Helping you Achieve Highest Grades in IB

IB Biology HL First Assesment 2025

Mark Scheme

Short Answer Questions

Theme: A- Unity & Diversity

Sub Topic - Water, Nuclic Acid, Cell Structure

Marks: 179

Total Marks: / 179

Suitable for HL Students sitting exams 2025+ onwards.
However, SL Students will also find this useful

Markschemes

19M.2.HL.TZ1.4

a. a. plasma membrane in phloem/sieve tubes but not in xylem/vessels
OR
xylem/vessels dead/acellular and phloem/sieve tubes alive ✓

b. xylem vessels have thicker walls «than phloem» ✓

c. xylem «vessel» walls are lignified «but phloem walls are not» ✓

d. phloem vessels have sieve plates «whereas xylem vessels have no cross walls» ✓

e. xylem/vessels are wider/larger than phloem/sieve tubes ✓

f. companion cells in phloem «but not in xylem» ✓

b.

a. water is polar/a dipole/oxygen slightly negative and hydrogen slightly positive ✓

b. polarity results in hydrogen bonds/attraction between water molecules ✓

c. hydrogen bonding/polarity causes cohesion of water «molecules» ✓

d. cohesion/hydrogen bonding allows water to withstand tension/withstand low pressure/be pulled «upwards»/moved against gravity ✓

e. cohesion/hydrogen bonding prevents column of water «in xylem» from breaking/column of water is maintained ✓

f. adhesion of water to xylem/vessel walls «due to hydrogen bonds» ✓

c. a. chains of glucose/1-4 glycosidic linkages/covalent bonding between glucose ✓

b. beta glucose so alternating orientation of glucose units
OR
beta glucose forms straight chains ✓

c. forms microfibrils/long and thin/thin fibres/parallel bundles of cellulose molecules
OR
hydrogen bonding/cross linkage between cellulose molecules holds them together ✓

d. high tensile strength/rigid/doesn't stretch so provides support/allows turgidity ✓

20N.2.HL.TZ0.7

a. water (molecules) are polar/dipolar/have partially positive and negative poles/have δ+ and δ-;
b. attraction/bonding between positive and negative (poles);
c. hydrogen bond formed between hydrogen and oxygen; Reject if H and O in same molecule.

d. bond/attraction between different water molecules/intermolecular;
Marks can be awarded in an annotated diagram. Reject answers stating or implyingthat therearewholepositiveornegativecharges

for mpa .

b. a. water moved/transported in xylem vessels;

b. transported under tension/suction/pulled up (in xylem vessels);
c. transpiration/loss of water (vapour) generates pulling forces/low pressure/tension;
d. tension/pull generated when water evaporates from cell walls (in mesophyll);
e. transpiration is loss of water vapour from leaf (surface)/stomata;
f. cohesivity/cohesion in water due to hydrogen bonding/attractions between water molecules;
g. cohesion/WTTE so chain/column of water (molecules) doesn't break/remains continuous;
h. transpiration stream is a column of/flow of water in xylem from roots to leaves;
Do not award marks for absorption of water by roots.

c.
a. osmoregulation is regulation of water and solute/salt balance/solute concentrations;
b. nephron (is the functional unit of the kidney/osmoregulates);
c. ultrafiltration in glomerulus / glomerular filtrate collected by Bowman's capsule;
d. loop of Henle establishes/maintains hypertonic conditions in medulla;
e. osmosis/reabsorption of water (from filtrate) in the collecting duct;
f. brain/hypothalamus monitors blood solute concentration / pituitary secretes ADH;
g. ADH secreted when solute concentration of blood is too high/hypertonic/when dehydrated;
h. ADH increases permeability of collecting duct to water;
i. ADH causes more aquaporins (in membranes of collecting duct wall cells);

j. more water reabsorbed resulting in more concentrated/hypertonic urine/less volume of urine;

k. less/no ADH secreted when solute concentration (of blood) is too low/hypotonic;

l. less water reabsorbed resulting in dilute/hypotonic urine/large volume of urine;

Reject 'water balance' and 'water concentration' for mpa.

21N.2.HL.TZ0.7

a. a. polarity of water;

b. hydrogen bonds between water molecules;

c. cohesion between water molecules/water molecules stick together;

d. cohesion allows tensions/low pressures/transpiration pull/movement

upward/against gravity;

e. adhesion to cellulose/cell walls generates tensions/pull (in xylem)

OR

adhesion to xylem walls/vessel walls causes capillary rise/upward movement;

f. solvent for many substances / many substances dissolve;

g. liquid at most temperatures experienced by plants / liquid so can flow;

b.

