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

GCE A LEVEL

A400U20-1

S25-A400U20-1

FRIDAY, 13 JUNE 2025 – MORNING

BIOLOGY – A level component 2
Continuity of Life

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**8**	
2.	**18**	
3.	**17**	
4.	**13**	
5.	**24**	
6.	**11**	
7.	**9**	
Total	**100**	

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ADDITIONAL MATERIALS

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 **7**.

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

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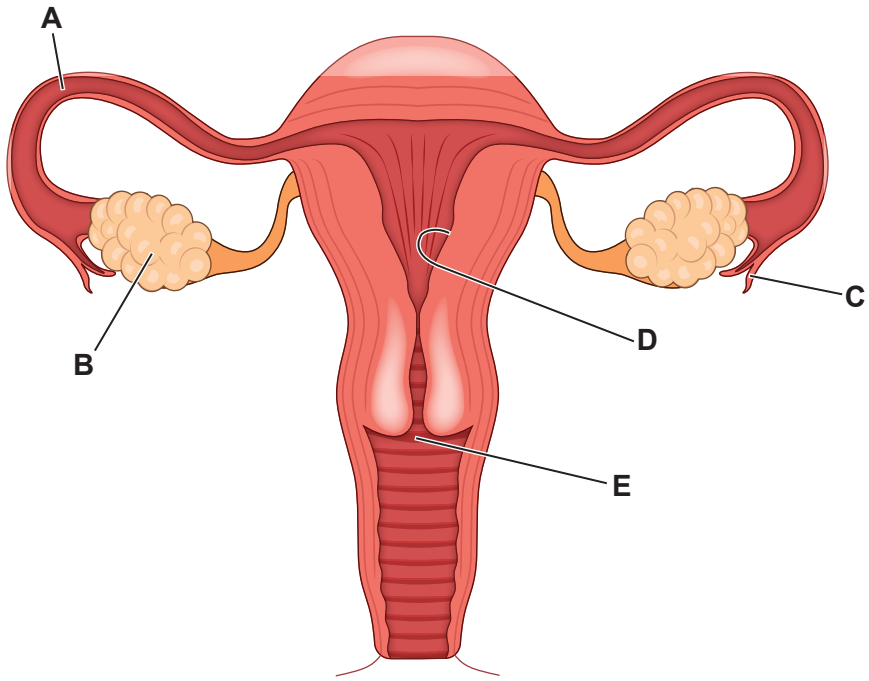
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Answer **all** questions.

1. **Image 1.1** shows a front view of the female reproductive system.

Image 1.1



(a) Using some of the letters **A–E** from **Image 1.1** complete **Table 1.2** to identify the site of the following processes. Letters may be used once, more than once or not at all. [3]

Table 1.2

	Letter
Sperm is normally deposited during sexual intercourse	E
Fertilisation of the ovum normally occurs	A
The blastocyst normally implants	D
The placenta normally forms	D

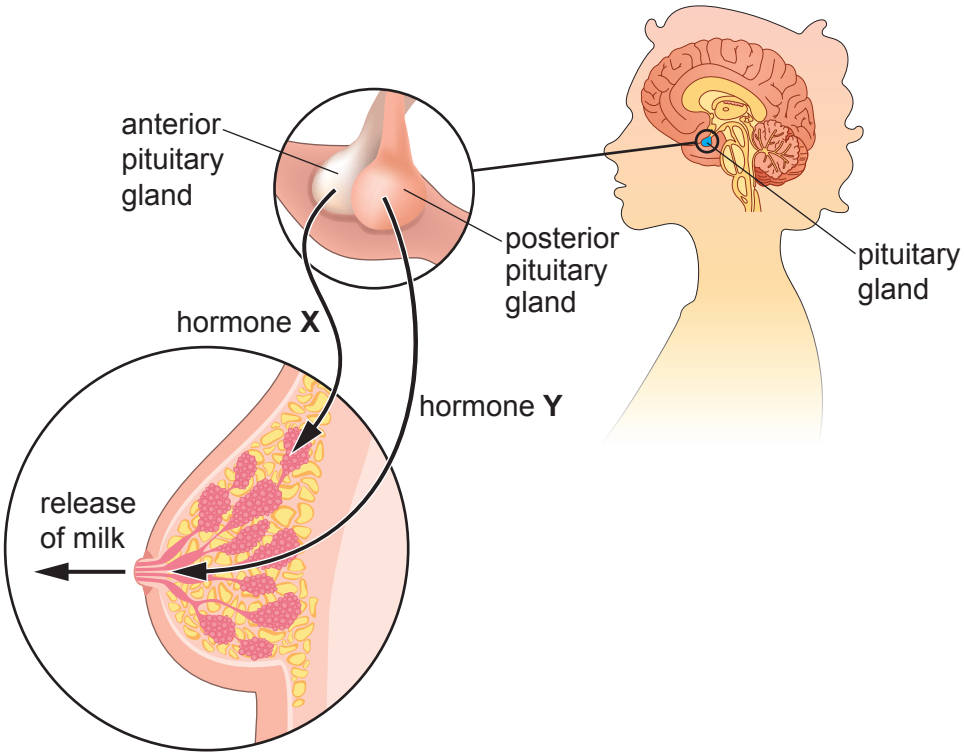
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(b) During breastfeeding, the baby feeds on milk from the mammary glands. **Image 1.3** shows the site of the action of two hormones involved in the control of lactation.

Image 1.3



(i) Hormone **X** stimulates the production of milk by the mammary glands.
Hormone **Y** stimulates the release of milk from the breast. It also stimulates the contraction of the uterine wall during birth.
Name hormones **X** and **Y**. [2]

X prolactin

Y oxytocin

(ii) When the baby starts to feed from the mother there is increased secretion of these two hormones.
Suggest how this is an example of positive feedback. [1]

The more the baby feeds, the more prolactin and oxytocin are released, so the more milk is produced and released (response amplifies stimulus).

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Table 1.4 shows the normal composition of human milk and cow milk.

