2.2 Water has a high specific heat capacity *[1 mark]*, which means it doesn't heat up as quickly as the air *[1 mark]*.

2.3 There is strong cohesion between water molecules *[1 mark]*. This allows water to travel in a column up the xylem/tube-like transport cells in a tree trunk *[1 mark]*.

3.1 phosphodiester bond *[1 mark]*

3.2 condensation reaction *[1 mark]*

3.3 The molecule contains uracil/U bases (in place of thymine/T bases) *[1 mark]*.

3.4 Complementary/specific base pairing *[1 mark]* means that hydrogen bonds will form between the base pairs A and U, and C and G *[1 mark]*. Because the two halves of the RNA sequence are complementary, it causes the RNA strand to fold into a stem-loop structure *[1 mark]*.

4.1 DNA helicase separates the nucleotide strands / causes the DNA helix to unwind *[1 mark]* by breaking the hydrogen bonds between bases *[1 mark]*. DNA polymerase joins the nucleotides in the new DNA strand together *[1 mark]* by catalysing condensation reactions between the nucleotides *[1 mark]*.

4.2 It is known as a nucleotide derivative because it has a similar structure to a(n) (adenine) nucleotide *[1 mark]* but it has been modified with the addition of two more phosphate groups *[1 mark]*.

4.3 It catalyses the breakdown of ATP *[1 mark]* into ADP and inorganic phosphate *[1 mark]*.

4.4 The results show that DNA replication will not occur in the absence of ATP or when ATP hydrolase is inactive *[1 mark]*. This indicates that the breakdown of ATP (by ATP hydrolase) is essential for DNA replication *[1 mark]*. A possible explanation is that DNA replication requires energy and/or inorganic phosphate released by the breakdown of ATP *[1 mark]*.

Topic Two — Cells

Pages 16-18: Cell Structure and Division — 1

1.1 The student could have placed the root tip on a microscope slide and cut 2 mm/a small section from the very tip of it *[1 mark]*. Then used a mounted needle to break the tip open and spread the cells out thinly *[1 mark]*. Then added a few drops of stain, e.g. ethano-orcein or toluidine blue O, and left it for a few minutes *[1 mark]*. Then placed a cover slip over the cells and pushed down firmly *[1 mark]*.

1.2 Any two from: e.g. worn goggles/gloves / taken care with glass beakers/slides/cover slips / taken care with sharp tools. *[1 mark for each correct answer]*

1.3 Root tips are actively growing so the cells here will be undergoing mitosis/dividing *[1 mark]*.

1.4 E.g. if a cell contains visible chromosomes this indicates that it is dividing *[1 mark]*.

1.5 mitotic index = $\frac{\text{number of cells with visible chromosomes}}{\text{total number of cells observed}}$

80 + 240 = 320 cells in total

240 ÷ 320 = **0.75**

[2 marks for the correct answer, otherwise 1 mark for the correct working]

2.1 E.g. because electron microscopes have a higher resolution *[1 mark]* so they can be used to look at smaller objects (like bacteria) in more detail *[1 mark]*.

2.2 A transmission electron microscope/TEM *[1 mark]*. E.g. transmission electron micrographs show a 2D cross section through a sample as seen in Figure 1 *[1 mark]*.

2.3 Any two from: e.g. a prokaryotic cell is smaller than a eukaryotic cell. / There is no nucleus present in a prokaryotic cell. / A prokaryotic cell contains no membrane-bound organelles. / Ribosomes are smaller in a prokaryotic cell than in a eukaryotic cell. / The DNA in a prokaryotic cell is circular, not linear. / A prokaryotic cell may contain plasmids. *[2 marks]*

2.4 Human cells have no cell wall, so the drugs will have no effect on them *[1 mark]*.

2.5 WNV has an attachment protein on its surface *[1 mark]* which binds to the complementary $\alpha_v\beta_3$ integrin present on human cells *[1 mark]*. If $\alpha_v\beta_3$ integrin isn't functioning on human cells, WNV wouldn't be able to invade and reproduce inside these cells *[1 mark]*.

3.1 Similarities: any one from: e.g. a sperm cell and a bacterial cell can both have a flagellum *[1 mark]*. / A sperm cell and a bacterial cell both have a cell membrane *[1 mark]*.

