MA99 EDUCATION

Cells as the basis of life: Summary 01

NSW BIOLOGY 11-12 SYLLABUS 2025 FOR HSC 2028 AND LATER

1. Key ideas

- **Two kinds of cell.** Prokaryotic cells have no nucleus and no membrane-bound organelles; their DNA is in a nucleoid. Eukaryotic cells keep DNA in a nucleus and have membrane-bound organelles. Size never decides the type: Thiomargarita magnifica is a bacterium about 1 cm long.
- **Nine prokaryotic structures:** capsule, cell wall, cell membrane, cytoplasm, nucleoid, plasmid, ribosomes, flagella, pili. **Eleven eukaryotic ones:** cell wall, cell membrane, cytoplasm, nucleus, mitochondria, chloroplast, ER, Golgi body, ribosomes, lysosomes, vacuoles.
- **Plant and animal cells differ because of what the organism does.** Wall, chloroplasts and a large vacuole in plants. Specialised cells show it best: a palisade cell full of chloroplasts, a muscle cell full of mitochondria.
- **Resolution, not magnification, limits what you see.** Light microscope about 200 nm; electron microscope about 0.1 nm. The electron microscope revealed ribosomes, ER and cristae.
- **The membrane is a fluid mosaic** (Singer and Nicolson, 1972): phospholipid bilayer, integral and peripheral proteins, protein channels, cholesterol, glycoproteins.
- **Passive transport goes down the gradient with no ATP:** simple diffusion, facilitated diffusion, osmosis. **Active transport goes against it using ATP**, and endocytosis and exocytosis also use ATP.
- **Size, charge and gradient decide the route.** O_2 and CO_2 diffuse through the bilayer; glucose needs a carrier; ions need channels or pumps; water uses osmosis and aquaporins; big molecules use vesicles.
- **Enzymes are specific biological catalysts.** They lower activation energy and are reused. Lock and key (Fischer, 1894); induced fit (Koshland, 1958).
- **Temperature and pH change the active site's shape;** past the optimum the enzyme is denatured. **Substrate concentration** raises the rate until every active site is busy.
- **DNA is a double helix of nucleotides:** A with T (2 hydrogen bonds), G with C (3), strands antiparallel. Replication is semi-conservative and new DNA grows 5′ to 3′, so the lagging strand is made in Okazaki fragments.
- **The cell cycle:** G1 growth, S DNA replication, G2 growth and checking, M mitosis then cytokinesis.
- **Mitosis keeps; meiosis halves and shuffles.** Crossing over, independent assortment and random segregation make every gamete different.

> If you remember one sentence, make it this: every route across a membrane is decided by the particle and the gradient.

2. Equations and formulas

WHAT	EQUATION	NOTE
Cellular respiration	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ + energy	Cytoplasm then mitochondria; about 30 to 32 ATP aerobic, 2 anaerobic
Photosynthesis	$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$	Write "light, chlorophyll" above the arrow; chloroplasts
Cell size (NESA)	diameter of field of view ÷ number of cells across the field of view	Use the field of view for the power you counted at
Field of view at higher power	$FOV_{low} \times magnification_{low} \div magnification_{high}$	4,500 µm at 40× becomes 450 µm at 400×
Total magnification	eyepiece × objective	10× and 40× give 400×

WHAT	EQUATION	NOTE
Actual size	image size ÷ magnification	1 mm = 1,000 µm
Percentage change in mass	(final − initial) ÷ initial × 100	Compares cylinders that started at different masses
Rate of reaction	amount of product ÷ time	15.3 mL in 60 s = 0.26 mL/s
Mitotic index	cells in mitosis ÷ total cells × 100	Share of cells in a phase = share of time in it
Independent assortment	2^n combinations for n pairs	Humans: 2^{23} = 8,388,608
Percentage error (NESA)	absolute error ÷ recorded value × 100	0.25 ÷ 4.5 × 100 = 5.6 per cent

3. Structures in one table

STRUCTURE	FUNCTION	FOUND IN
Capsule	Protection from drying and from being engulfed; sticking	Some prokaryotes
Cell wall	Shape; stops bursting (peptidoglycan, cellulose or chitin)	Prokaryotes, plants, fungi
Cell membrane	Selectively permeable boundary; recognition	All cells
Nucleoid	Region holding the circular chromosome	Prokaryotes
Plasmid	Extra genes, such as antibiotic resistance; transferable	Prokaryotes
Flagella; pili	Movement; attachment and plasmid transfer	Prokaryotes
Ribosomes	Protein synthesis (70S prokaryotic, 80S eukaryotic)	All cells
Nucleus	Holds DNA and controls the cell; nucleolus makes ribosome parts	Eukaryotes
Mitochondria	Aerobic respiration, ATP	Eukaryotes
Chloroplast	Photosynthesis	Plants and algae
Rough and smooth ER	Make and transport proteins; make lipids	Eukaryotes
Golgi body	Modify, sort and package into vesicles	Eukaryotes
Lysosomes	Digest worn parts and engulfed material	Mainly animal cells
Vacuoles	Storage; turgor in plants	Large and central in plants