Table 1.4

	Human milk / g dm^{-3}	Cow milk / g dm^{-3}
Protein	9	34
Fat	38 Of which 48.2% saturated and 51.8% unsaturated	38 Of which 65.2% saturated and 34.8% unsaturated
Lactose	70	48

(iii) Use only the information in **Table 1.4** to identify **two** ways in which human milk is more beneficial to feed to a human baby than cow milk. [2]

I. *Human milk contains more lactose (70 g dm^{-3} compared with 48 g dm^{-3}), giving more energy.*

II. *A smaller proportion of its fat is saturated (48.2% v 65.2%), i.e. more unsaturated fat.*

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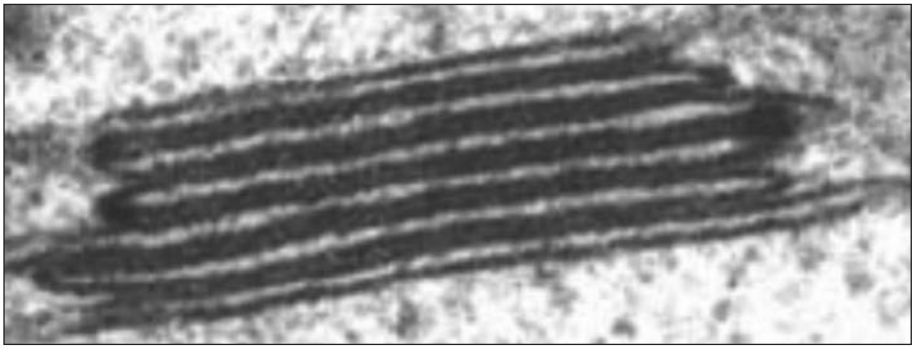
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2. Scientists have been investigating a genetic approach that improves food crops.

The scientists studied photosynthesis in tobacco plants (*Nicotiana tabacum*) and wheat plants (*Triticum aestivum*).

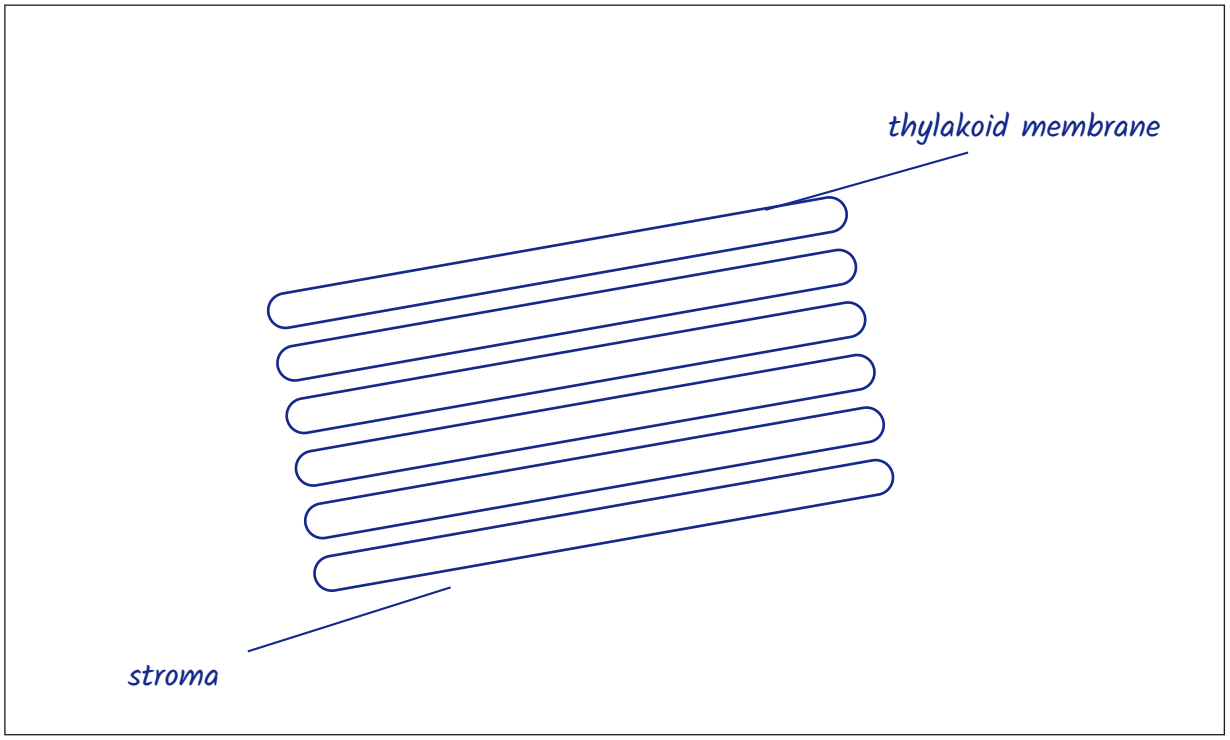
Image 2.1 shows a granum from a chloroplast from a tobacco plant.

Image 2.1



(a) In the box below, produce a scientific drawing of the granum shown in **Image 2.1**.

Label the stroma and thylakoid membrane on your diagram. [4]



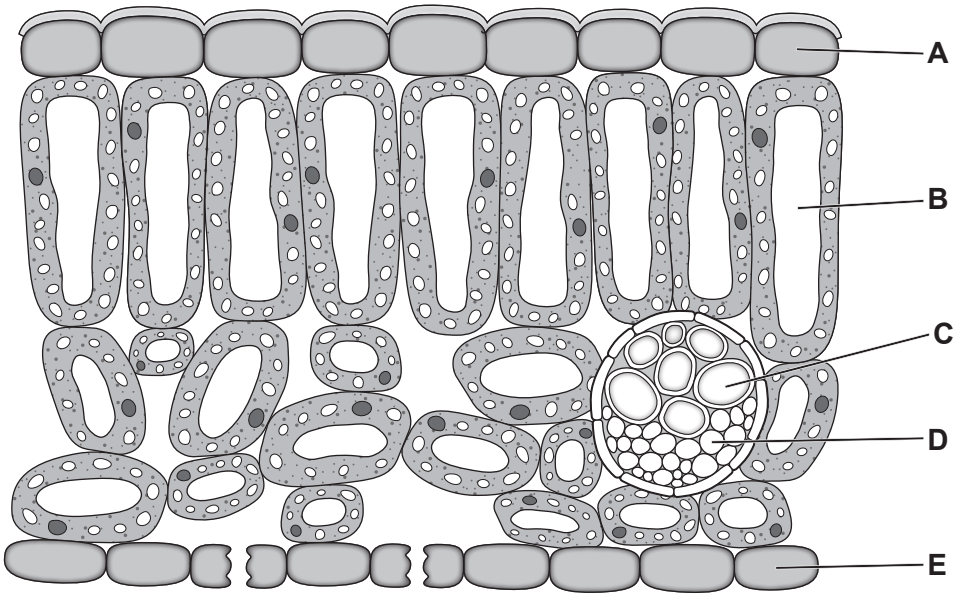
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(b) **Image 2.2** shows a diagram of a transverse section of a tobacco leaf.

