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

GCE AS

B400U10-1

Z22-B400U10-1

FRIDAY, 20 MAY 2022 – AFTERNOON

BIOLOGY – AS component 1
Basic Biochemistry and Cell Organisation

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	12	
2.	18	
3.	13	
4.	12	
5.	11	
6.	9	
Total	75	

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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 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 quality of extended response (QER) will take place in question **6**.

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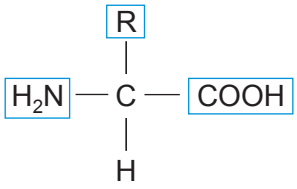
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Answer **all** questions.

1. Proteins are polymers of amino acids and are found in all living organisms. **Image 1.1** shows the general structural formula of an amino acid molecule.

Image 1.1



(a) **Complete the table** to name the groups shown in **Image 1.1**. [2]

Group	Name
R	Variable group (functional group)
NH_2	Amine (amino) group
COOH	Carboxyl group (carboxylic acid)

(b) Apart from the elements shown in **Image 1.1**, state **one** other element which is found in some amino acids. [1]

Sulfur (S)

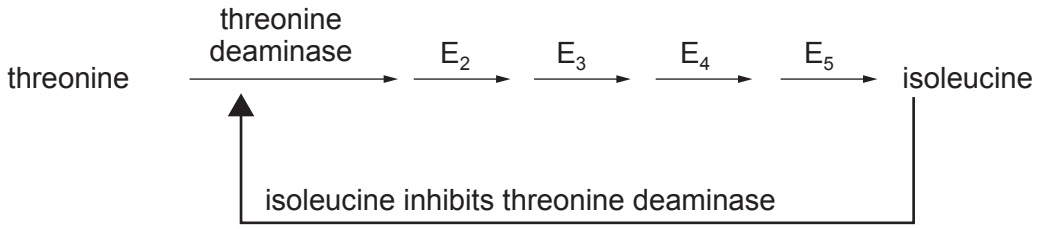
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(c) Plants can synthesise the amino acid isoleucine from a different amino acid, threonine, in a five-step metabolic pathway controlled by five different enzymes as shown in **Image 1.2**.

Image 1.2



Isoleucine acts as an inhibitor to the enzyme threonine deaminase. Predict and explain what would happen to the concentration of threonine as the concentration of isoleucine increases. [2]

The concentration of threonine would increase.

As the concentration of isoleucine increases, the activity of threonine deaminase decreases, so fewer enzyme-substrate complexes are formed.

So less threonine is converted, allowing its concentration to increase.

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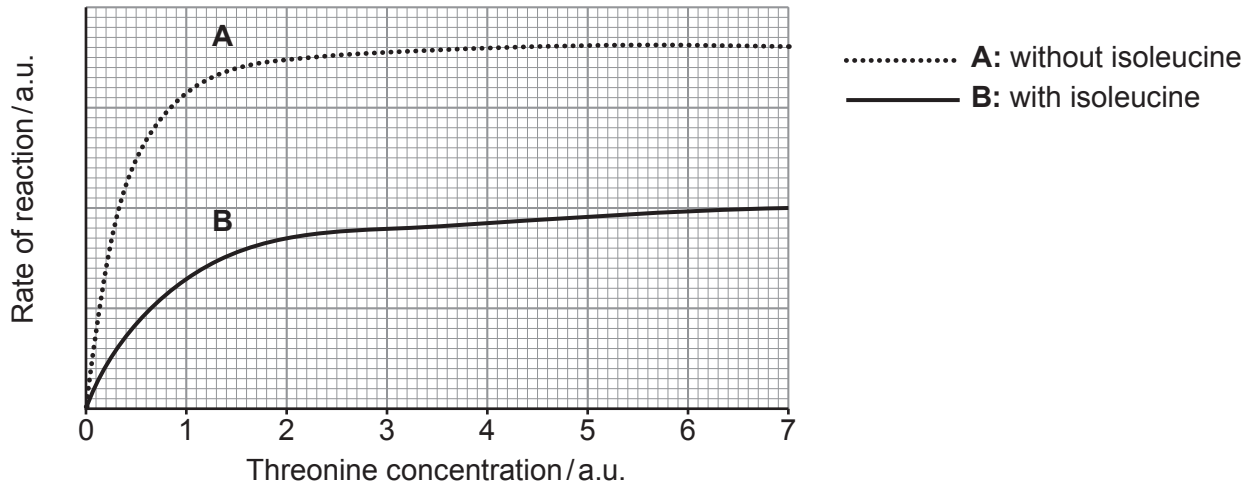
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(d) Threonine deaminase was extracted from a plant and isolated. The effect of isoleucine on the activity of the enzyme threonine deaminase was investigated. The rate of reaction was measured at increasing threonine concentrations both with and without isoleucine. The results of the investigation are shown in **Graph 1.3**.