Polarity of water and/or hydrogen bonding can be shown in an annotated diagram.

	Xylem	***Phloem***
a	transports water/mineral ions	sucrose/sugars/amino acids/organic/carbon compounds/products of photosynthesis/food;
b	from roots to leaves	from source/leaves to sink/roots;
c	dead/no membranes/no organelles	living/membranes present/some organelles;
d	no cross/end walls/hollow/continuous tubes	sieve plates/perforated walls/separate elements;
e	flow due to low pressures/tension/suction	flow due to high pressure/pressure gradient;
f	thicker walls	thinner walls
g	lignified walls / gives support / forms wood	does not provide support/strength;
h	wider lumen	narrower lumen

c. a. light-dependent reactions produce ATP/reduced NADP;
b. ATP generated by chemiosmosis/by photophosphorylation/by ATP synthase;
c. reduced NADP produced by/using electrons from Photosystem I;

d. RuBP + CO 2 to glycerate 3-phosphate (in light independent reactions);
e. glycerate 3-phosphate reduced to triose phosphate (in light independent reactions);
f. ATP/reduced NADP used in the light-independent reactions;
g. reduced NADP provides electrons/hydrogen / to reduce (glycerate 3-phosphate)
OR

reduced NADP used to convert glycerate 3-phosphate to triose phosphate;
h. ATP provides energy (for reduction of glycerate 3-phosphate);
i. ATP needed to regenerate RuBP
j. ATP/reduced NADP run out in darkness
k. Calvin cycle only possible with light/in the day/is indirectly dependent on light;

19N.2.HL.TZ0.6

a.
a. sugar, phosphate and base linked correctly to form at least one nucleotide ✓ For mpa, ignore labelling of the subunits of the nucleotide. Carbon atoms in deoxyribose do not have to be numbered but the phosphate should be linked to C5 and the base to C1. Shapes other than circles and rectangles could be used for the phosphate and base.
b. deoxyribose, phosphate and base/named base labelled at least once ✓
c. adenine paired with thymine and cytosine paired with guanine ✓ For mpc, full names of all four bases are required, but not relative sizes of the purine and pyrimidine bases.
d. two antiparallel chains of nucleotides linked by hydrogen bonds with all sugar-phosphate bonds in correct position ✓ For mpd, a bond should connect the C3 of deoxyribose on one nucleotide to the phosphate on the adjacent nucleotide. Two nucleotides in each strand is sufficient.

b.
a. linear/not circular DNA molecule
OR
one chromosome is one molecule of DNA/one chromosome is two DNA molecules «after replication» ✓
b. associated with histone proteins/nucleosomes ✓
c. centromere joins sister chromatids «after DNA replication» ✓
d. telomeres at the end «of the chromosome/chromatid» ✓
e. carries a sequence of genes / each gene occupies a specific locus ✓ Do not accept ‘sequence of bases’ for mpe.
f. alternative alleles of genes / homologous chromosomes carry same sequence of genes ✓
g. chromosomes in pairs / two «homologous chromosomes» of each type «in a diploid cell» ✓
h. non-coding sequences/example of a non-coding sequence ✓ Do not allow mph if the response states that chromosomes are always condensed.
i. supercoiled/condensed «during mitosis/meiosis» ✓

c.
a. translation occurs on ribosomes ✓
b. tRNA-activating enzymes attach amino acids to tRNAs ✓
c. small and large ribosome units assemble on mRNA
OR
translation/polypeptide synthesis starts at a start codon ✓
d. each tRNA arriving at the ribosome binds to the A site ✓
e. anticodon «on tRNA» binds to codon «on mRNA» ✓
f. according to complementary base pairing/A with U and G with C ✓
g. ribosome moves along the mRNA / mRNA moves over ribosome ✓
h. t-RNA shifts from the A site to P site/from the P to the E site ✓
i. peptide bond between amino acids «on tRNAs at A and P sites» ✓
j. tRNA released from ribosome at E site ✓
k. cycle repeats with other tRNAs / polypeptide grows as tRNAs bring more amino acids ✓
l. until stop codon on mRNA is reached ✓
m. components are disassembled / polypeptide leaves the ribosome ✓
Accept these points in an annotated diagram.
Do not award any marks for events in transcription.