Image 2.2



The chloroplast in **Image 2.1** was taken from a cell in a leaf.

(i) Using a label (**A–E**) from **Image 2.2**, identify from which cell the chloroplast was taken.
Name the tissue in which this cell would have been found. [1]

Cell ..B..

Name of tissue ..palisade mesophyll..

(ii) Carbon dioxide is taken in by the leaf and is fixed to form sugars. Rubisco is the enzyme that catalyses the reaction between ribulose bisphosphate and carbon dioxide.

Name the three-carbon compound produced in this reaction. [1]

glycerate 3-phosphate (GP)

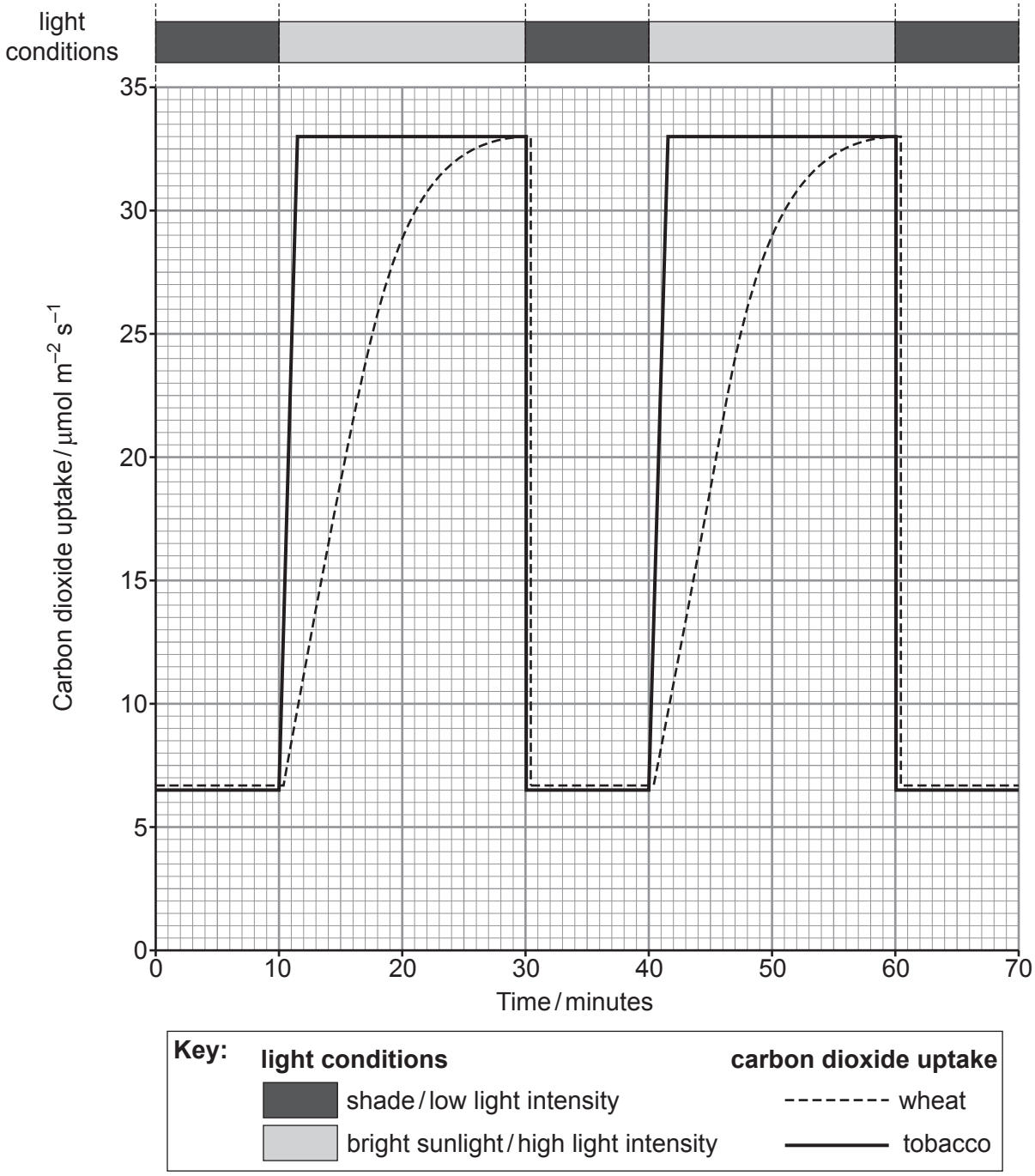
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The scientists measured the effect of intensity of light on the uptake of carbon dioxide by leaves of tobacco and wheat over a period of an hour. **Graph 2.3** shows the results.

Graph 2.3



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(iii) Use **Graph 2.3** to describe and explain why tobacco grows faster than wheat. [3]

When the light changes from shade to bright sunlight, the tobacco CO_2 uptake reaches its maximum much faster (about 1.5 minutes) than wheat (about 19 minutes), so it stays at maximum for longer.

So there is a faster rate of the light-dependent reaction (photophosphorylation), more ATP and reduced NADP for the Calvin cycle: more photosynthesis.

More products, e.g. glucose and amino acids, for growth and protein synthesis.

The scientists have found that the structure of Rubisco in tobacco is slightly different to the structure of Rubisco in wheat. They have removed the genes for Rubisco from tobacco and inserted them into wheat cells using a vector.

(iv) Explain how named enzymes would be used to cut genes for Rubisco from tobacco and splice them into a vector. [3]

A restriction endonuclease (e.g. EcoRI) cuts out the Rubisco genes from tobacco DNA at recognition sequences at the start and end of the gene.

The staggered cut leaves sticky ends (unpaired bases).

The same restriction enzyme cuts open the plasmid vector, giving complementary sticky ends.

DNA ligase then splices the gene into the plasmid by forming phosphodiester bonds.

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The genetically modified wheat may be used for wheat crops in the future.

(v) Give **one** benefit and **one** concern over the use of this genetically modified wheat crop. [2]

Benefit:

Higher yield, as the wheat photosynthesises and grows faster, so more food is produced.

Concern:

The gene may spread by pollen to wild plants, which then grow faster and outcompete other plants, reducing biodiversity.

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(c) Flowers may be insect or wind-pollinated. **Image 2.4** shows wheat flowers, which are wind-pollinated.