4. Membranes and transport

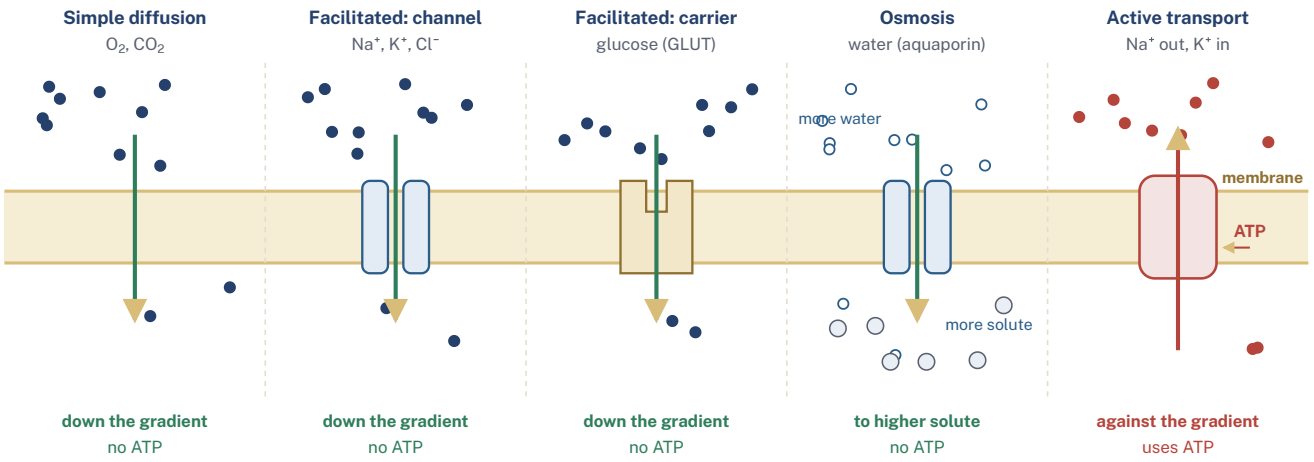


Figure 1 · The routes across a membrane. Source: MA99 Education.

SOLUTION COMPARED WITH THE CELL	ANIMAL CELL	PLANT CELL
Hypotonic	Swells, may burst (lysis)	Turgid; the wall stops bursting
Isotonic	No net change	Flaccid
Hypertonic	Shrinks and crenates	Plasmolysed

Normal saline, 0.90 per cent sodium chloride, is approximately isotonic to blood (osmolarity 308 mOsm/L; Health Canada product monograph).

5. How to answer the question

Wet mount. Thin specimen, drop of water, coverslip lowered at 45°, stain drawn under (iodine for onion, methylene blue for cheek cells), lowest power first. Identify cytoplasm, cell wall and nucleus.

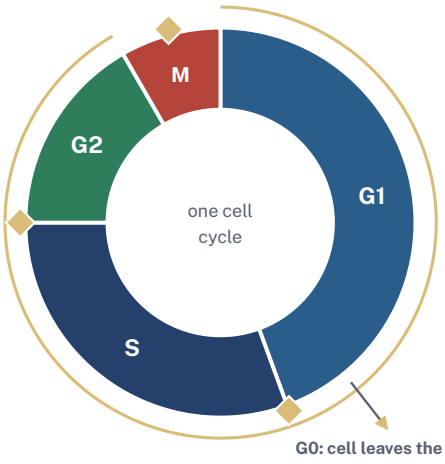
Cell size with a mini-grid. Count 1 mm squares across the field at 40×. Scale the field to the power you use. Count cells across. Divide. Repeat and give a mean.

Osmosis. Equal potato cylinders, three per sucrose concentration, 24 hours. Plot percentage change in mass against concentration. The isotonic point is where the line crosses zero: interpolate.

Enzyme experiment. One independent variable (temperature, pH or substrate concentration); measure product per unit time; control everything else; boiled enzyme as the experimental control; three trials; check for outliers; risk assessment for hydrogen peroxide and hot water.