Graph 1.3



(i) Describe and explain the results shown in curve **A**. [3]

At lower threonine (substrate) concentrations, from 0 to 1 a.u., the rate of reaction increases as the substrate concentration increases, because substrate concentration is limiting.

As the substrate concentration increases above 2 a.u. the curve levels off (plateaus).

This is because enzyme concentration is now limiting: all the active sites are occupied and the enzymes are working at their maximum turnover rate.

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(ii) Explain the shape of curve **B**. [4]

Curve B plateaus at a lower rate: the rate of reaction is lower at all substrate concentrations.

This is because isoleucine is acting as a non-competitive inhibitor.

Isoleucine binds to a site on the enzyme away from the active site (an allosteric site).

This causes the shape of the active site to change, so it is no longer complementary to threonine and fewer enzyme-substrate complexes can form.

This reduces the maximum rate of enzyme activity, and the inhibition is not reduced by increasing the substrate concentration.

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2. An investigation was carried out to determine the water potential of potato tissue using the following method.

1. Cut four cylinders of potato tissue, each approximately 50 mm long.
2. Place 30 cm^3 distilled water and three different concentrations of sodium chloride (NaCl) solution into four different boiling tubes.
3. Record the mass of each cylinder to the nearest 0.1 g.
4. Place one cylinder into each boiling tube.
5. Leave at room temperature for 45 minutes.
6. Gently blot and re-weigh the cylinders.

The results of the investigation are shown in **Table 2.1**.

Table 2.1

Concentration of NaCl / mol dm^{-3}	Initial mass of cylinder / g	Final mass of cylinder / g	Change in mass / g	Percentage change in mass
0.0	4.2	4.5	0.3	7.14
0.2	4.1	4.2	0.1	2.44
0.6	4.4	3.9	–0.5	–11.36
0.8	4.2	3.5	–0.7	–16.67

(a) (i) Calculate the percentage change in mass of the potato cylinder in the 0.8 mol dm^{-3} sodium chloride solution. **Write your answer in the table. Give your answer to two decimal places.** [2]

percentage change = −0.7 ÷ 4.2 × 100

= −16.666... = −16.67 %

(ii) Explain why it is necessary to calculate the percentage change in mass. [1]