Image 2.4



(i) State **two** ways in which **the appearance** of wheat flowers might be different if they were insect-pollinated. [2]

I. Large, brightly coloured petals would be present.

II. Anthers and stigma would be enclosed inside the flower, not exposed, and the stigma would not be feathery.

(ii) In some plant species the stamen and stigma mature at different times. Explain the importance of this. [2]

It prevents self-pollination (self-fertilisation) and ensures cross-pollination takes place, preventing inbreeding.

This leads to greater genetic variation (diversity) in the offspring.

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3. In the UK prepacked food is required to be labelled with a list of individual components and the mass of each present.

(a) (i) Give **two** reasons why it is important to know the individual components of the food. [2]

I. People may be allergic to a component (e.g. nuts) or have health concerns, e.g. sugar and diabetes.

II. Religious, ethical or dietary choices, e.g. avoiding pork or being vegetarian.

Samples of meat products are tested for the presence of different types of meat. Small quantities of DNA are extracted and copied using the polymerase chain reaction (PCR). Genetic fingerprinting is then carried out on the samples to check for the presence of different types of meat.

(ii) DNA replication takes place in both human cells and in PCR.

State **two** similarities and **two** differences between DNA replication in PCR and DNA replication in cells. [4]

Similarities

I. Both use DNA polymerase to join nucleotides.

II. Both use complementary base pairing and are semi-conservative.

Differences

I. PCR uses heat (95 °C) to break hydrogen bonds and separate the strands instead of enzymes (helicase).

II. PCR uses thermostable Taq polymerase and needs added DNA primers, which cells do not.

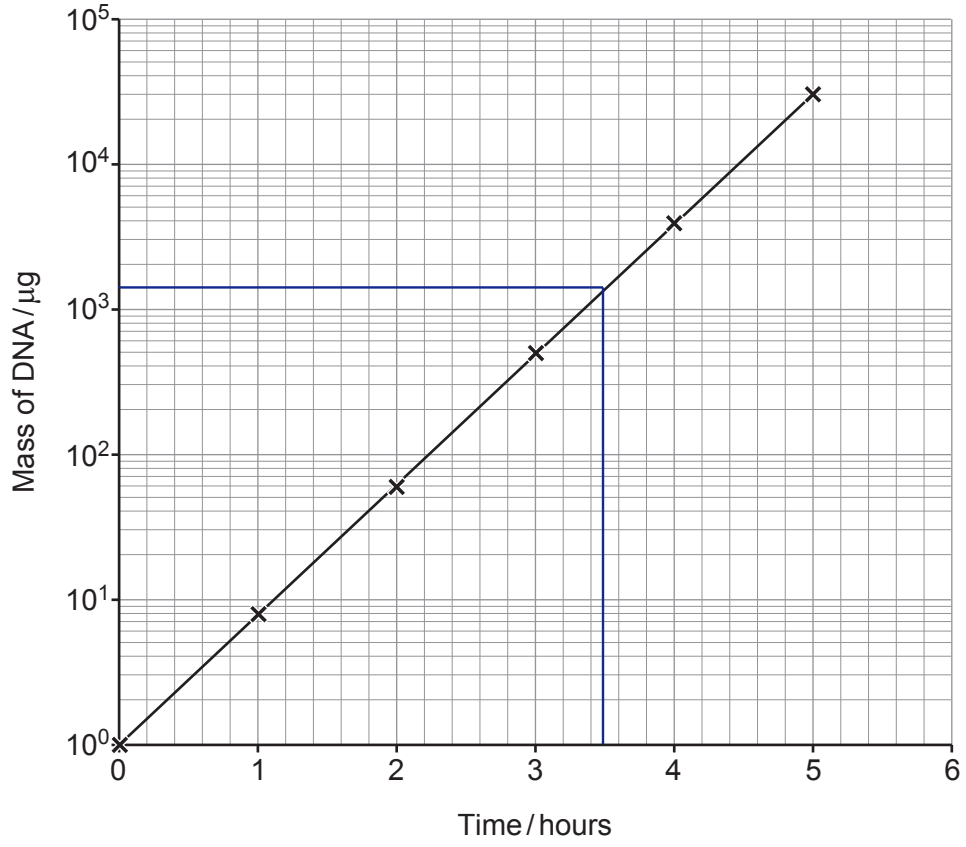
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Graph 3.1 shows the mass of DNA produced in PCR over five hours.

Graph 3.1



(iii) Use **Graph 3.1** to estimate the mass of DNA obtained after **210 minutes**. **Show how you estimated the value on Graph 3.1.** [2]

Mass of DNA obtained after 210 minutes = 1400 µg

(iv) When the PCR cycle is repeated it is theoretically possible to produce over 3.35×10^7 copies of the target sequence from just one piece of DNA.

Suggest **one** reason why the actual number of copies is likely to be less than this theoretical number. [1]

Primers or nucleotides run out, so not every strand is copied in every cycle.

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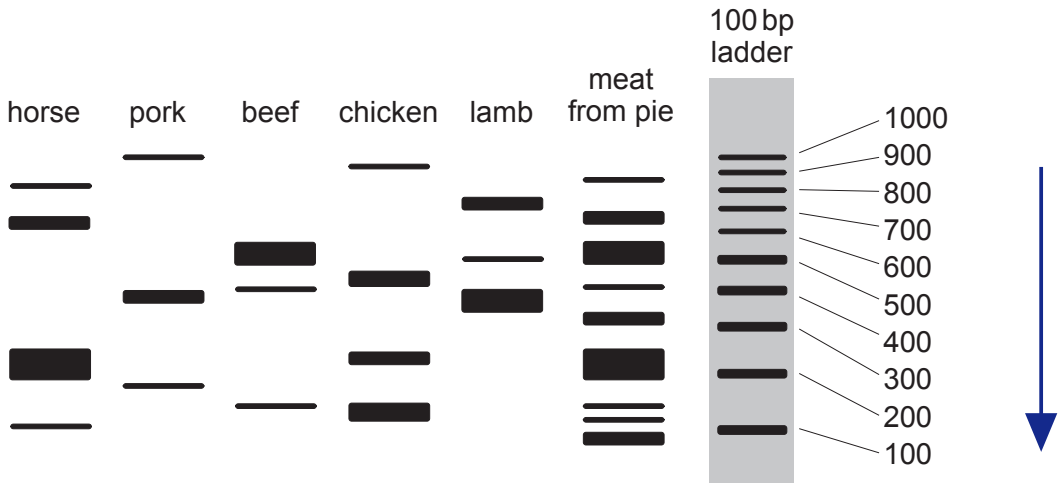
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(b) Genetic fingerprinting was used to identify the types of meat present in a sample of a meat pie. **Image 3.2** shows the gel electrophoresis results for the meat from this pie. It also shows the results for pure samples from horse, pork, beef, chicken and lamb.