Differences: any one from: e.g. a sperm cell has a nucleus but a bacterial cell has circular DNA floating freely in the cytoplasm *[1 mark]*. / A bacterial cell has a cell wall but a sperm cell only has a cell membrane *[1 mark]*.

[Maximum 2 marks available]

3.2 The flagellum requires ATP to move, which is generated by mitochondria *[1 mark]*.

3.3 E.g. a transmission/scanning electron microscope *[1 mark]* because these have a higher resolution than light microscopes, which would be needed to study the internal detail of mitochondria *[1 mark]*.

3.4 As the function of sperm is to deliver the genetic material to the egg, it isn't necessary for it to make lots of proteins for cell growth and repair / having lots of organelles may reduce its motility *[1 mark]*. A mitotic body cell is undergoing mitosis/division *[1 mark]*, so it requires ribosomes for cell growth prior to division *[1 mark]*.

Pages 19-21: Cell Structure and Division — 2

1.1 A cell that carries out a particular function *[1 mark]*.

1.2 E.g. each cell would only contain one nucleus. / Each nucleus would contain the same amount of genetic material. *[1 mark]*

1.3 The role of cell type A is to ingest invading pathogens because a greater percentage of the cell contains lysosomes than cell type B *[1 mark]*. Lysosomes are necessary to digest pathogens once they have been ingested by the cell *[1 mark]*. The role of cell type B is to secrete enzymes because a greater percentage of the cell contains rough endoplasmic reticulum than cell type A *[1 mark]*. This organelle is covered with ribosomes which synthesise proteins, such as enzymes / is responsible for folding and processing proteins, such as enzymes *[1 mark]*.

1.4 E.g. chloroplasts contain thylakoid membranes/grana, whereas mitochondria contain a folded membrane that form structures called cristae *[1 mark]* / Chloroplasts are the site of photosynthesis, whereas mitochondria are the site of aerobic respiration *[1 mark]*.

2.1 Any five from: clip the slide onto the stage *[1 mark]*. Select the lowest-powered objective lens *[1 mark]*. Use the coarse adjustment knob to bring the stage up to just below the objective lens *[1 mark]*. Look down the eyepiece and use the coarse adjustment knob to move the stage down until the image is roughly in focus *[1 mark]*. Adjust the focus with the fine adjustment knob until you get a clear image of what's on the slide *[1 mark]*. If a greater magnification is required, refocus using a higher-powered objective lens *[1 mark]*.
[Maximum of 5 marks available]

2.2 One division of the stage micrometer is the same as four eyepiece divisions.
0.1 mm ÷ 4 = 0.025 mm
0.025 mm × 1000 = **25 μm**
[2 marks for the correct answer, otherwise 1 mark for the correct working]

2.3 The stage micrometer will appear larger, so each eyepiece division will be a smaller measurement *[1 mark]*.

2.4 E.g. length of cell = 36 mm
36 mm × 1000 = 36 000 μm
object size = image size ÷ magnification
= 36 000 μm ÷ 100
= **360 μm**
[accept values between 350 μm and 370 μm, 2 marks for the correct answer, otherwise 1 mark for the correct working]

3.1 The production of ATP *[1 mark]*.

3.2 Abnormal mitochondria might not produce as much ATP as normal mitochondria *[1 mark]*. This means the heart tissue may not have sufficient energy to work properly/for muscle contraction *[1 mark]*.

3.3 inner membrane *[1 mark]*

3.4 E.g. abnormal mice have smaller mitochondria/fewer cristae *[1 mark]*. This will reduce the surface area of the mitochondria and reduces ATP production *[1 mark]*. Abnormal mice have mitochondria with a less dense matrix *[1 mark]*. The matrix contains the enzymes needed for aerobic respiration, so this will also impair ATP production *[1 mark]*.

3.5 Object size = 1.5 μm ÷ 1000
= 0.0015 mm
magnification = image size ÷ object size
= 29 mm ÷ 0.0015 mm
= × **19 333**
[accept values between × 18 667 and × 20 000, 2 marks for the correct answer, otherwise 1 mark for using the correct rearrangement of the magnification formula]

Pages 22-25: Cell Structure and Division — 3

1.1 E.g. they could add a buffer solution to the sample *[1 mark]* and grind the cells in a blender *[1 mark]*. They could then filter the solution to remove the cell and tissue debris *[1 mark]*.