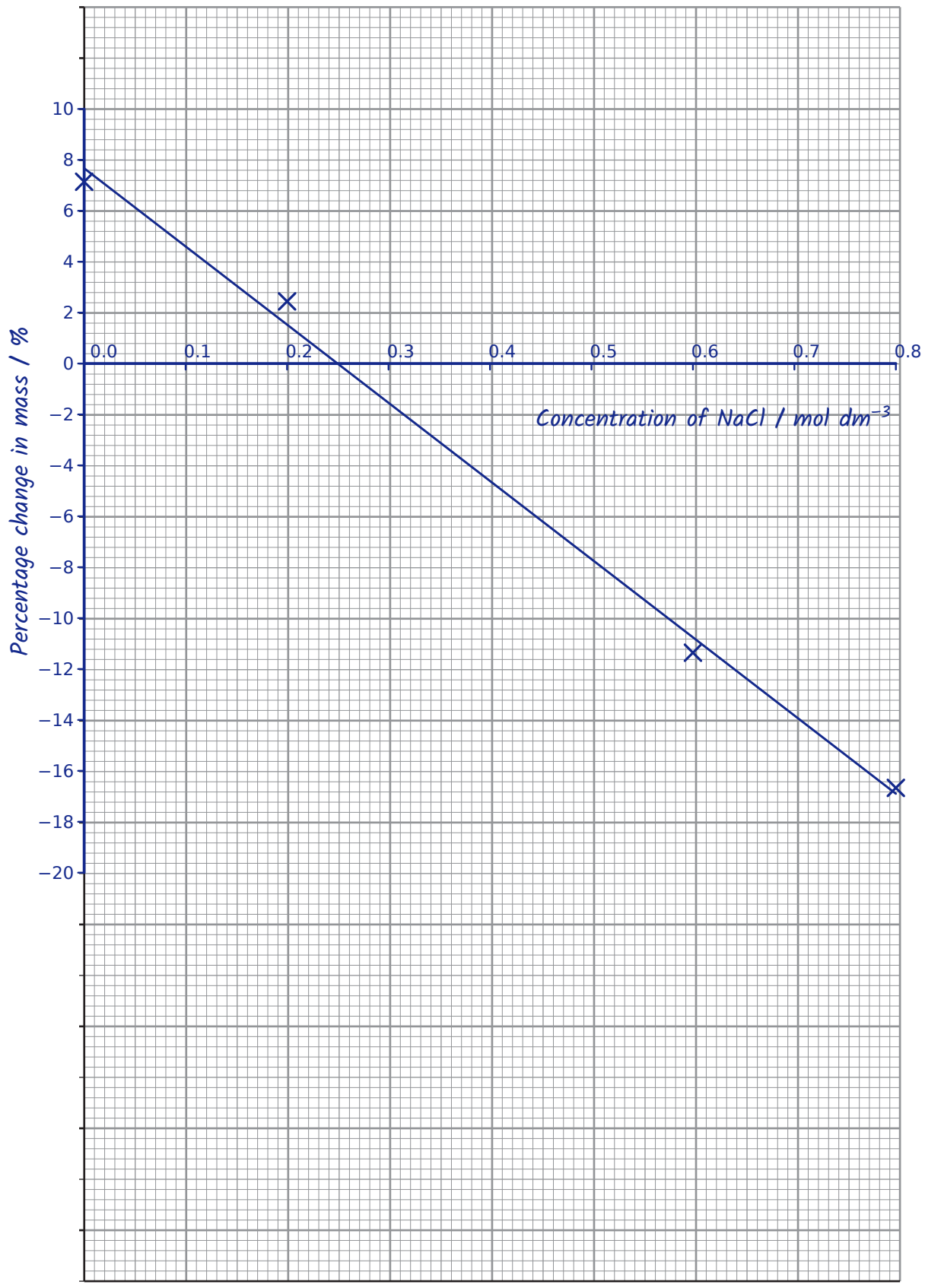
Because the masses of the cylinders at the start were different, so this gives comparable results.

(iii) **Use the results from Table 2.1 to plot a graph** showing how the percentage change in mass is affected by the concentration of sodium chloride solution. [4]

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(iv) With reference to the results of this investigation, describe **and** explain the relationship between the concentration of NaCl and the percentage change in mass of the potato cylinders. [4]

As the concentration of NaCl increases, the percentage change in mass decreases (negative correlation).

Between 0.0 and 0.2 mol dm^{-3} the water potential of the bathing solution is higher than that of the cells (hypotonic), so water moves into the tissue by osmosis down the water potential gradient and the mass increases.

At 0.6 and 0.8 mol dm^{-3} the water potential of the bathing solution is lower than that of the cells (hypertonic), so water moves out of the tissue by osmosis down the water potential gradient.

Where my line crosses zero (about 0.25 mol dm^{-3}) the tissue and solution are in equilibrium (isotonic): there is no water potential gradient, so no net movement of water into or out of the tissue.

(v) State what additional information would be required in order to determine the water potential of the potato tissue. [1]

The solute potential of the bathing (NaCl) solution, at the concentration where there is no change in mass.