Image 3.2



Key: bp = DNA base pairs

(i) **Draw** an **arrow** on **Image 3.2** to show the direction in which the fragments moved during electrophoresis.

Explain why you have drawn the arrow in that direction. [2]

Smallest fragments (fewest base pairs) move fastest and furthest towards the anode, so the 100 bp band is lowest.

(ii) Explain why a DNA ladder is run alongside fragments in gel electrophoresis. [1]

To estimate the size (number of base pairs) of fragments by comparing them with fragments of known size.

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(iii) Although a DNA ladder was present, it was not needed in this case. Explain why. [2]

We do not need to know the sizes of the fragments, as the bands from the pie only need to be compared with the bands from the pure (known) meat samples to identify which meat is in the pie.

(iv) Conclude what the results in **Image 3.2** show about the contents of the meat in the pie. [2]

The pie contains horse and beef, as all their bands match bands in the pie sample.

Some pie bands match none of the known meats, so another unidentified meat (or contaminating DNA) is also present.

(v) The use of PCR and genetic fingerprinting does not allow the scientists to calculate the percentage of the meat types present. Suggest **one** reason why. [1]

The bands do not give quantitative data, as PCR amplifies even tiny amounts of DNA to large amounts, so band size does not show how much of each meat was in the pie.

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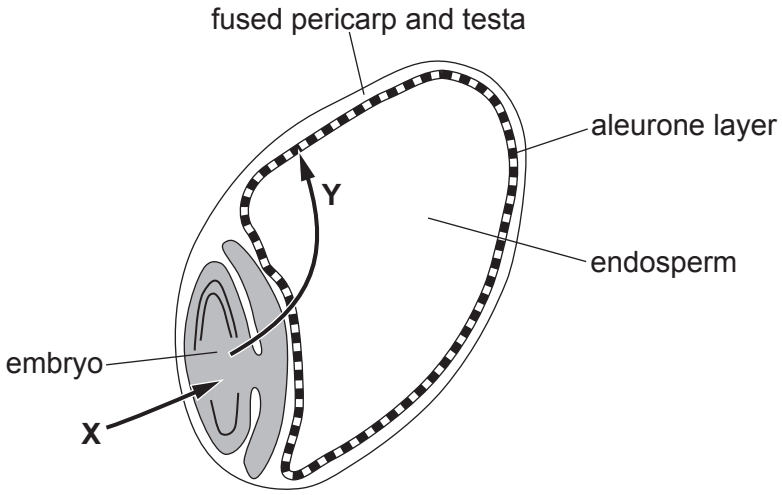
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4. **Image 4.1** shows a section through a barley grain starting the process of germination.

Image 4.1



(a) (i) Name substance **X** which enters the barley grain in order to start germination. [1]

water

(ii) Name substance **Y** and state how it moves to the aleurone layer. [2]

Y is gibberellin (gibberellic acid).

It moves from the embryo to the aleurone layer by diffusion.

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(b) A scientist investigated the germination of barley grains.

The scientist used three barley grains. The grains were treated in one of three ways.

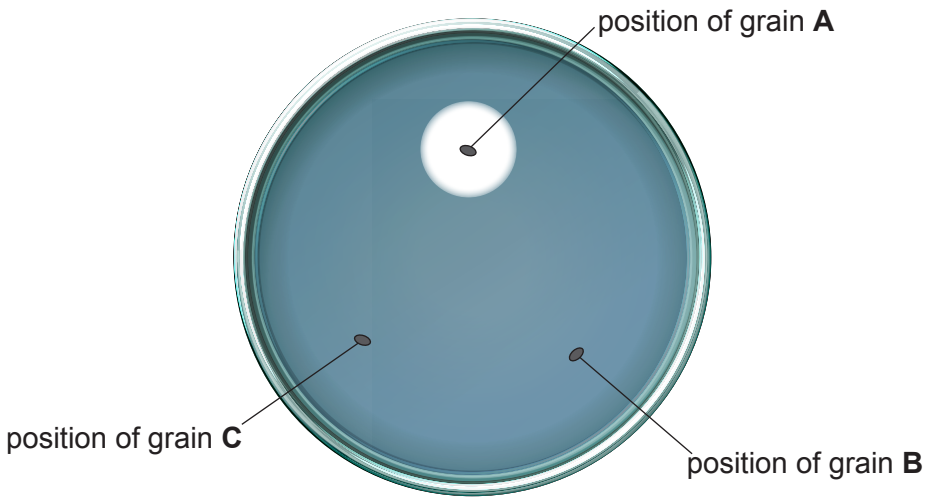
Grain A was soaked in water at 20 °C for 24 hours.

Grain B was boiled for 10 minutes and soaked in water at 20 °C for 24 hours.

Grain C was left dry.

The grains were then cut in half and placed cut surface downwards onto a starch agar medium in a Petri dish. The grains were left for 12 hours and removed. The dish was then flooded with iodine solution. The results are shown in **Image 4.2**.

Image 4.2



(i) A sharp scalpel was used to cut the grains in half. There is a risk of cutting fingers when using a scalpel to cut the grains.

State **one** way of reducing the risk when carrying out this procedure. [1]

Cut away from the body onto a white tile, holding the grain with forceps.

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(ii) Explain the results for:

I. **Grain A** [2]

The aleurone layer synthesises and secretes amylase, which diffuses into the agar and hydrolyses the starch to maltose, so there is no blue-black colour: a clear zone.

II. **Grain B** [1]

Boiling denatured the enzymes, so amylase could not hydrolyse the starch; the agar stays blue-black.

III. **Grain C** [1]

No water for hydrolysis, so gibberellin was not activated and no amylase was synthesised: the seed is still dormant.

(c) Before soaking and germination, it was found that 30% of the mass of the grains was due to water content.

(i) Calculate the total dry mass of 420 g of grains. **Give your answer to two significant figures.** [3]

water = 30% of 420 g = 0.3 × 420 = 126 g

dry mass = 420 − 126 = 294 g = 290 g (2 s.f.)