Modelling replication, mitosis and meiosis. Colour code the parent strands or chromosomes, mark 5′ and 3′ ends, act out each enzyme or phase in NESA's order, and check the count: one old and one new strand; 2n to 2n; 2n to n.

6. Cell division at a glance



INTERPHASE: G1 + S + G2

G1, gap 1
Cell grows, makes proteins and organelles, does its normal job. Most variable in length.

S, synthesis
DNA is replicated: each chromosome becomes two identical sister chromatids.

G2, gap 2
More growth; organelles and proteins for division are made; the copied DNA is checked.

M, mitosis
The nucleus divides (prophase, metaphase, anaphase, telophase), then cytokinesis.

Checkpoints: the cycle pauses if DNA is damaged or incomplete

Arcs are not to scale. Cycle length varies widely between cell types, mostly because G1 differs.

Figure 2 · The cell cycle. Source: MA99 Education, after Alberts et al., Molecular Biology of the Cell, 2002.

ENZYME	JOB AT THE REPLICATION FORK
Helicase	Unwinds the helix; breaks hydrogen bonds
Primase	Lays a short RNA primer
DNA polymerases	Add nucleotides 5′ to 3′ (pol III in E. coli); replace primers with DNA (pol I)
Ligase	Joins Okazaki fragments

	MITOSIS	MEIOSIS
Divisions; cells made	One; two	Two; four
Chromosome number	2n to 2n	2n to n
Variation	None: identical cells	Crossing over (prophase I), independent assortment (metaphase I), random segregation (anaphase I)
Role	Growth and repair (somatic cells)	Gametes

Real examples to quote. Shark Bay stromatolites, built mainly by cyanobacteria. Zanamivir (Relenza), designed at the Victorian College of Pharmacy using CSIRO scientists' structure of influenza neuraminidase, to fit that enzyme's active site. Elizabeth Blackburn, born in Hobart, Nobel Prize 2009 for telomeres. A species in the jack jumper ant complex (Myrmecia pilosula): one pair of chromosomes. Tasmanian devil facial tumour disease: a transmissible cancer, first photographed in 1996.

7. Common errors

COMMON ERROR	CORRECT STATEMENT
"Prokaryotes have no organelles"	No membrane-bound organelles; they have ribosomes
"Osmosis: high to low concentration"	From lower to higher solute concentration
"Mitochondria make energy"	They release energy from glucose and transfer it to ATP

COMMON ERROR	CORRECT STATEMENT
“Enzymes are killed by heat”	Denatured: the active site changes shape
“Photosynthesis produces water” (NESA’s glossary wording)	Use the content point’s equation: glucose and oxygen only
“The lagging strand is copied 3′ to 5′”	All new DNA grows 5′ to 3′, hence the fragments
“Sister chromatids separate in meiosis I”	Homologues separate in meiosis I; chromatids in meiosis II

8. Checklist

- ☐ Compare a prokaryotic and a eukaryotic cell in four features.
- ☐ Calculate a cell size from a field of view of 1,800 µm and 6 cells across. (300 µm)
- ☐ Draw the fluid mosaic model with six labels.
- ☐ Predict and explain what happens to an onion cell in 1.0 mol/L sucrose.
- ☐ Explain how glucose and oxygen cross a membrane, and why they differ.
- ☐ Write both summary equations.
- ☐ Explain the shape of an enzyme’s temperature graph on both sides of the optimum.
- ☐ Write the complement of 5′ ATGCCGTT 3′ and count its hydrogen bonds. (3′ TACGGCAA 5′; 20)
- ☐ Draw a replication fork with all four enzymes.
- ☐ Describe the three sources of variation in meiosis and when each happens.

About this resource

MA99 EDUCATION

Scope

NSW Biology, Year 11. Written to the NSW Biology 11-12 Syllabus 2025, Cells as the basis of life, for students sitting the HSC in 2028 and later years. Written to the new syllabus, taught in Year 11 from 2027. Real organisms, studies and data are named with their source; any data not from a named source is labelled hypothetical.

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MA99 EDUCATION

Cells as the basis of life: Practice Questions

01

NSW BIOLOGY 11-12 SYLLABUS 2025

FOR HSC 2028 AND LATER

1. Instructions

How to use this booklet. 70 marks in about 125 minutes, the HSC rate of about 1.8 minutes a mark. Work Section I in 25 minutes and Section II in about 100, with no notes, then mark yourself against the guidance at the back. Real organisms, experiments and published values are named with their source; class results are labelled hypothetical, because they are practice data, not evidence to quote.