1.2 At lower temperatures the activity of enzymes that break down organelles is reduced *[1 mark]*.

1.3

Contents of pellet	Sequence of Separation
Mitochondria and chloroplasts	2
Nuclei	1
Ribosomes	4
Endoplasmic reticulum	3

[1 mark]

1.4 It contains chloroplasts, which are responsible for photosynthesis, so would not be needed by root cells *[1 mark]*.

1.5 Ribosomes are made in the nucleolus *[1 mark]*. The nucleolus is found within the nucleus *[1 mark]*. If there was reduced function of the nuclear pore complexes, then fewer ribosomes could pass through the nuclear pore into the cytoplasm *[1 mark]*.

2.1 Both replicate inside a host cell *[1 mark]*. Both can cause a cell to burst (lysis) and release infective bodies *[1 mark]*. Viruses replicate by injecting their DNA or RNA into a host cell, whereas bacteria, such as *C. trachomatis*, replicate by binary fission/cell division *[1 mark]*.

2.2 E.g. the inhibition of ribosomes by azithromycin means that bacteria can't synthesise proteins *[1 mark]*. Protein synthesis is needed for mitosis/cell division, so the drug prevents bacteria multiplying *[1 mark]*.

2.3 Viruses don't have ribosomes *[1 mark]*.

2.4 During replication, plasmids can be replicated many times and can be shared unequally between the daughter cells *[1 mark]*. This means that the daughter cells can have a different number of plasmids, and therefore relative DNA content, to the parent cell and to each other *[1 mark]*.

3.1 Metaphase *[1 mark]*. The chromosomes are lined up along the middle of the cell *[1 mark]*.

3.2 A peak in the concentration of cyclin E occurs when the mass of DNA starts to increase *[1 mark]*. This suggests that cyclin E may trigger DNA replication in the cell / entry into the S stage of interphase *[1 mark]*. The peak in the concentration of cyclin B is followed by a decrease/ halving in the mass of DNA *[1 mark]*. This suggests that cyclin B may trigger the cell to enter the mitosis stage *[1 mark]*.

4.1 DNA synthesis is needed to double the genetic content of the cell before it divides *[1 mark]*.

4.2 Because chemotherapy aims to reduce/control the rate of cell division in dividing cells *[1 mark]* and other non-cancerous body cells don't divide as often as hair follicle cells *[1 mark]*.

4.3 $\text{mitotic index} = \frac{\text{number of cells dividing}}{\text{total number of cells observed}}$
number of cells dividing = 0.9 × 200
= **180 cells**
[2 marks for the correct answer, otherwise 1 mark for using the correct formula]

The chromosomes would not line up in the middle of the cell and attach to the spindle fibres ***[1 mark]***. This could mean that there isn't separation of the sister chromatids, and could result in there being an incorrect amount of genetic material in each daughter cell/mitosis would not progress to anaphase ***[1 mark]***. This disruption of the cell cycle would kill the cancerous cells ***[1 mark]***.

ges 26-28: Cell Membranes — 1

Proteins are scattered amongst the phospholipids, like tiles in a mosaic ***[1 mark]***. The phospholipids are constantly moving, so the structure is fluid ***[1 mark]***.

The cholesterol molecules would restrict the movement of the phospholipids ***[1 mark]***, making the structure less fluid and more rigid ***[1 mark]***.

E.g. the cell-surface membranes are likely to have a high proportion of carrier or channel proteins ***[1 mark]*** in order to carry nutrients via facilitated diffusion or active transport ***[1 mark]***. The cell-surface membrane is likely to have a large surface area/microvilli ***[1 mark]*** to maximise the rate of absorption of nutrients ***[1 mark]***.

E.g. a large number of carrier or channel proteins ***[1 mark]*** in order to allow cations to cross the cell membrane quickly ***[1 mark]***.