Total dry mass of grains = 290 g

(ii) The grains were then soaked in water and allowed to germinate. During the first four days of germination there was a 44% decrease in total dry mass. Explain why the dry mass of grains decreased during germination. [2]

Stored starch (and oil) is hydrolysed to glucose, which is used in respiration to produce ATP for growth.

So carbon is lost as CO_2, decreasing the dry mass.

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5. Glycosylation is the addition of short carbohydrate chains to another molecule. When carbohydrates are added to a protein this forms a glycoprotein.

(a) (i) State the term used for the carbohydrates attached to the extracellular surface of a cell. [1]

glycocalyx

The formation of glycoproteins on red blood cell membranes is carried out by enzymes.

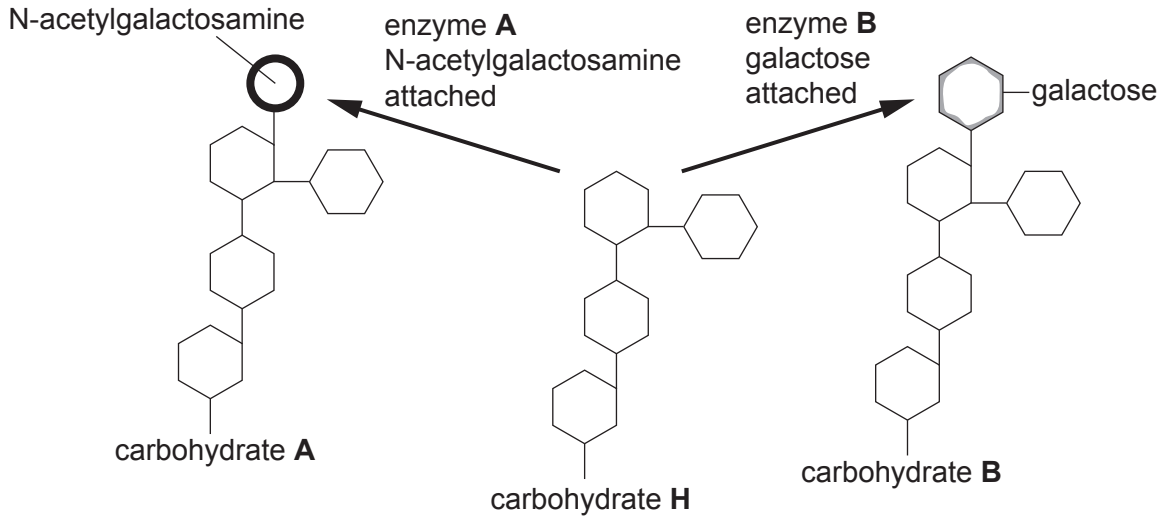
The ABO blood group system depends on the type of glycoproteins present on red blood cells. There are different forms of carbohydrate chain that can be found as part of the glycoprotein. The basic structure of this carbohydrate is called **H**.

N-acetylgalactosamine can be attached to carbohydrate **H** by enzyme **A** to make carbohydrate **A**.

Galactose can be attached to carbohydrate **H** by enzyme **B** to make carbohydrate **B**.

This is summarised in **Image 5.1**.

Image 5.1



(ii) Use **Image 5.1** to suggest why different enzymes are needed to attach N-acetylgalactosamine and galactose to carbohydrate **H**. [2]

N-acetylgalactosamine and galactose have different shapes (structures).

Enzymes are specific: each enzyme has an active site complementary to only one of these substrates.

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(b) The ABO blood groups are determined by a single gene with three different alleles.

Allele I^A codes for enzyme **A**.

Allele I^B codes for enzyme **B**.

Allele I^O does not code for either enzyme.

Alleles $\mathbf{I^A}$ and $\mathbf{I^B}$ are codominant and $\mathbf{I^O}$ is recessive to both.

(i) Using the information given, complete **Table 5.2** giving **all** the possible genotypes of individuals with the blood groups shown.
Use symbols $\mathbf{I^A}$, $\mathbf{I^B}$ and $\mathbf{I^O}$ to represent the alleles. [2]

Table 5.2

Blood group	Genotype(s)
A	I^AI^A and I^AI^O
B	I^BI^B and I^BI^O
AB	I^AI^B
O	I^OI^O

(ii) A child with blood group O was born to parents with blood groups A and B.

Complete the genetic diagram below to show a cross between these parents that could produce a child with blood group O. [2]

Parental phenotypes — Blood Group A — Blood Group B

Parental genotypes — I^AI^O — I^BI^O

Genotypes of gametes — I^A, I^O — I^B, I^O

Genetic diagram

gametes	I^B	I^O
I^A	I^AI^B	I^AI^O
I^O	I^BI^O	I^OI^O

Genotypes of children I^AI^B I^AI^O I^BI^O I^OI^O

(iii) State the probability that another child born to these parents will have blood group O. [1]

0.25

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(c) In the UK some people regularly donate blood. The proportions of the different blood groups donated are recorded. The results are shown in **Table 5.3**.

Table 5.3

ABO Blood group	% of blood donors
A	37
B	11
O	49
AB	3

(i) State the type of variation displayed by blood group. [1]

discontinuous

(ii) Using the values in **Table 5.3** and the equations below, calculate the % frequency of people carrying a dominant and recessive allele for blood group. [4]

$p + q = 1$

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

where p = frequency of dominant alleles ($I^A + I^B$)

q = frequency of recessive allele (I^O)

q^2 = frequency of group O = 49% = 0.49

$q = \sqrt{0.49} = 0.7$

$p = 1 - 0.7 = 0.3$

$2pq = 2 \times 0.3 \times 0.7 = 0.42$

Frequency of the recessive I^O allele in the UK = *0.7*

Frequency of dominant alleles in the UK = *0.3*

Frequency of people carrying a dominant and recessive allele for blood group = *0.42*

% frequency of people carrying a dominant and recessive allele for blood group = *42%*

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Four years before this data was published the percentage of the donors with blood group O was found to be 46%.

(iii) Assuming the figures given are reliable estimates, give **one** reason this population is not at Hardy-Weinberg equilibrium for blood groups. [1]

Migration (immigration / emigration) is changing allele frequencies, as group O rose from 46% to 49%.

(iv) Give **one** reason why the data in **Table 5.3** may not be a reliable estimate of the proportions of the different blood groups in the UK population as a whole. [1]

Group O (universal) donors may be encouraged to donate more than others, so group O is over-represented.

Question continued overleaf

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(d) *FUT1* is a gene that codes for an enzyme that catalyses the final step in the synthesis of carbohydrate **H**.