(vi) With reference to the method given, suggest and explain how confidence in the data collected could be improved. [2]

Repeat each concentration at least three times and calculate a mean (and standard deviation).

This increases reliability, as anomalous results can be identified and excluded, reducing the effect of anomalies.

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(vii) Suggest **two** ways in which the accuracy of the investigation might be improved. [2]

Weigh the cylinders to 0.01 g using a more precise balance.

Standardise the blotting method, e.g. blot every cylinder in the same way for the same time.

Due to rising sea levels, it is expected that some coastal regions of the UK will experience more frequent flooding by sea water. This will increase the salt concentration of the soil in the flooded regions. Increased salt concentrations in the soil may have an effect on the growth of potatoes in these areas.

Some varieties of potato may be more suitable than others for growing in soil with a high salt concentration due to differences in the water potential of the potato tubers.

An investigation was carried out to determine the water potential of three different varieties of potato. **Table 2.2** shows the water potential of the three varieties of potato.

Table 2.2

Variety of potato	Water potential /kPa
A	–550
B	–890
C	–430

(b) Suggest which variety of potato might be best suited to planting in soil with a higher salt content. Explain your answer. [2]

Variety B, as it has the lowest (most negative) water potential, –890 kPa.

So it would be less likely to lose water by osmosis in soil with a higher salt content (lower water potential).

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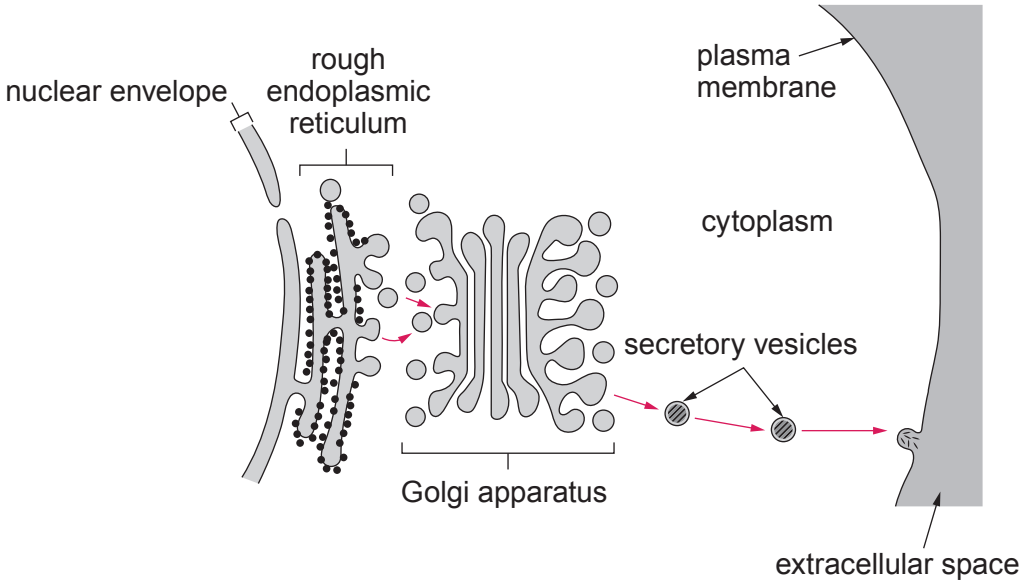
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3. A number of organelles are involved in the production and secretion of enzymes by cells. **Image 3.1** shows how different organelles are involved in this process in a eukaryotic cell.

Image 3.1



(a) Describe the sequence of events involved in the production and secretion of enzymes as shown in **Image 3.1**. [5]

mRNA, produced by transcription in the nucleus, leaves the nucleus through the nuclear pores.

Protein synthesis occurs on the ribosomes of the rough ER; the protein is transported in its cisternae.

Vesicles containing the protein pinch off the rough ER and fuse with the Golgi apparatus.

The protein is modified in the Golgi apparatus.

Secretory vesicles pinch off the Golgi apparatus and transport the enzyme to the plasma membrane.

The vesicles fuse with the plasma membrane and the enzyme is released outside the cell by exocytosis.