Figure 1 · How the 70 marks are split. Your time should follow the same split. Source: MA99, 2026.

2. Section I · Multiple choice

15 marks. Attempt all questions. Circle the letter, (A) to (D), that best answers each question.

Question 1

1 MARK

Which structure is found in both prokaryotic and eukaryotic cells?

A Nucleus
B Ribosome
C Mitochondrion
D Golgi body

Question 2

1 MARK

A sex pilus allows a bacterium to

A swim toward a source of food.
B make proteins for export.
C pass a plasmid to another bacterium.
D resist bursting when water enters.

Question 3

1 MARK

A student's wet mount shows box-shaped cells, each with a cell wall, a large central vacuole and a nucleus, but no chloroplasts. The specimen is most likely

A onion bulb epidermis.
B human cheek cells.
C an Elodea leaf.
D a culture of Escherichia coli.

Question 4

1 MARK

With a mini-grid, a student measures the field of view at 40× as 4.5 mm. The field of view at 100× is

A 11.25 mm.
B 1.8 mm.
C 0.45 mm.
D 180 µm.

Question 5

1 MARK

At 400× the field of view is 450 µm. Fifteen cells fit across it. Each cell is about

A 30 µm.
B 6,750 µm.
C 3.0 µm.
D 0.033 µm.

Question 6

1 MARK

Which part of the fluid mosaic model steadies the fluidity of an animal cell membrane as temperature changes?

A Glycoprotein
B Peripheral protein
C Protein channel
D Cholesterol

Question 7

1 MARK

Human red blood cells are placed in distilled water. They will

A crenate, because water leaves by osmosis.
B swell and may burst, because water enters by osmosis.
C stay the same, because distilled water is isotonic.
D plasmolyse, because the membrane pulls away from the wall.

Question 8

1 MARK

In a eukaryotic cell, the aerobic breakdown of glucose is completed in the

A chloroplast.
B ribosome.
C mitochondrion.
D nucleus.

Question 9

1 MARK

Which process moves particles against their concentration gradient using energy from ATP?

A Facilitated diffusion through GLUT carriers
B Osmosis through aquaporins
C The sodium-potassium pump
D Simple diffusion of oxygen

Question 10

1 MARK

Which statement describes the induced fit model of enzyme action?

A The active site changes shape as the substrate binds.
B The active site is rigid and exactly complementary to the substrate.
C The substrate changes the enzyme permanently.
D The enzyme is used up as the product forms.

Question 11

1 MARK

Pepsin is most active near pH 2 and has very little activity at pH 7. Its activity at pH 7 is very low because

A the substrate is denatured at pH 7.
B the shape of its active site is altered.
C the enzyme has been used up.
D the temperature is too low at pH 7.

Question 12

1 MARK

Students measure the oxygen released by potato catalase at six temperatures. Which is the experimental control?

A Boiled extract mixed with hydrogen peroxide at each temperature
B Three trials at each temperature
C The same volume of hydrogen peroxide in every tube
D The water bath set to 40 °C

Question 13

1 MARK

In a sample of double stranded DNA, 18 per cent of the bases are cytosine. The percentage of adenine is

A 18.
B 36.
C 32.
D 64.

Question 14

1 MARK

Which enzyme joins Okazaki fragments into a continuous strand?

A Helicase
B Primase
C DNA polymerase III
D Ligase

Question 15

1 MARK

Independent assortment of homologous chromosomes happens during

A prophase I.
B anaphase II.
C S phase.
D metaphase I.

3. Section II · Short answer

55 marks. Attempt all questions. Show your working in every calculation: the working earns marks as well as the answer.

Question 16

4 MARKS

Describe the structure and function of the plasmid and the capsule in a prokaryotic cell.

Question 17

4 MARKS

A student placed a mini-grid on the stage at 40× and counted 4.0 squares of 1 mm across the field of view. She then viewed a blood smear at 400× and counted 50 red blood cells across the field (hypothetical data).

(a) Calculate the diameter of the field of view at 400×, in micrometres. (1 mark)

(b) Calculate the size of one red blood cell. (1 mark)

(c) The mini-grid can be read to ± 0.25 mm. Calculate the percentage error in the field of view at 40×. (1 mark)

(d) A human red blood cell is approximately 8 µm across (Chen et al., Journal of Nanobiotechnology, 2023). Comment on the accuracy of the student's result. (1 mark)

Question 18

4 MARKS

(a) Draw a labelled diagram of the fluid mosaic model of the cell membrane, showing phospholipids, an integral protein, a peripheral protein and cholesterol. (3 marks)

(b) Explain the function of a glycoprotein in the membrane. (1 mark)

Question 19

7 MARKS

Students placed potato cylinders in sucrose solutions for 24 hours. The table shows the mean percentage change in mass of three cylinders at each concentration (hypothetical data).