21M.2.HL.TZ2.7

a.
a. two stranded/double helix ✓
b. antiparallel / strands running in opposite directions
OR
one strand organized 5’ to 3’ and the other 3’ to 5’ ✓
c. sugar-phosphate backbone ✓
d. each strand formed by chains of nucleotides ✓
e. each nucleotide is formed by a phosphate, a deoxyribose and a base / annotated diagram of a nucleotide clearly indicated as a nucleotide ✓
f. the bases are adenine, guanine, cytosine and thymine ✓
g. strands held together by hydrogen bonds (between complementary base pairs)
OR
A pairs with T and C pairs with G ✓
Both helix and two strands needed for mp a. Double helix is sufficient for the mark.
Points can be awarded to annotated diagrams.
For mp c, the explicit label sugar phosphate backbone is required.
To award mp d from a diagram, at least three pairs of nucleotides should be shown.
For mp e, the diagram would need to be labelled as a nucleotide.
For mp e, expect deoxyribose not just sugar.
The written names of the bases are required for mp f.
Do not penalize twice for mp f and g for using letters.
If they only ever use the symbols A,T,C and G they are ineligible for mp f. If however, they say A pairs with T and C pairs with G, then they would get mp g. If they wrote adenine pairs with thymine and cytosine pairs with guanine, then they would obtain both mp f and mp g.

b.

a. helicase to separate/unwind DNA strands ✓

b. gyrase / toposiomerase to relax the tension as bacterial DNA is being uncoiled / prevent supercoiling ✓

c. primase to synthesise primers ✓

d. polymerase (I) removes primers and replaces with nucleotide ✓

e. polymerase (III) adds nucleotides (in a 5' to 3' direction) ✓

f. ligase joins (Okazaki) fragments together ✓

Accept the enzyme name without 'DNA' included; e.g. 'DNA ligase' or 'ligase' can both be accepted.

b.

a. insulin production is determined by a gene ✓

b. gene for insulin (is found in all cells), but only activated in (β cells of) pancreas ✓

c. stem cells differentiate into specialized cells/(into pancreatic β) ✓

d. during differentiation some genes are turned on and others off ✓

e. insulin is a hormone that regulates the amount of glucose/sugar in blood ✓

f. pancreatic β cells have sensors that detect glucose level in blood ✓

g. an increase in glucose will increase transcription of mRNA of insulin ✓

h. the site of transcription of insulin is in the pancreatic β cells ✓

i. gene transcription is regulated by proteins that bind to specific base sequence in DNA/ enhancers/silencers/promoter proximal elements ✓

j. regulatory sequences/proteins are specific to the gene they regulate / insulin regulator proteins are only found in in the pancreatic β cells ✓

k. (DNA) methylation (usually) inhibits gene expression / (histone) acetylation promotes gene expression / tightness of coiling of DNA around histones affects gene expression ✓

Accept sugar as equivalent to glucose.

21N.2.HL.TZ0.6

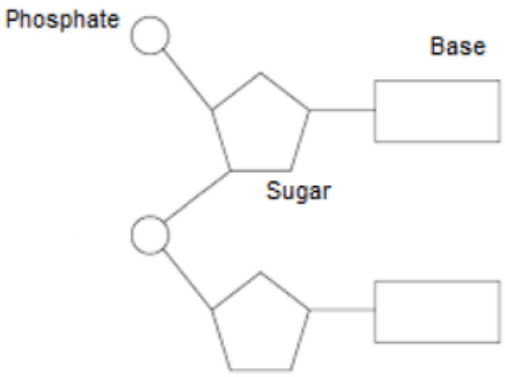
a.

a. ribose drawn as pentagon and labelled sugar/ribose;

b. base drawn with correct link to (C1 of) ribose and labelled base/nitrogenous base;

c. phosphate drawn with correct link to (C5 of) ribose and labelled P/phosphate;

d. two (or more) ribonucleotides drawn with correct link (C3 to C5)



b.

