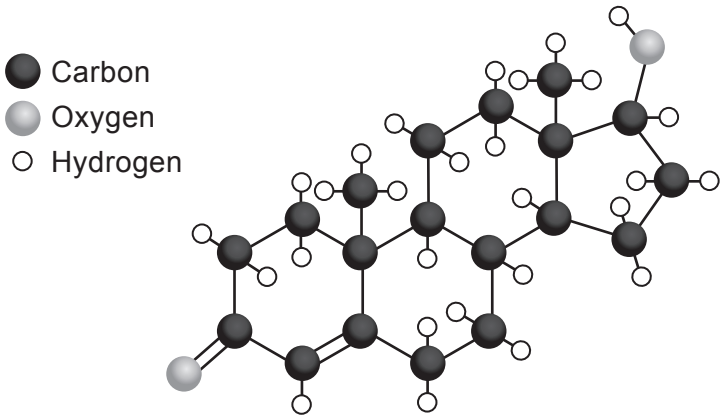
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(b) (i) State the name of the cells in the testes that secrete testosterone. [1]

Leydig cells (interstitial cells).

Testosterone is a steroid hormone. Its formula is $C_{19}H_{28}O_2$. Its structure is shown in **Image 4.2**.

Image 4.2



(ii) Testosterone is classified as a lipid.

Use **Image 4.2** and the information given to explain why testosterone is not classified as a:

I. carbohydrate; [1]

It has far too many hydrogen atoms compared with oxygen (H_{28} but only O_2), so it does not follow the $C_nH_{2n}O_n$ pattern.

II. protein. [1]

It contains no nitrogen, but proteins contain nitrogen in the amine (NH_2) groups of amino acids.

(c) It is estimated that one gram of testis tissue produces 400 000 sperm every hour. If a man has 2 500 000 sperm in 1cm^3 of his ejaculate and his testes have a total mass of 24 g, calculate how long it will take to produce the sperm for 1 cm^3 of ejaculate.
Give your answer to the nearest minute. [3]

Sperm per hour = 400 000 × 24 = 9 600 000

Sperm per minute = 9 600 000 ÷ 60 = 160 000

Time = 2 500 000 ÷ 160 000 = 15.63 minutes

Time = 16 minutes

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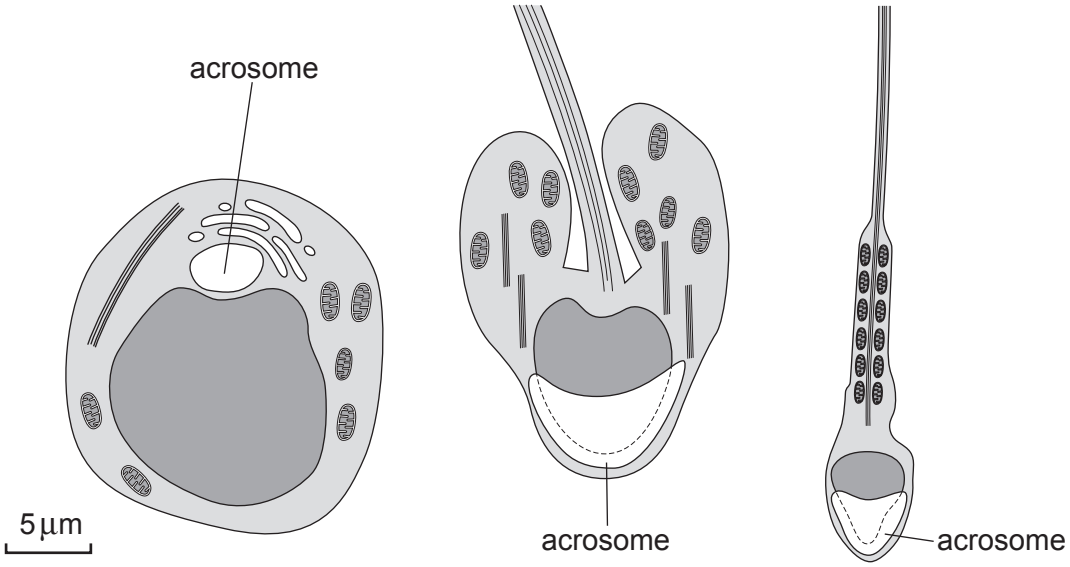
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(d) **Image 4.3** shows the maturation of a spermatid to form a spermatozoon. All the diagrams are to the same scale.