SUCROSE (MOL/L)	0.0	0.2	0.4	0.6	0.8
Mean change in mass (%)	+12.0	+5.5	−1.5	−7.0	−11.0

(a) One cylinder in 0.0 mol/L sucrose went from 3.20 g to 3.58 g. Calculate its percentage change in mass. (1 mark)

(b) Plot the mean data on the grid and draw a line of best fit. (3 marks)

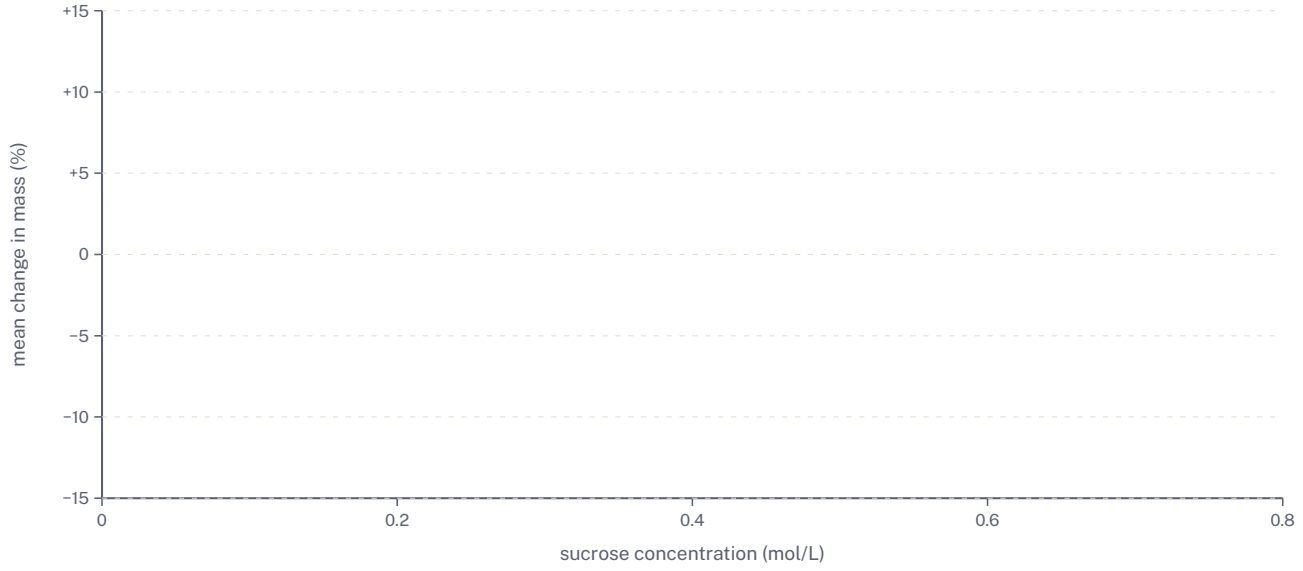


Figure 2 · Grid for Question 19(b).

(c) Use the data to estimate the sucrose concentration that is isotonic with the potato cells. (1 mark)

(d) Explain the change in mass of the cylinders in 0.8 mol/L sucrose. (2 marks)

Question 20

3 MARKS

Explain how glucose and carbon dioxide cross the membrane of a respiring liver cell. Refer to the characteristics of each substance and to concentration gradients.

Question 21

7 MARKS

Plan a laboratory experiment to demonstrate the effect of pH on the efficiency of salivary amylase. In your answer, identify the variables, describe how you would measure the efficiency of the enzyme, and outline how you would make the results valid and reliable.

Question 22

5 MARKS

Students measured the rate of oxygen release by a fixed amount of catalase at different concentrations of hydrogen peroxide (hypothetical data).