a. synthesis of RNA/mRNA / transcription of DNA to RNA;
b. RNA nucleotides linked together to form a strand/chain;
c. RNA strand assembled on DNA template/antisense strand / copy made of sense strand;
d. RNA polymerase carries out transcription/links RNA nucleotides;
e. uncoiling/separation of DNA strands;
f. 5' end of nucleotides linked to 3' end of (growing RNA) strand;
g. complementary base pairing (is the basis of copying the base sequence);
h. uracil instead of thymine in RNA;
i. starts at/RNA polymerase binds to a promoter;
j. regulated by transcription factors/DNA binding proteins/nucleosomes;

Annotated diagrams can be used.

c.

	continuous variation	*discrete variation*
a	no distinct categories / intermediates / many possible phenotypes	distinct categories / non-overlapping classes / few possible phenotypes;
b	multiple genes/polygenic	one/few influencing genes;
c	environmental influences	not influenced by environment;
d	height/weight/skin colour/intelligence/other example	blood groups/number of eggs/ other example;

22M.2.HL.TZ2.5

a.i.

a unit of DNA wound/coiled around 8 histone proteins / octamer;

a.ii. a.hydrogen bonding between nucleotides / bases;
b.complementary base pairs;
c.adenine-thymine and cytosine-guanine form base pairs (between the two strands with H-bonding);
d. 2 bonds between A and T, while 3 bonds between C and G;

Full names required for c and d though use ecf.

a.iii.

a.tandem repeats (at one locus) vary in number of times sequence repeats / represent different alleles for one locus;
b. DNA sample cut by restriction enzymes into fragments;
c. samples of DNA are amplified at specific genetic sites with PCR;
d. the fragments are separated by their size/number of repeats with gel electrophoresis;
e. fluorescent/radioactive label attached to different tandem repeats;
f. data from several loci at one time uniquely identify individuals / like a fingerprint, combinations of alleles are specific to an individual;
g. comparisons/similarities between fragment patterns to determine paternity/evidence match to a suspect's profile / otgher example of comparison/similarity;

b.i.
a.insulin is necessary to control/regulate blood glucose concentrations
OR
insulin is necessary for the cells to take up glucose (for energy);
b. insufficient insulin is made by the pancreas
OR
autoimmune response/antibodies destroy the (β) cells of the pancreas that make insulin;
c. reduced uptake of glucose from the blood / glucose accumulates in the blood / elevated blood glucose levels;

"sugar" is NOT accepted in place of glucose. However, this should only be penalized once; i.e., utiltize ECF.

b.ii
a. inject insulin / monitoring blood glucose / devices that release insulin;
b. decrease consumption of sugars/CHO / diet modification;
c.increase exercise;
d. keep weight in healthy range;

SPM.2.HL.TZ0.10

(a)

- affects/damages/causes change in oncogenes/errors in DNA repair;
- UV radiation might alter complementary base pairing/break hydrogen bonds/fuse bases;
- double helix may uncoil;
- strands may separate/break;
- DNA sequence may be altered/DNA bases may re-connect to different bases after separating;
- DNA strand may break into pieces / fragments of DNA may be lost;

(b)

- DNA base sequence provides information;
- gene expression / genes provides a template for the construction of a protein;
- transcription occurs / mRNA is built using DNA as a template;
- DNA nucleotide structure described/sugar and phosphate and base;
- polymer of nucleotides makes a DNA strand;
- DNA has two anti-parallel strands;
- complementary base pairs/A pairs with T and C with G;
- strands linked by hydrogen bonding between bases;
- double helix shape / helix held by hydrogen bonds;

(c)

- gene knockout technology is a genetic engineering technique/intentional alteration in the sequence of a gene;
- making a gene inactive;
- using site specific nucleases / CRISPR;
- researcher observes changes in phenotype of organism;
- allows researcher to determine function of the gene;
- entire library of knockout organisms exists;
- made available to researchers;

19M.2.HL.TZ1.2

a.
a. prokaryotes have circular DNA/chromosome but eukaryote chromosomes linear/OWTTE ✓
OR
eukaryotes have telomeres/centromeres whereas prokaryotes do not ✓
b. some prokaryotes have plasmids whereas eukaryotes do not ✓
c. eukaryotes have multiple chromosomes whereas prokaryotes «typically» have only one ✓
d. histones/nucleosomes/proteins associated with DNA in eukaryotes but not in prokaryotes/naked DNA in prokaryotes
OR
eukaryote DNA can coil/supercoil/condense «due to histones» but not prokaryote DNA ✓

b.
a. genetic disease/caused by a gene
OR
inherited «from parents»
OR
caused by mutation «of a gene» ✓
b. base substitution
OR
GAG → GTG ✓

c. hemoglobin gene mutated / different allele/form/version of hemoglobin gene
OR
HbA → HbS ✓
d. leads to change in amino acid sequence «in hemoglobin»
OR
glutamic acid → valine ✓
e. only homozygotes have full disease/sickled cells / heterozygote has milder form
OR
hemoglobin crystallizes at low oxygen concentration ✓
f. «selected for/spreads in population» as it gives resistance to malaria ✓

c.i

male because «X and» Y chromosome present

OR

male because sex chromosomes/last two chromosomes/pair 21 are unpaired/different «from each other»/not homologous ✓