Image 4.3



The acrosome labelled on each diagram is a large lysosome.

(i) State the name of the organelle that produces the acrosome. [1]

Golgi body (Golgi apparatus)

(ii) Use **Image 4.3** to describe what happens to the volume of the nucleus and the cytoplasm during maturation and suggest why this occurs. [2]

The volume of both the nucleus and the cytoplasm decreases during maturation.

This makes the spermatozoon smaller and more streamlined, so it swims more efficiently and more can fit into a small space.

(iii) On contact with the zona pellucida, the acrosome reaction occurs. One of the hydrolytic enzymes released from the acrosome is acrosin. It is stored in the acrosome in a non-hydrolytic form that only becomes active when it is released from the sperm.

Suggest a reason for it being stored in a non-active form. [1]

So that it does not hydrolyse the contents of the sperm itself (autolysis) before it reaches the zona pellucida.

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(e) A group of scientists used golden hamsters (*Mesocricetus auratus*) to study the acrosome reaction.

Two groups of male hamsters were used.

Group 1: produced normal sperm.

Group 2: genetically modified to produce sperm that did not carry out acrosin production.

Two sets of ova were then taken from female hamsters. These were treated in two different ways.

Set A: Ova were left complete.

Set B: The zona pellucida were removed from around the ova.

The sperm from both groups were then mixed with the ova from each set in vitro.

The percentage of the oocytes that were fertilised was calculated and the results are shown in **Table 4.4**.

Table 4.4

Sperm and ova types	% of oocytes fertilised
Group 1 (normal) sperm with Set A (normal) ova	89
Group 1 (normal) sperm with Set B (no zona pellucida) ova	100
Group 2 (no acrosin) sperm with Set A (normal) ova	0
Group 2 (no acrosin) sperm with Set B (no zona pellucida) ova	100

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(i) Use the information given in **Table 4.4** to suggest what conclusions could be made about the role of acrosin. Explain your answer. [3]

Acrosin is needed for fertilisation when the zona pellucida is present:

Group 2 sperm with no acrosin fertilised 0% of normal ova.

Acrosin is not needed if there is no zona pellucida, as both groups

fertilised 100% of Set B ova.

So acrosin hydrolyses (breaks down) the zona pellucida. It does not

always fully break it down, as normal sperm fertilised only 89% of Set

A ova.

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This experiment was performed in vitro.

(ii) State where fertilisation normally occurs in a mammal. [1]

In the oviduct (Fallopian tube).

(iii) An acrosin inhibitor has been suggested as a form of contraception. Explain how a non-competitive inhibitor could act on acrosin to prevent fertilisation. [3]

The non-competitive inhibitor binds to acrosin at an allosteric site, away from the active site.

This changes the shape (tertiary structure) of the active site, so it is no longer complementary to its substrate.

Acrosin therefore cannot hydrolyse the zona pellucida, so the sperm cannot reach and fertilise the ovum.