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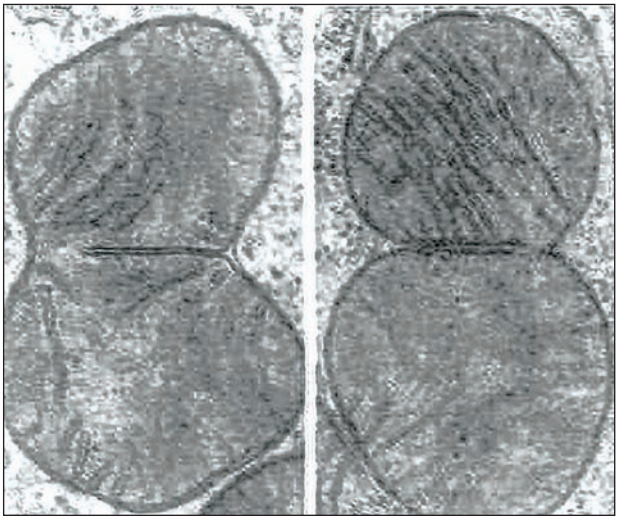
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Image 3.2 shows another organelle which is also involved in the process of enzyme secretion.

Image 3.2



(b) (i) **Using the scale bar** provided, calculate the magnification of **Image 3.2**. [2]

length of scale bar = 9 mm = 9000 µm

magnification = image size ÷ actual size

= 9000 ÷ 0.5 = 18 000

Magnification = × *18 000*

(ii) Name the organelle shown in **Image 3.2** and suggest its function in enzyme secretion. [3]

Mitochondrion.

It produces ATP by aerobic respiration.

ATP is the source of energy for exocytosis (moving the secretory vesicles and fusing them with the plasma membrane).

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(iii) The organelle shown in **Image 3.2** is in the process of self-replication. This is a similar process to that seen in bacteria.
Suggest and explain how this organelle is able to self-replicate. [3]

Mitochondria contain their own (circular) DNA, as they evolved from bacteria (endosymbiont theory).

They have their own ribosomes, so they can synthesise their own proteins.

The DNA is replicated, so both new mitochondria have a copy of the DNA, and the mitochondrion then divides by binary fission.

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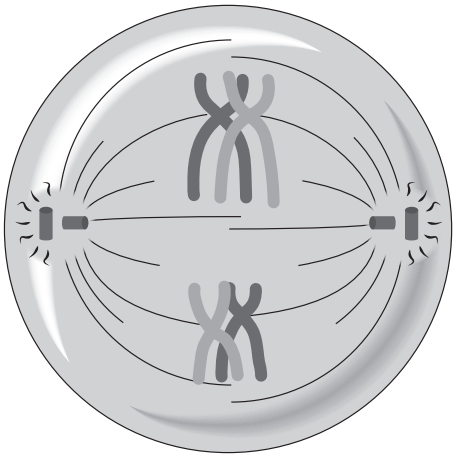
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4. Sexual reproduction in animals involves cell division by mitosis and meiosis. **Image 4.1** shows a cell undergoing meiosis.

Image 4.1



(a) (i) Name the stage of meiosis shown in **Image 4.1** and give **two** reasons for your choice. [3]

Stage: Metaphase I

Reasons: Bivalents have formed: chromosomes are in homologous pairs.

The bivalents (homologous pairs) are arranged at the equator of the spindle.

(ii) With reference to **Image 4.1**, explain **two** ways by which the process of meiosis contributes to genetic variation in an organism. [2]

Crossing over has occurred: non-sister chromatids of homologous chromosomes break and rejoin at chiasmata, exchanging alleles and producing new combinations of alleles.

Independent assortment: each bivalent (homologous pair) lines up on the equator independently, so maternal and paternal chromosomes are distributed randomly into the gametes.