The answer must include “male” and the reason.

c.ii. 21

d.i. 21

Heterozygous offspring «grey body, normal wings»		*Homozygous recessive parent «black body, vestigial wings»*	
	b+ b vg+ vg		b b vg vg
OR	$b^+b\ vg^+vg$	**OR**	*bb vgvg*
OR	$b^+vg^+\ b\ vg$ ✓	**OR**	*bvg bvg* ✓

d.ii.

a. not a 1:1:1:1 ratio «because of linkage»

OR

not independent assortment

OR

grey normal and black vestigial types/parental combinations/double dominant and double recessive were commoner than 25 %/commoner than expected ✓

b. «linked genes» so were on the same chromosome ✓

c. grey body vestigial wing and black body normal wing are recombinants

OR

2 % plus 3 % of the offspring are recombinants ✓

d. recombinants due to crossing over/exchange of genes between «non-sister» chromatids

OR

2 % and 3 % of offspring were due to crossing over

OR

genes inherited together unless separated by crossing over ✓

e. crossing over between the two loci/between the two genes on the chromosomes ✓

f. few recombinants/not much crossing over because genes/gene loci close together ✓

Accept any of these points from an annotated diagram.

19M.2.HL.TZ1.3

a.

differences

a. prokaryote has cell wall but mitochondrion does not ✓

b. mitochondrion has double membrane whereas prokaryote has single membrane

OR

«Gram negative» bacteria have cell wall between two membranes whereas mitochondria has intermembrane space between two membranes ✓

c. mitochondrion has cristae/invaginations of inner membrane but prokaryote does not

OR

prokaryote «may have» flagella/pili/«slime» capsule which mitochondria do not have ✓

similarities

d. 70S ribosomes in both ✓

e. DNA in both / loop of DNA in both / naked DNA in both ✓

f. shape similar/both rod shaped/OWTTE

OR

size of both is similar/both about 3 μm long ✓

g. both are membrane-bound/OWTTE ✓

b.

a. endocytosis/engulfing of prokaryote by a larger/another/anaerobic prokaryote/cell ✓

b. double membrane of the mitochondrion is the result of endocytosis

OR

inner membrane of mitochondrion from engulfed cell and outer from food vacuole ✓

c. «engulfed prokaryotic cell» was aerobic/respired aerobically/consumed oxygen

OR

«engulfed prokaryotic cell» provided energy/ATP ✓

d. «engulfed prokaryotic cell» not destroyed/not digested

OR

«endo»symbiotic/mutualistic relationship developed ✓

e. «engulfed prokaryotic cell» had its own DNA/own «70S» ribosomes ✓

Do not award mpc for “mitochondrion makes ATP”.

20N.2.HL.TZ0.2

a.i.

a.part hydrophobic/not attracted to water/non-polar AND part hydrophilic/attracted to water/polar;

b. bilayer formed (formed naturally by phospholipids in water);

c. hydrophilic heads/parts face outwards and hydrophobic tails/parts face inwards.

Do not allow water loving/hating in mpa or mpc.

a.ii.
a. controls/regulates/reduces fluidity of membrane / prevents crystallization of phospholipids;
b. reduces permeability to some substances.
Do not accept ‘stabilizes membrane’.

b.
a. nuclear membrane breaks down/disappears (in prophase/at start of mitosis);
b. nuclear membrane reforms around two new nuclei (in telophase/at end of mitosis);
c. plasma membrane pulled inwards at equator / cleavage furrow formed;
d. membrane pinches apart to form two cells / cytoplasm divided / cytokinesis

c.i.
synapse/synaptic
Allow any answer including either of these terms unless out of context.
c.ii.
a. depolarization of pre-synaptic membrane / action potential/nerve impulse arrives;
b. uptake of calcium / calcium ions diffuse in / calcium channels open;
c. structures containing neurotransmitter/vesicles move to/fuse with membrane;
d. neurotransmitter/acetylcholine released by exocytosis into cleft/binds to postsynaptic membrane/receptors;
Must see exocytosis.