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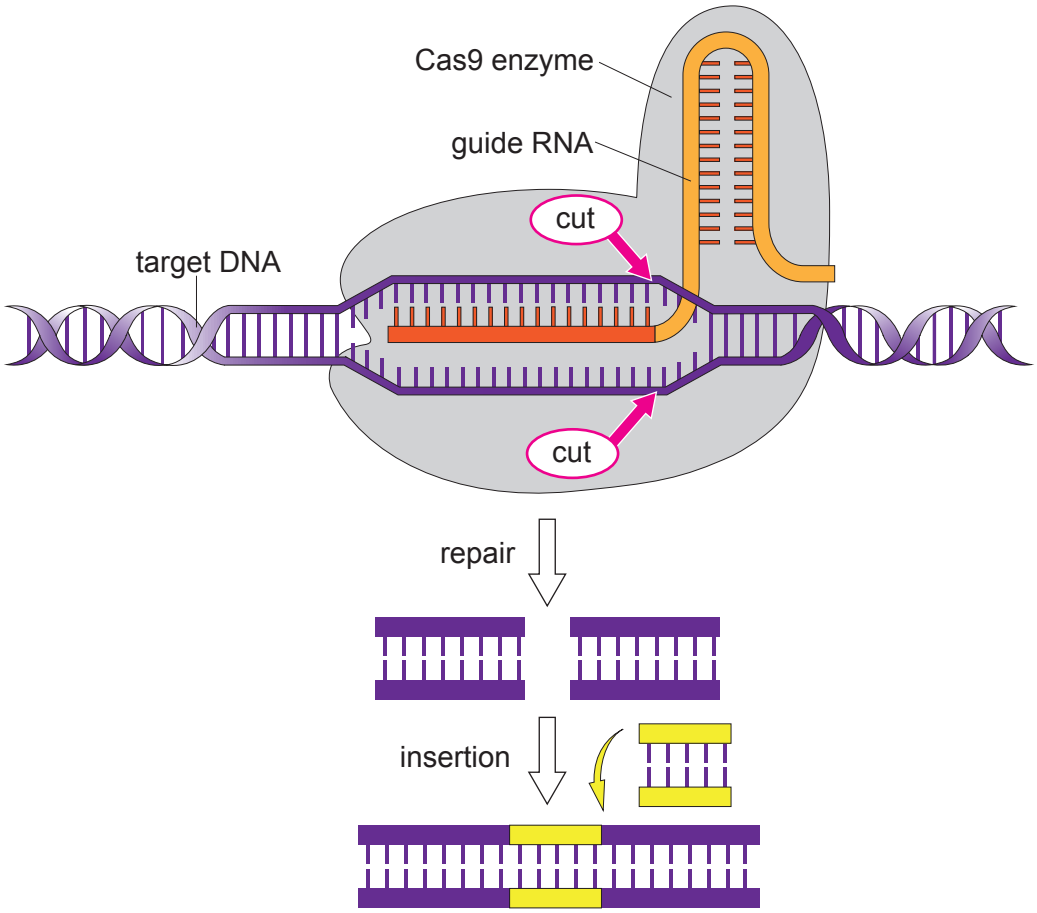
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5. Cas9 is a DNA endonuclease that is associated with a strand of guide RNA (gRNA). The enzyme unwinds DNA and breaks the hydrogen bonds between the DNA strands. The base sequence on part of the gRNA then aligns next to a specific target sequence on the DNA. The endonuclease then makes a double stranded cut at this target sequence. During the repair of the DNA molecule a double-stranded length of DNA can be inserted. This is shown in **Image 5**.

Image 5



(a) (i) State **two** differences between nucleotides of RNA and nucleotides of DNA. [2]

RNA nucleotides contain the pentose sugar ribose, whereas DNA nucleotides contain deoxyribose.

RNA nucleotides can contain the base uracil, whereas DNA nucleotides contain thymine instead.

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(ii) Cas9 can be used to inactivate specific human genes by cutting them. The section of gRNA used to locate the gene is usually only 20 bases long. Suggest why using gRNA, which is only 20 bases long, may affect other parts of the genome. [1]

The same 20-base sequence may also occur at other places in the genome, so Cas9 could cut other (non-target) genes too.

(iii) Artificial gRNA molecules can be made that have specific base sequences. Double stranded DNA containing functional alleles of genes associated with recessive genetic disorders can also be produced. These functional alleles can be inserted into human DNA as shown in **Image 5** using an enzyme.

It has been suggested that the Duchenne Muscular Dystrophy (DMD) allele could be replaced with a functioning allele in germ-line therapy.

Suggest how Cas9 and these functional alleles could be used to alter an embryo's genotype so that it no longer has DMD. [3]

Artificial gRNA is made with a base sequence complementary to the recessive DMD allele, so Cas9 is guided to it.

Cas9 makes a double-stranded cut in the recessive DMD allele.

The double-stranded functional allele is inserted into the cut, faulty allele and joined into the DNA using DNA ligase, so the embryo now has a functional allele.

(iv) Suggest **two** advantages of germ-line therapy. [2]

The functional allele is inherited, so it is passed on to future generations.

It is present in all cells of the body and the treatment does not need to be repeated.

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(b) The size of a DNA fragment can be measured using the kilobase (1 kilobase = 1000 base pairs).

The length of 1 kilobase is 0.34 µm.

The DNA in a nucleus of a cell from a male with DMD is 2.95×10^6 kilobases in total.

(i) Calculate the length of DNA in the nucleus of the cell from a male with DMD in millimetres (mm). **Give your answer in standard form**. Show your working. [3]

Length = $2.95 \times 10^6 \times 0.34 = 1.003 \times 10^6$ µm

1 mm = 1000 µm, so $1.003 \times 10^6 \div 1000 = 1003$ mm

Length = 1.003×10^3 mm

(ii) When the **total length** of DNA from a human male cell with DMD is calculated it is longer than 2.95×10^6 kilobases. Explain why. [1]

The total also includes the DNA in the mitochondria (mitochondrial DNA), not just the DNA in the nucleus.