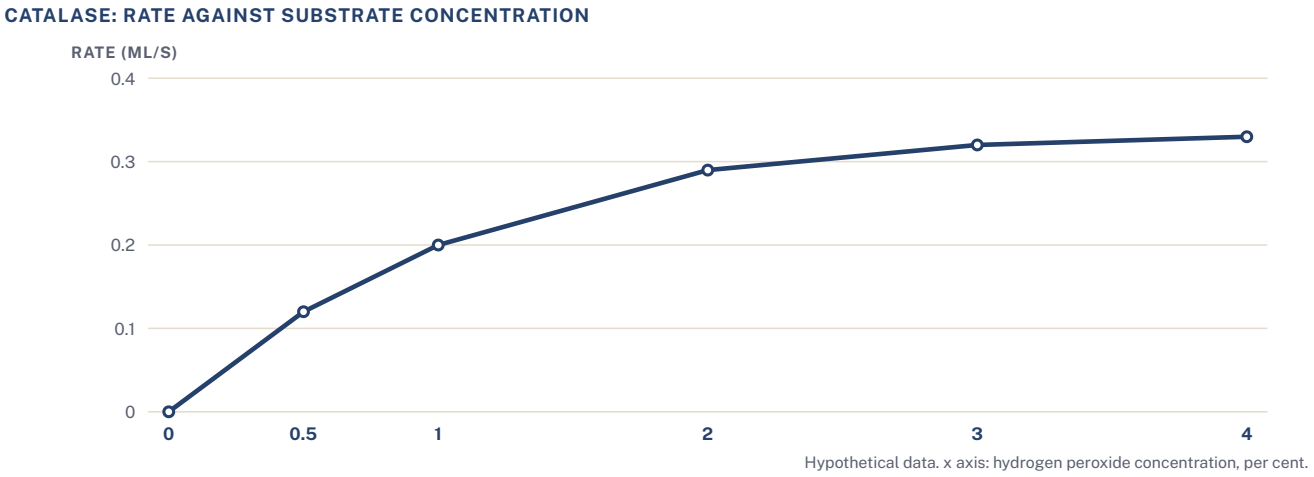


Figure 3 · Rate of oxygen release against hydrogen peroxide concentration (hypothetical class data).

(a) Describe the trend in the data. (2 marks)

(b) Explain why the rate changes little above 3 per cent hydrogen peroxide. (2 marks)

(c) Predict the effect on the rate at 4 per cent of doubling the amount of catalase. (1 mark)

Question 23

4 MARKS

One strand of a DNA fragment reads 5′ GCGATCGA 3′.

(a) Write the complementary strand, labelling its 5′ and 3′ ends. (1 mark)

(b) Calculate the number of hydrogen bonds holding the two strands together. Show your working. (2 marks)

(c) Explain why hydrogen bonds suit the role of holding the strands together. (1 mark)

Question 24

6 MARKS

Explain how a DNA molecule is replicated at a replication fork. In your answer, refer to helicase, primase, DNA polymerases and ligase, and to the leading and lagging strands.

Question 25

4 MARKS

A student counted onion root tip cells in each stage (hypothetical data).

STAGE	INTERPHASE	PROPHASE	METAPHASE	ANAPHASE	TELOPHASE
Number of cells	412	48	20	8	12

(a) Calculate the mitotic index. (1 mark)

(b) One cell cycle in these cells takes 18 hours. Estimate the length of anaphase in minutes. (2 marks)

(c) Explain why counting cells in several fields of view improves this estimate. (1 mark)

Question 26

7 MARKS

Assess how far advances in microscope technology have changed scientific understanding of cell structure and function.

4. Marking guidance

Mark your response before reading the model answers. The guidance gives what a full mark answer contains; the criteria for the longer items are MA99's own, written in the style of NESA marking guidelines.

4.1 Section I

Q	ANSWER	WHY THE OTHERS ARE WRONG
1	B	All cells make proteins on ribosomes. Nucleus, mitochondria and Golgi body are eukaryotic only.
2	C	A sex pilus joins two cells for plasmid transfer. A is a flagellum; B ribosomes; D the cell wall.
3	A	Wall and vacuole mean a plant cell; no chloroplasts means a non-green tissue. Cheek cells have no wall; Elodea has chloroplasts; E. coli has no nucleus.
4	B	4.5 × 40 ÷ 100 = 1.8 mm. A multiplies instead of dividing; C is the 400× field; D is a factor of 10 out.
5	A	450 ÷ 15 = 30 µm. B multiplies; C and D misplace the decimal or invert.
6	D	Cholesterol sits between the tails. Glycoproteins are for recognition.
7	B	Distilled water is hypotonic. A is a hypertonic result; D happens only to cells with walls.
8	C	Glycolysis starts in the cytoplasm; the rest is in mitochondria. A is photosynthesis.
9	C	3 Na^+ out and 2 K^+ in per ATP, against both gradients. The others are passive.
10	A	B is lock and key. Enzymes are not used up or permanently changed.
11	B	pH changes the active site's shape and charge. The enzyme is denatured, not the substrate.
12	A	The boiled extract shows the enzyme causes the reaction. B is reliability; C is a controlled variable; D is one value of the independent variable.
13	C	G = C = 18, so G + C = 36 and A + T = 64; A = 32. D is A + T.
14	D	Ligase seals gaps. Helicase unwinds; primase lays primers; pol III extends.
15	D	Pairs orient at random on the equator in metaphase I. Crossing over is prophase I.