(iii) Name **one** structure in a flower where meiosis occurs. [1]

Anther

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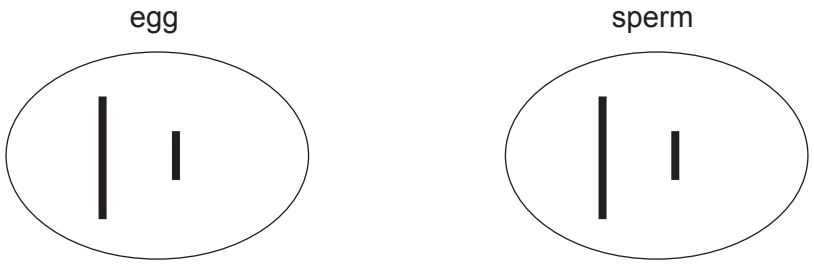
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(b) Honey bees have a complex social structure where only the queen bee produces eggs. If fertilised, these develop into female worker bees. If not fertilised they develop into males called drones, which produce sperm.

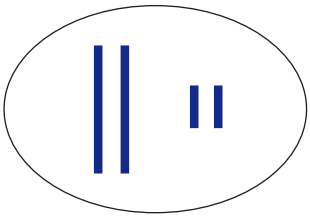
Image 4.2 shows two chromosomes in the nuclei of bee gametes.

Image 4.2

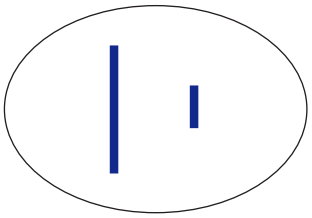


(i) In the nuclei below, draw the chromosomes as they would appear in the **body cells** of female and male bees. [2]

female body cell nucleus



male body cell nucleus



(ii) Explain why sperm cells in drones are produced by mitosis and not by meiosis. [2]

Because drones are haploid (they develop from unfertilised eggs).

Meiosis halves the chromosome number, which is not possible as there are no homologous pairs; mitosis maintains the chromosome number, so the diploid number is restored at fertilisation.

(iii) Explain why male drones would not be clones. [2]

The eggs that develop into drones are produced by meiosis in the queen, so each egg would vary genetically (crossing over and independent assortment), so the drones are genetically different.

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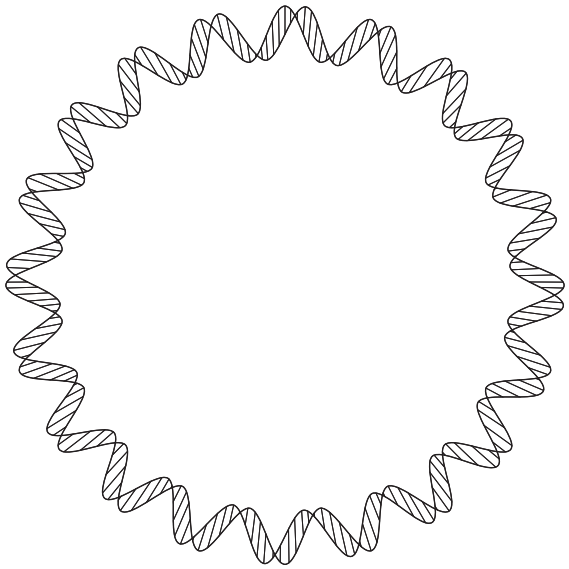
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5. The human papillomavirus (HPV) infects epithelial cells. The virus DNA molecule is 8 kb (kilobases) in length. The genome includes approximately 8 major genes.

Image 5.1 shows the genetic material of the human papillomavirus.

Image 5.1



(a) (i) State **three** differences between the DNA of the human papillomavirus and the nuclear DNA of the host cell. [3]

Human papillomavirus DNA	Host cell nuclear DNA
Circular DNA	Linear DNA (chromosomes)
Smaller: only 8 kb (8000 bases)	Much larger: about 6 billion bases
Only about 8 genes	Many more genes (about 20 000)

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(ii) With reference to the structure of viruses, suggest a role for the viral genes. [1]

The viral genes code for viral proteins, e.g. the capsid proteins and enzymes needed to make new viruses.

Once inside the host cell, the virus capsid breaks down and the viral DNA enters the host cell nucleus. Inside the nucleus, the viral DNA is replicated, using the DNA apparatus of the host cell.