20N.2.HL.TZ0.3

a.
X: large/increased SA area for ATP production/electron transport/oxidative phosphorylation/proton pumping
OR
X: small/narrow intermembrane space for generating proton gradient (rapidly/steeply);
Y: contains enzymes for Krebs cycle/link reaction;

b.
a. protons pumped across inner membrane of mitochondria/into intermembrane space;
b. using energy released by flow of electrons/by electron transport/by electron carriers;
c. proton gradient established/maintained / proton motive force generated;
d. protons pass/diffuse back through inner membrane/membrane of cristae/to matrix;
e. through ATP synthase;
f. ATP production coupled to flow of protons / ATP from ADP and Pi using energy from protons;
Marks can be awarded in an annotated diagram.

21M.2.HL.TZ1.2

a.
a. (a loop of) DNA ✓
b. 70S ribosomes ✓
c. double membrane ✓
d. electron transport chains/enzyme complexes in (internal) membranes ✓
e. enzymes in a region of fluid/in stroma and matrix ✓
f. large area of (internal) membrane/cristae and thylakoids ✓
Only two answers should be marked – the first on each line.
Do not award marks for functions rather than structures, for example ATP production.
Allow spaces inside cristae and thylakoids for mpf.
b.
a. ATP produced by both / ADP used by both ✓
b. oxygen produced by chloroplasts and used by mitochondria ✓
c. carbon dioxide produced by mitochondria and used by chloroplasts ✓
d. carbon/organic compounds built up in chloroplasts/anabolism and broken down in mitochondria/catabolism ✓
Do not award mpd for statements about carbohydrates or glucose (because the pyruvate used by mitochondria is not a carbohydrate).
c.
a. in phloem ✓
b. loading into sieve tubes/by active transport/by cotransport/by companion cells ✓
c. entry of water (to phloem) by osmosis/because of high solute concentration ✓
d. causes high/hydrostatic pressure ✓
e. flow from high pressure to lower pressure down pressure gradient ✓ from source to sink ✓
Do not award mpa if xylem included with phloem.
Do not award a mark solely for mentioning the term ‘translocation'.

21M.2.HL.TZ2.5

a.
a. unlinked genes are on different chromosomes / vice versa ✓
b. unlinked alleles migrate/segregate/are inherited independently (during meiosis) / vice versa ✓
c. (In unlinked inheritance) there is an equal chance for all 4 options to occur / AB, Ab, aB, ab / vice versa ✓
d. (dihybrid crosses involving) linked genes do not produce Mendelian ratios ✓
e. (excluding recombinants) there is a 1:1 chance of inheriting the different options/AB or ab ✓
f. in linked characteristics alleles might not migrate together if there is crossing over/ recombinants are formed ✓
g. crossing over occurs in prophase I of meiosis ✓
h. when the sister chromatids migrate in meiosis II the characteristics forming gametes are different/Ab, aB ✓
i. formation of recombinants causes changes in ratio/probability of inheritance/genetic variation ✓
j. correct named example of inheritance of linked/unlinked characteristics ✓
k. Punnett/paired diagrams of both unlinked and linked characteristics ✓
l. genes which are linked but are far apart on the chromosome can display independent assortment ✓

Mp a could be awarded from an annotated diagram.
Allow annotated diagram of inheritance / could be shown in a Punnett square.
Allow annotated diagram of linked inheritance for mp f.
For mp K, accept sex linked examples involving two genes.
If the student interprets the question as sex-linked and autosomal inheritance, look for WTTE marks from the scheme.

b.
a. germinal epithelium divide endlessly (by mitosis giving rise to spermatagonia)
b. spermatogonia are diploid/2n ✓
c. spermatogonia divide by mitosis / provide a continuous supply throughout adult life ✓
d. (some) spermatogonia enlarge forming primary spermatocytes ✓
e. primary spermatocytes undergo the first division of meiosis/meiosis I ✓
f. secondary spermatocytes produced are haploid/n ✓
g. secondary spermatocytes undergo the second division of meiosis (to produce spermatids) ✓
h. spermatids develop tails
OR
spermatids differentiate into spermatozoa / spermatids associate with Sertoli cells ✓
Marks can be awarded to an annotated diagram.
Do not accept sperm or spermatozoa as equivalent to spermatagonia or spermatocytes.