Answer key spread: A 4, B 4, C 4, D 3.

4.2 Section II

Q	MARKS	WHAT A FULL MARK ANSWER CONTAINS
16	4	Plasmid: a small circle of DNA separate from the chromosome (1); carries extra genes, such as antibiotic resistance, and can be passed to other bacteria (1). Capsule: a sticky polysaccharide layer outside the wall, not in all bacteria (1); protects against drying out and being engulfed by white blood cells, and helps attachment (1).
17(a)	1	4.0 mm = 4,000 µm; 4,000 × 40 ÷ 400 = 400 µm.
17(b)	1	400 ÷ 50 = 8.0 µm.
17(c)	1	0.25 ÷ 4.0 × 100 = 6.25, about 6.3 per cent.
17(d)	1	8.0 µm matches the published value of approximately 8 µm, so the result is accurate; the 6.3 per cent error allows 7.5 to 8.5 µm.
18(a)	3	Bilayer with heads out and tails in, labelled (1). Integral protein spanning the bilayer and peripheral protein on one surface, both labelled (1). Cholesterol between the tails, labelled (1).
18(b)	1	Carbohydrate chains on the outer surface act as markers for cell recognition, for example by the immune system.
19(a)	1	(3.58 − 3.20) ÷ 3.20 × 100 = 11.9 per cent increase.

Q	MARKS	WHAT A FULL MARK ANSWER CONTAINS
19(b)	3	Axes as given, points plotted accurately (2: lose 1 for each wrong point, minimum 0); a straight or smooth line of best fit through the points, not dot to dot (1).
19(c)	1	About 0.36 mol/L: 0.2 + 0.2 × 5.5 ÷ 7.0 = 0.36. Accept 0.34 to 0.38 from the graph.
19(d)	2	The solution is hypertonic to the potato cells, so water left the cells by osmosis (1), from lower to higher solute concentration, so the cylinders lost 11 per cent of their mass and the cells became plasmolysed (1).
20	3	Carbon dioxide is small and non-polar, so it diffuses directly through the bilayer (1); respiration keeps its concentration higher inside, so it moves out down its gradient (1). Glucose is large and polar, so it needs a carrier protein (GLUT) and enters by facilitated diffusion down its gradient, without ATP (1).
21	7	See the criteria below. Independent variable pH (buffers, for example pH 4 to 9); dependent variable time for starch to disappear, tested with iodine on a spotting tile every 30 s, or rate as 1 ÷ time; controlled: amylase and starch volume and concentration, temperature (water bath, 37 °C), mixing; experimental control: boiled amylase, or starch with buffer and no amylase; three trials and a mean; risk assessment (iodine, glassware).
22(a)	2	The rate rises steeply from 0 to 1 per cent (to 0.20 mL/s) (1), then increases more slowly and levels off near 0.33 mL/s above 3 per cent (1).
22(b)	2	Every active site is occupied, so the enzyme is saturated (1); the amount of enzyme, not substrate, now limits the rate (1).
22(c)	1	The rate roughly doubles, to about 0.66 mL/s, because there are twice as many active sites.
23(a)	1	3′ CGCTAGCT 5′.
23(b)	2	5 G-C pairs × 3 = 15 and 3 A-T pairs × 2 = 6 (1); total 21 (1).
23(c)	1	Each is weak, so the strands separate easily for replication, but many together hold the molecule stable.
24	6	Helicase unwinds the helix and breaks hydrogen bonds, forming the fork (1). Primase lays an RNA primer (1). DNA polymerase adds complementary nucleotides only to the 3′ end, so strands grow 5′ to 3′ (1). Leading strand: made continuously toward the fork (1). Lagging strand: made away from the fork in Okazaki fragments, each with its own primer, which DNA polymerase I replaces with DNA (1). Ligase joins the fragments; each new molecule has one old and one new strand (1).
25(a)	1	(48 + 20 + 8 + 12) ÷ 500 × 100 = 88 ÷ 500 × 100 = 17.6 per cent.
25(b)	2	8 ÷ 500 = 0.016 of cells (1); 0.016 × 18 h × 60 = 17 minutes (1).
25(c)	1	A larger sample reduces the effect of chance clusters of cells in one stage, so the proportions, and the times, are more reliable.
26	7	See the criteria below. Light microscope (Hooke 1665, van Leeuwenhoek 1674, Brown names the nucleus 1831): cell theory. Electron microscope (Knoll and Ruska 1931; beat light resolution 1933; about 0.1 nm against 200 nm): ribosomes (Palade 1955), ER, cristae, the two layers of the membrane. Limits: dead, dried specimens, artefacts; fluidity shown by other evidence (Frye and Edidin 1970). Later developments: fluorescence and super-resolution (Nobel 2014), cryo-EM (Nobel 2017). A judgement about the size of the impact.