B ***[1 mark]***

Phospholipids have a hydrophobic tail and a hydrophilic head ***[1 mark]***. The hydrophilic heads are attracted to the water molecules in the cytoplasm or cell surroundings ***[1 mark]***, and the hydrophobic tails are repelled from them, so a bilayer is formed ***[1 mark]***.

The water will move from the exterior to the interior of the cell ***[1 mark]*** because the water potential of the exterior is higher/less negative than the water potential of the interior ***[1 mark]***.

Any five from: e.g. sodium ions are actively transported out of the ileum epithelial cells into the blood ***[1 mark]*** by the sodium-potassium pump ***[1 mark]***. This creates a concentration gradient of sodium ions between the lumen of the ileum and the interior of the epithelial cells ***[1 mark]***. Sodium ions diffuse down this concentration gradient into the epithelial cells ***[1 mark]*** via sodium-glucose co-transporter proteins ***[1 mark]***. The co-transporter proteins transport glucose into the cells along with the sodium ions ***[1 mark]***.

To make sure any betalains/pigments released by the cutting of the beetroot were washed away ***[1 mark]***.

Colorimetry analysis of distilled water ***[1 mark]***.

Any four from: e.g. increasing the temperature from 20 °C to 40 °C increases the fluidity of the phospholipids in the beetroot cell membranes ***[1 mark]***. At temperatures above 40 °C, the membrane starts to break down / proteins in the membrane start to denature ***[1 mark]***. The membrane surrounding the vacuole therefore becomes more permeable with increasing temperature ***[1 mark]***, meaning that betalains/pigments leak out into the distilled water ***[1 mark]***. The more pigments released, the higher the absorbance reading ***[1 mark]***.

4.4 Cell membranes contain channel proteins and carrier proteins ***[1 mark]***. Proteins are denatured by extremes of pH / extremes of pH interfere with the bonding in proteins, causing them to change shape ***[1 mark]***. If the proteins are not able to function and control what goes in or out of the cell, membrane permeability will increase ***[1 mark]***.

Pages 29-30: Cell Membranes — 2

1.1

Concentration of sucrose solution to be made up / mol dm^{-3}	Volume of 1 mol dm^{-3} sucrose solution used / cm^3	Volume of water used / cm^3	Final volume of solution to be made up / cm^3
1	20	0	20
0.75	15	**5**	20
0.5	**10**	**10**	20
0.25	**5**	**15**	20
0	**0**	**20**	20

[2 marks for all 5 rows correct, otherwise 1 mark for 4 rows correct]

1.2 Any two from: e.g. the temperature the potato samples were incubated at / the length of time the potato samples were incubated for / the volume of sucrose solution used / the variety of potato used / the age of potato used. ***[2 marks]***

1.3 The line of best fit crosses the *x*-axis of Figure 1 halfway between 0.25 and 0.50, so the sucrose concentration of potato cells = approximately 0.375 mol dm^{-3}.
A 0.3 mol dm^{-3} sucrose solution has a water potential of −850 kPa. A 0.4 mol dm^{-3} sucrose solution has a water potential of −1130 kPa.
So a 0.375 mol dm^{-3} sucrose solution has a water potential of approximately:
$(-1130) - (-850) = 280 \times 0.75 = 210$
$-850 - 210 =$ **−1060 kPa**
[2 marks for an answer > −850 and < −1130 kPa, otherwise 1 mark for estimating the sucrose concentration of the potato cells to be between 0.3 and 0.4 mol dm^{-3}]

1.4 The sweet potato tissue is likely to have a lower water potential than that of the white potato ***[1 mark]*** because it is likely to have a higher sucrose concentration ***[1 mark]***.

The extra sucrose (with some other sugars too) is what makes the sweet potato sweet.

2.1 ATP is made inside the cell, rather than outside it, so the ATP binding site has to face inwards ***[1 mark]***.

2.2 To catalyse the hydrolysis of ATP (into ADP and P_i) ***[1 mark]*** in order to release energy for the active transport of the calcium ions ***[1 mark]***.

2.3 Ca^{2+} ions carry a charge, making them water soluble/hydrophilic ***[1 mark]***. This makes it difficult for them to travel directly through the hydrophobic centre of the phospholipid bilayer ***[1 mark]***.