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6. The leaves of maize have characteristics that are controlled by genes. The leaves can be glossy or rough. They can also be green or green with white stripes.

Pollen from a pure-bred plant with glossy green leaves was transferred to the stigma of a pure-bred plant with rough striped leaves. All of the F1 generation had glossy green leaves.

(a) Give **three** practical precautions that should be taken to ensure that the offspring produced are only from the desired cross. [3]

Remove the anthers (stamens) from the recipient flowers before they mature, so they cannot self-pollinate.

Transfer the pollen by hand using a clean brush.

Isolate the recipient flowers by covering them in a bag, before and after pollination.

(b) Pollen from the F1 generation was transferred to the stigma of pure-bred plants with rough striped leaves. The expected ratio of the phenotypes of the offspring from this cross is 1:1:1:1.

Seeds from this cross were grown and the following phenotypes were seen.

Glossy green leaves	64
Glossy striped leaves	12
Rough green leaves	11
Rough striped leaves	73

A null hypothesis was proposed that there was 'no significant difference between the observed and expected numbers of each phenotype in the offspring'.

A χ^2 (chi-squared) test can be carried out to find the probability of the results being significantly different from the expected ratio.

The χ^2 calculation is shown below.

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

Where O = observed results
E = expected results
Σ = sum of

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(i) Use the information given to complete **Table 6.1** and calculate χ^2 for these results. [3]

Table 6.1

Phenotype	Observed number (O)	Expected number (E)	$O-E$	$(O-E)^2$	$\frac{(O-E)^2}{E}$
Glossy green leaves	64	40	24	576	14.40
Glossy striped leaves	12	40	−28	784	19.60
Rough green leaves	11	40	−29	841	21.03
Rough striped leaves	73	40	33	1089	27.23

χ^2 = 82.26

(ii) State the number of degrees of freedom for these results. [1]

3

Table 6.2

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

(iii) Use the calculated value of χ^2 and the table of probabilities in **Table 6.2** to find the probability of the results being significantly different from the expected ratio. [1]

Probability = less than 0.01

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(iv) State what conclusion can be made from these results and explain your answer. [2]

There is a significant difference between the observed and expected numbers, so the results are not due to chance.

The null hypothesis should be rejected, as 82.26 is far greater than the critical value of 7.82 at $p = 0.05$ with 3 degrees of freedom.

(v) With reference to the results of the cross, explain why the actual ratio of phenotypes obtained was different from the expected ratio. [4]

The genes for leaf texture and leaf colour are linked: they are on the same chromosome (autosomal linkage).

There is a large number of non-recombinants (glossy green 64 and rough striped 73).

There is a small number of recombinants (glossy striped 12 and rough green 11).

The recombinants come from crossing over between non-sister chromatids of homologous chromosomes in prophase I of meiosis.

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7. Scientists studied the diet and length of jaws of tiger snakes (*Notechi scutatus*) on the mainland of Australia and an island 5 km off its coast.

When captured and handled, some of the snakes regurgitated their prey. This allowed the scientists to identify the diet of the snakes. The results are shown in **Table 7.1**.

Table 7.1

Area snake found	Prey	Mass of prey / g	Circumference of prey / mm	Number of snakes in which prey item found
Island	Seagull chick	133.10	155.00	1
Island	Silver gull chick	39.70	121.80	10
Island	Skink (lizard)	26.43	58.42	21
Island and mainland	Mouse	19.28	55.82	28
Mainland	Tree frog (type 1)	18.64	58.85	21
Mainland	*Ctenotus* (lizard)	9.85	33.45	40
Mainland	Tree frog (type 2)	1.00	21.55	20
Mainland	Tree frog (type 3)	0.88	21.76	33
				TOTAL 174

(a) (i) In total, 168 snakes were studied. Suggest why the total for the number of snakes in which the prey items were found was 174. [1]

Some snakes ate more than one prey item (more than one type of prey), so they were counted more than once.

(ii) Evaluate the method by which the scientists gathered the data on the diet of the snakes. [3]

Advantage: the snakes did not need to be killed to find out their diet.

However, only some of the snakes regurgitated their prey, so the sample may not be representative, and diet may vary over time.

Some prey may have been partly digested, so accurate mass, circumference or identification is not possible; handling may also distress the snakes.