4.3 Criteria for the longer items

Question 21, 7 marks

MARKS	CRITERIA
6 to 7	Identifies the independent, dependent and at least three controlled variables. Describes a valid method of measuring enzyme efficiency, including an experimental control. Explains how reliability is achieved and includes a relevant risk.
4 to 5	Identifies the variables and describes a workable method with some features of a valid, reliable design.
2 to 3	Outlines a method or identifies some variables.
1	Provides some relevant information.

Question 26, 7 marks

MARKS	CRITERIA
6 to 7	Makes a clear judgement of the impact. Links at least two named developments to specific changes in understanding of structure and function, with dates or figures. Identifies limitations.
4 to 5	Makes a judgement with some support. Describes developments and what they revealed.
2 to 3	Describes one or more developments in microscopy.
1	Provides some relevant information.

4.4 Model answers for the longer items

Question 21. The independent variable is pH, set with buffers at pH 4, 5, 6, 7, 8 and 9. The dependent variable is the efficiency of amylase, measured as the time taken for starch to be fully digested. Put 2 mL of 1 per cent amylase and 2 mL of buffer in a tube, and 5 mL of 1 per cent starch in another, and stand both in a 37 °C water bath for 5 minutes. Mix them and start a timer. Every 30 seconds, transfer a drop to a spotting tile containing iodine; record the time when the iodine stays orange-brown, showing no starch is left. Calculate the rate as 1 ÷ time. Controlled variables are the volumes and concentrations of enzyme and starch, the temperature, and the sampling interval. The experimental control is boiled amylase at each pH: if starch remains, the digestion was caused by the enzyme. For reliability, repeat three times at each pH and calculate a mean, checking for outliers; for validity, change only pH. Iodine stains and irritates eyes, so wear safety glasses.

Question 26. Technological developments in microscopy had a very large impact, because each one revealed structures that changed how cell function was explained. Light microscopes showed that organisms are made of cells: Hooke named cells in 1665, van Leeuwenhoek saw living single cells in 1674, and Robert Brown named the nucleus in 1831, which led to cell theory. Light, however, cannot resolve detail finer than about 200 nm. The electron microscope, built by Knoll and Ruska from 1931, resolves about 0.1 nm. It revealed ribosomes (Palade, 1955), the endoplasmic reticulum, and the cristae of mitochondria, so functions could be linked to structures: the folded cristae give a large surface for respiration. It also showed the membrane as two layers. Its limitation was that specimens are dead, dried and stained, so images could contain artefacts and showed no movement; the fluid nature of the membrane came from Frye and Edidin's experiment of 1970. Newer methods have answered this: super-resolution fluorescence microscopy (Nobel Prize 2014) follows molecules in living cells, and cryo-electron microscopy (Nobel Prize 2017) shows membrane proteins near atomic detail without drying. Overall, microscopy has been the main driver of our understanding of cell structure, and, with these newer methods, increasingly of function.

Where to go next. Lost marks on Questions 1 to 9 and 16 to 20: Topic Notes sections 2 and 3. Questions 10 to 12, 21 and 22: sections 4.4 to 4.7. Questions 13 to 15 and 23 to 25: section 5. Question 26: section 2.7.

> Mark yourself before you read the Exemplar. The gap you find is the thing worth fixing.

Attempt record

Come back every few weeks and date it. Improvement in a science is easy to miss from the inside, which is why students who are getting better so often believe they are not.

DATE	MARK OUT OF 70	THE ONE THING TO FIX NEXT TIME

DATE	MARK OUT OF 70	THE ONE THING TO FIX NEXT TIME

Fill one row every time you sit a set. A tracker with three rows in it is worth more than a perfect one you never started, because the pattern you are looking for only shows up across attempts, not inside one.

About this resource

MA99 EDUCATION

Scope

NSW Biology, Year 11. Written to the NSW Biology 11-12 Syllabus 2025, Cells as the basis of life, for students sitting the HSC in 2028 and later years. Written to the new syllabus, taught in Year 11 from 2027. Real organisms, studies and data are named with their source; any data not from a named source is labelled hypothetical.

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