Image 5.4 shows the sequence of bases in a section of the mRNA strand used to synthesise this enzyme.

Image 5.4

$^{5'}$ CUG GAC UAC GGG $^{3'}$

(i) Give the DNA sequence which would be complementary to this section of mRNA. [1]

GAC CTG ATG CCC

Table 5.5 shows mRNA codons and the amino acids coded for by each codon.

Table 5.5

Codons found in messenger RNA

First Base	Second Base U	Second Base C	Second Base A	Second Base G	Third Base
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	Hls	Arg	U
	Leu	Pro	Hls	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

(ii) Use the mRNA codons provided in **Table 5.5** to give the amino acid sequence coded for by the section of mRNA in **Image 5.4**. [1]

Leu Asp Tyr Gly

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Some mutations occur when one nucleotide is substituted by a different nucleotide in a strand of DNA.

(iii) Explain how the substitution of a nucleotide may cause a gene to code for a different protein. [3]

The substitution changes the base sequence of the DNA, so a different codon is produced in the mRNA.

This codon attracts a tRNA with a different anticodon, so a different amino acid is inserted, changing the amino acid sequence (primary structure); or a stop codon may form, giving a shorter protein.

(iv) Some nucleotide substitutions have no effect on the protein coded by the exons of this gene.
Use an example from **Table 5.5** to explain why. [2]

The genetic code is degenerate: more than one codon codes for the same amino acid.

E.g. GGG, GGA, GGU and GGC all code for Gly, so if the last G of GGG is substituted by A, glycine is still coded for.

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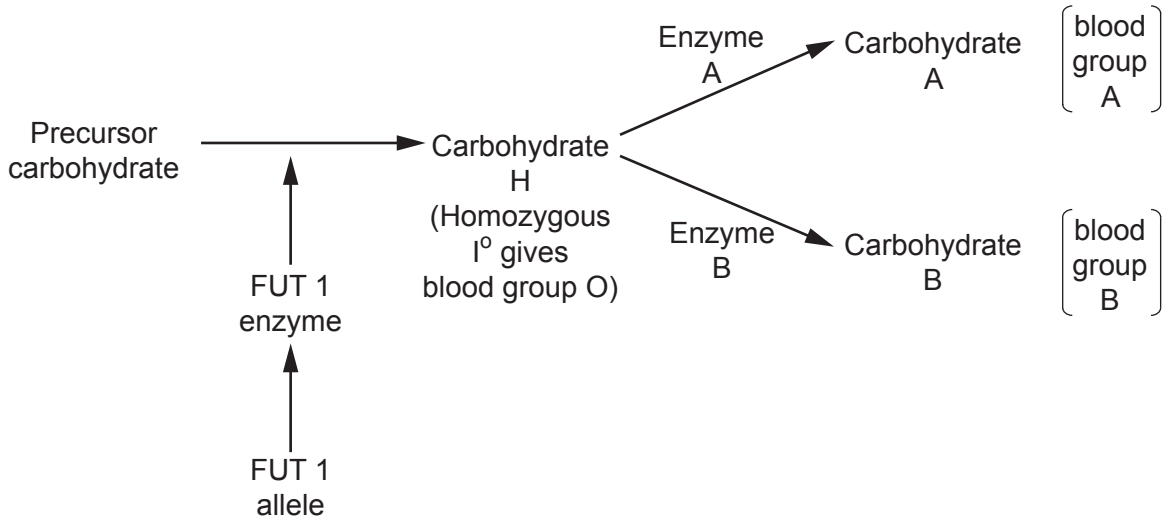
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(v) Bombay blood group is a very rare blood type. People with this blood type always show up as type O on a blood test, but they can carry the allele for blood group A or blood group B. They have two mutated *FUT1* alleles.

Image 5.6 summarises the reactions involved in producing the blood groups.

Image 5.6



Use **Image 5.6** to suggest how these people show up as blood group O even though they have the allele for blood group A or B. [2]

No functional FUT1 enzyme is produced, so carbohydrate H is not made and only the precursor carbohydrate is present.

So enzymes A and B have no substrate (carbohydrate H) and cannot produce carbohydrate A or B.

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6. (a) A local council were approving planning permission for a car park measuring 60 m by 30 m. They had identified two possible sites. The council commissioned a biodiversity study of the two sites to help them decide which to use. The study was carried out on one day in March.

The method used to collect data from both sites was as follows:

1. Place tape measures at right angles to each other to form a pair of axes 20 m × 20 m.
2. Generate random numbers to produce the figures for the x and y co-ordinates to identify a sampling position.
3. Place a 50 cm × 50 cm quadrat at the generated sampling position.
4. Identify all the plant species present and record the numbers of each species in the quadrat.
5. Repeat steps 2–4 for a total of 10 quadrats.

(i) Explain why **random** numbers were generated in **Step 2**. [1]

To reduce (prevent) sampling bias.

The results for the two sites are shown in **Table 6.1**.

Table 6.1

	Mean number of plants per quadrat	
Plant species	Site **1**	Site **2**
A	22	17
B	16	12
C	4	7
D	7	10
E	3	8
F	0	3
G	4	13
H	7	12
I	2	0

(ii) State a numerical value for the species **richness** of: [1]

Site **1** = 8

Site **2** = 8

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The data collected were used to calculate a Simpson's Diversity Index for both sites. The data for Site **2** is given in **Table 6.2**.

Table 6.2

Plant Species	n	(n − 1)	n(n − 1)
A	17	16	272
B	12	11	132
C	7	6	42
D	10	9	90
E	8	7	56
F	3	2	6
G	13	12	156
H	12	11	132
I	0	0	0
(N)	82	$\sum$n(n − 1) =	886
N(N − 1) =	6642		

Site **1** had a Simpson's Diversity Index of 0.80.

(iii) Use **Table 6.2** and the formula below to calculate the Simpson's Diversity Index for Site **2**. [3]

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

where N = number of organisms present and n = number in each species.

D = 1 − 886 / 6642

= 1 − 0.1334

= 0.8666 = 0.87

D = 0.87

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(iv) Use the answers to (ii) and (iii) to suggest why using species richness alone is not a valid measure of biodiversity in this study. [2]

Both sites have the same species richness (8), but Site 2 has a higher diversity index (0.87 v 0.80).

Richness ignores species evenness (how abundant or dominant each species is).