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(iii) Use **Table 7.1** to compare the diet of the snakes on the island and on the mainland. [3]

Island snakes eat prey with a larger (heavier) mass and a larger circumference than mainland snakes.

Mainland snakes eat more types of prey (5 types) than island snakes (4 types).

Both populations eat mice, and the island has a wider range of prey mass and circumference.

Question continued overleaf

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The scientists wanted to investigate the effect of prey size on jaw development in snakes.

- They used newly hatched snakes from both locations; 123 snakes were measured from the island and 129 from the mainland.
- The snakes were fed either large or small mice over several months until they reached maturity.
- The jaw length of each snake was measured from the tip of the nose to the point of articulation of the upper jaw using digital callipers with a precision of 0.01 mm.

The results are shown in **Table 7.2**.

Table 7.2

	Experiment 1		Experiment 2	
	Mainland snakes		Island snakes	
	Group A – fed small mice	Group B – fed large mice	Group C – fed small mice	Group D – fed large mice
Mean length of snakes' jaws at hatching / mm	13.26	13.28	13.85	13.79
Mean length of snakes' jaws at maturity / mm	26.37	26.64	29.20	33.83

(iv) The scientists thought the data produced by their investigation was accurate and reliable. State what is meant by accuracy and reliability. [2]

Accuracy: how close a measurement is to the true value.

Reliability: the results are repeatable and consistent, with little variation around the mean.

(v) State the independent variable in **Experiment 2** shown in **Table 7.2**. [1]

The size of mice fed to the snakes (large or small mice).

(vi) The scientists could express the results as percentage change in length of jaw. Explain why this may be a better way of expressing the results. [2]

Percentage change allows a valid comparison between the groups, because the mean jaw lengths at hatching were different (e.g. 13.26 mm in A and 13.85 mm in C).

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(vii) The scientists concluded that the island snakes:

- may carry genes that determine a larger relative jaw size
- jaw sizes increase if fed larger prey.

Use the results shown in **Table 7.2** to explain the evidence that suggests the size of the tiger snakes' jaws at maturity is:

I. a genetically inherited trait; [1]

Island Group C had longer jaws (29.20 mm) than mainland Group A (26.37 mm) fed the same small mice.

II. affected by environmental factors. [1]

Group D fed large mice had longer jaws at maturity (33.83 mm) than Group C fed small mice (29.20 mm).

(b) It has been proposed that the two populations of snakes may eventually evolve into two separate species.

(i) With reference to all the information about the snakes in the two populations, outline how the two separate species may evolve. [3]

The island population is geographically isolated from the mainland by the sea, a physical barrier (allopatric speciation), so there is no gene flow.

Each population has different selection pressures: island snakes eat larger prey of greater mass and circumference.

Snakes with a selective advantage (e.g. larger jaws on the island) survive, reproduce and pass on their alleles, changing allele frequencies.

(ii) Explain how the scientists would know that the two populations were separate species. [1]

They would no longer be able to interbreed to produce fertile (viable) offspring.

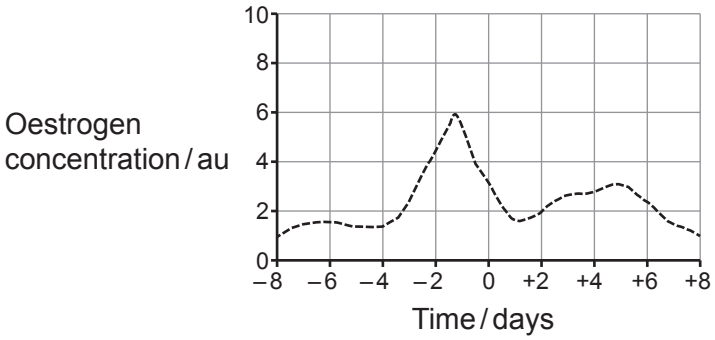
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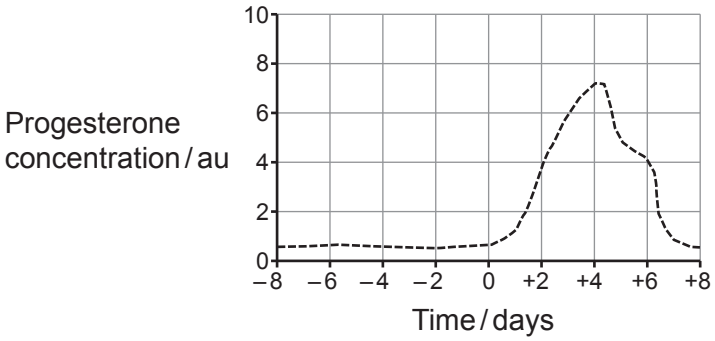
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8. **Graphs 8.1–8.4** show the concentrations of four hormones found in the plasma of a mature ewe (female sheep). The hormone concentrations are plotted over a time period of 16 days. The days are numbered either side of the peak concentration of LH secretion.