(b) (i) Suggest how the viral DNA enters the nucleus. [1]

Through the nuclear pores in the nuclear envelope.

(ii) Using your knowledge of DNA replication, describe the process by which the viral DNA is replicated. [4]

DNA helicase unzips the DNA double helix, breaking the hydrogen bonds between complementary base pairs.

Free DNA nucleotides pair up with the exposed bases by complementary base pairing; both strands act as templates.

DNA polymerase joins the nucleotides, catalysing the formation of covalent bonds to form the sugar-phosphate backbone of the new strand, moving in the 5' to 3' direction.

This is semi-conservative replication: each new DNA molecule is made of one original and one new strand.

(iii) Explain why the viral DNA cannot be replicated outside the nucleus of the host cell. [1]

The replication enzymes (DNA helicase and DNA polymerase) and free DNA nucleotides are only found in the nucleus.

(iv) The viral genome contains eight genes and therefore codes for a minimum of eight polypeptides.
State the name of the hypothesis represented by this statement. [1]

One gene one polypeptide hypothesis

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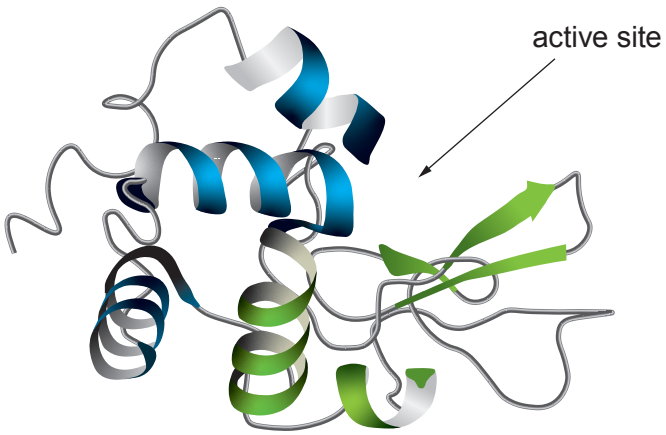
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6. Lysozyme is an enzyme which catalyses the breakdown of glycosidic bonds in polysaccharides in bacterial cell walls. It works using the induced fit model of enzyme action. **Image 6.1** shows a computer-generated model of lysozyme.

Image 6.1



Describe the three levels of protein structure present in the lysozyme molecule shown in **Image 6.1**.
Explain how the three levels of protein structure are maintained.
Describe and explain the induced fit model of enzyme action as shown by lysozyme. [9 QER]

Lysozyme is a globular protein with three levels of structure. The primary structure is the specific sequence (order) of amino acids in the polypeptide chain. It is maintained by peptide bonds, which are covalent bonds formed between the amino group of one amino acid and the carboxyl group of the next by condensation reactions.

The secondary structure is the folding of the primary structure (polypeptide chain) into alpha-helices and beta-pleated sheets, both of which can be seen in Image 6.1. It is maintained by hydrogen bonds between the polar groups (the –NH and –C=O groups, and –OH / polar R groups) along the chain.

The tertiary structure is the further folding of the secondary structure into a specific 3D shape, forming a globular protein with a specifically shaped active site. It is maintained by hydrogen bonds between –OH / polar R groups, ionic bonds between oppositely charged R groups, disulphide bonds between sulphur-containing R groups (cysteine), and hydrophobic interactions: the

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hydrophobic R groups are in the centre of the molecule, away from water, while the hydrophilic R groups are on the outside, making lysozyme soluble.

Lysozyme works by the induced fit model. Its active site is complementary to only one substrate, the polysaccharide in the bacterial cell wall. The substrate binds to the enzyme's active site, and the active site changes shape slightly to fit more closely around the substrate, forming an enzyme-substrate complex. This puts strain on the glycosidic bonds in the substrate, so less energy is needed to break them: the activation energy is lowered and the glycosidic bonds are hydrolysed.

The products are not complementary to the active site, so they leave (are released), and the active site returns to its original shape, ready to bind another substrate molecule. The bacterial cell wall is weakened, so the bacterium bursts (lysis).

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