(b) To preserve biodiversity the local council decided to use Site **1**. However, environmentalists queried the validity of the method used to gain the results. Identify **four** limitations in the method used to collect the data. [4]

I. Only plants recorded; animals / invertebrates not taken into account.

II. Only carried out once, on one day in March; species present change during the year.

III. Only a 20 m × 20 m (400 m^2) area was sampled, not the whole 60 m × 30 m site.

IV. Only 10 quadrats and 50 cm × 50 cm quadrats are too small, so not representative.

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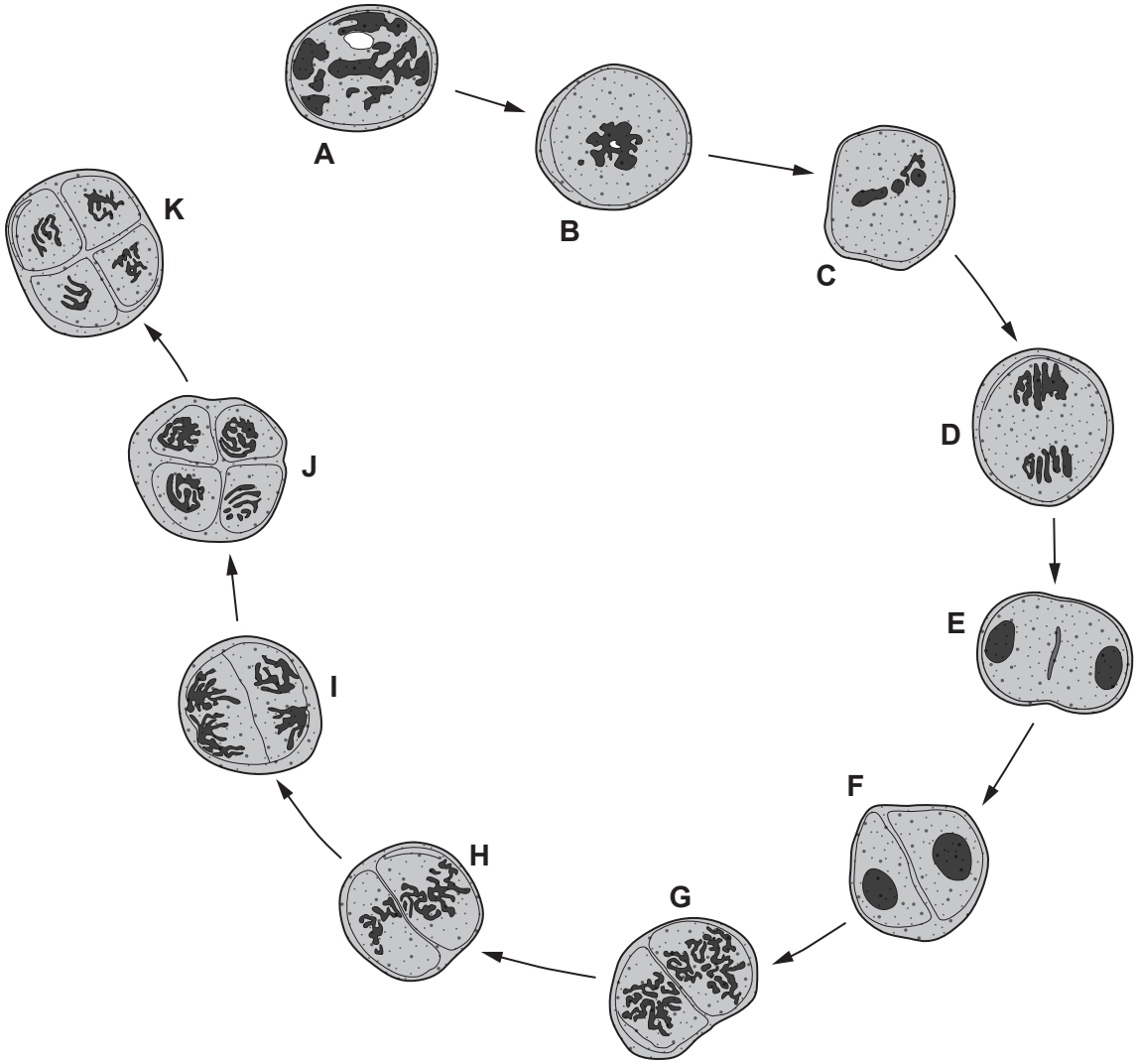
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7. Pollen grain formation in flowering plants involves both mitosis and meiosis.
Image 7 shows the stages of meiosis in the formation of pollen grains in an anther of a species of lily (*Lilium sp.*).

Image 7



Describe the role of mitosis and meiosis in the development of fully mature pollen grains in an anther.
Describe the events taking place at stages **B** and **C** in **Image 7**.
Explain the importance of meiosis to this plant species. [9 QER]

Role of mitosis and meiosis: inside the pollen sacs of the anther, diploid cells divide by mitosis to produce many pollen mother cells (microspore mother cells), which are genetically identical and diploid.

Each pollen mother cell then divides by meiosis to produce a tetrad of four

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haploid cells (microspores). Each microspore develops a tough wall to become an immature pollen grain.

The haploid nucleus of each pollen grain then divides by mitosis to form a tube nucleus and a generative nucleus. The generative nucleus divides again by mitosis to form two male nuclei (male gametes), so a fully mature pollen grain contains a pollen tube nucleus and two male nuclei.

Stage B (prophase I): the chromatin condenses so the chromosomes shorten, thicken and become visible. Homologous chromosomes pair up to form bivalents. Non-sister chromatids of each bivalent cross over at points called chiasmata, where sections of chromatid are exchanged (crossing over), producing new combinations of alleles. The nuclear envelope breaks down and the spindle forms.

Stage C (metaphase I): the bivalents (homologous pairs) line up across the equator of the spindle. Spindle fibres attach to the centromeres. Each pair is orientated randomly, independently of the other pairs (independent assortment), so the maternal and paternal chromosomes are sorted into different combinations when the homologues separate in anaphase I.

Importance of meiosis: crossing over and independent assortment mean meiosis produces genetically different haploid cells, so the pollen grains (male gametes) are all genetically different. Random fertilisation of these gametes gives genetic variation in the offspring plants.

This variation is the raw material for natural selection and evolution: if the environment changes, for example a new disease or a change in climate, some plants are more likely to have alleles giving a selective advantage, so they survive and reproduce, and the species is less likely to die out.

Meiosis also halves the chromosome number, so when a haploid male nucleus fertilises a haploid egg cell, a diploid zygote is formed. This maintains the

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chromosome number of the lily from generation to generation.

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