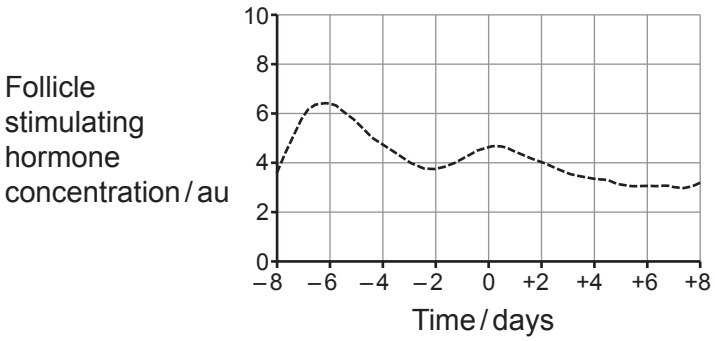
Graph 8.1



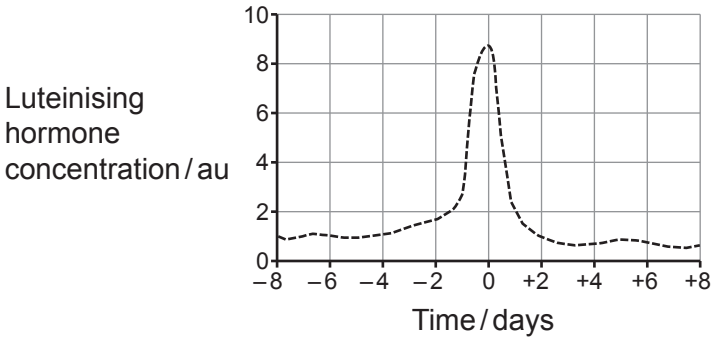
Graph 8.2



Graph 8.3



Graph 8.4



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If sheep are given progesterone for eight days and then the treatment is stopped, they will ovulate eight to twelve days later. In this way, the oestrus cycle of a flock of sheep can be synchronised.

Use **Graphs 8.1**, **8.2**, **8.3** and **8.4** to explain the role of oestrogen in the control of the timing of ovulation in the sheep.

Explain why the sheep will ovulate after the doses of progesterone are stopped.

Suggest why is it useful for a farmer to be able to determine when ovulation will occur and suggest why some people are against injecting reproductive hormones into sheep that are used for food. [9 QER]

Oestrogen: Graph 8.3 shows FSH is high at about day −7. FSH stimulates follicles to develop, and the developing follicles secrete oestrogen. Oestrogen rises to a peak (about 6 au) at day −1 (Graph 8.1).

At first oestrogen inhibits FSH release by negative feedback, so FSH falls from day −7 to day −3. When oestrogen reaches a high level it stimulates LH release by positive feedback, causing the LH surge at day 0 (Graph 8.4). The LH surge causes ovulation, so the timing of the oestrogen peak controls the timing of ovulation. After ovulation the corpus luteum forms and secretes progesterone, which rises to a peak at about day +4 (Graph 8.2).

Progesterone: progesterone inhibits the release of FSH and LH. While the sheep are given progesterone for eight days, FSH and LH are inhibited, so follicles do not develop and no ovulation takes place. When the progesterone is stopped, this inhibition is removed, so FSH is released and increases. FSH makes the follicles develop and mature, and they secrete more oestrogen. High oestrogen stimulates LH release, and the LH surge causes ovulation eight to twelve days later. Because all the sheep stop treatment on the same day, they all ovulate at about the same time.

Uses and problems: if the farmer knows when ovulation will occur, they know when it is best to introduce the ram or to artificially inseminate the ewes, which increases the chance of fertilisation. This increases the stock of lambs,

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giving more meat, and the lambs are all born around the same time, so they are ready for market at the same time.

However, some people are against this because the hormones may remain in the meat eaten by humans. The hormones may be toxic or have unknown effects in humans, for example they may affect the human female menstrual cycle or alter fertility. Injections may also cause stress or injury to the sheep.

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