c.
a. nucleus/nuclear membrane ✓
b. membrane bound organelles ✓
c. mitochondria ✓
d. rough ER/smooth ER/golgi apparatus ✓
e. lysosomes / centrioles ✓
f. large/80S ribosomes / ribosomes attached to a membrane ✓
g. linear chromosomes / histones ✓

21M.2.HL.TZ2.7

a.
a. two stranded/double helix ✓
b. antiparallel / strands running in opposite directions
OR
one strand organized 5’ to 3’ and the other 3’ to 5’ ✓
c. sugar-phosphate backbone ✓
d. each strand formed by chains of nucleotides ✓
e. each nucleotide is formed by a phosphate, a deoxyribose and a base / annotated diagram of a nucleotide clearly indicated as a nucleotide ✓
f. the bases are adenine, guanine, cytosine and thymine ✓
g. strands held together by hydrogen bonds (between complementary base pairs)
OR
A pairs with T and C pairs with G ✓

Both helix and two strands needed for mp a. Double helix is sufficient for the mark.
Points can be awarded to annotated diagrams.
For mp c, the explicit label sugar phosphate backbone is required.
To award mp d from a diagram, at least three pairs of nucleotides should be shown.
For mp e, the diagram would need to be labelled as a nucleotide.
For mp e, expect deoxyribose not just sugar.
The written names of the bases are required for mp f.
Do not penalize twice for mp f and g for using letters.
If they only ever use the symbols A,T,C and G they are ineligible for mp f. If however, they say A pairs with T and C pairs with G, then they would get mp g. If they wrote adenine pairs with thymine and cytosine pairs with guanine, then they would obtain both mp f and mp g.

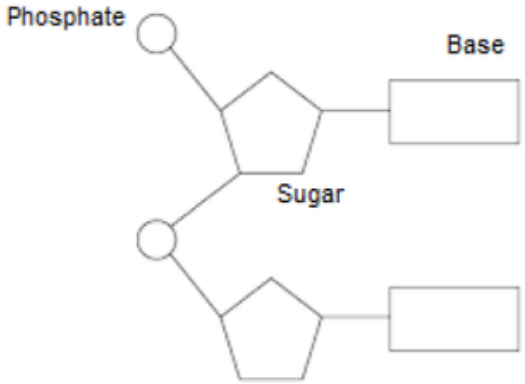
b.
a. helicase to separate/unwind DNA strands ✓
b. gyrase / toposiomerase to relax the tension as bacterial DNA is being uncoiled / prevent supercoiling ✓
c. primase to synthesise primers ✓
d. polymerase (I) removes primers and replaces with nucleotide ✓
e. polymerase (III) adds nucleotides (in a 5' to 3' direction) ✓
f. ligase joins (Okazaki) fragments together ✓
Accept the enzyme name without ‘DNA’ included; e.g. ‘DNA ligase’ or ‘ligase’ can both be accepted.
c.
a. insulin production is determined by a gene ✓
b. gene for insulin (is found in all cells), but only activated in (β cells of) pancreas ✓
c. stem cells differentiate into specialized cells/(into pancreatic β) ✓
d. during differentiation some genes are turned on and others off ✓
e. insulin is a hormone that regulates the amount of glucose/sugar in blood ✓
f. pancreatic β cells have sensors that detect glucose level in blood ✓
g. an increase in glucose will increase transcription of mRNA of insulin ✓
h. the site of transcription of insulin is in the pancreatic β cells ✓
i. gene transcription is regulated by proteins that bind to specific base sequence in DNA/ enhancers/silencers/promoter proximal elements ✓
j. regulatory sequences/proteins are specific to the gene they regulate / insulin regulator proteins are only found in in the pancreatic β cells ✓
k. (DNA) methylation (usually) inhibits gene expression / (histone) acetylation promotes gene expression / tightness of coiling of DNA around histones affects gene expression ✓

Accept sugar as equivalent to glucose.

21N.2.HL.TZ0.6

a.

a. ribose drawn as pentagon and labelled sugar/ribose;
b. base drawn with correct link to (C1 of) ribose and labelled base/nitrogenous base;
c. phosphate drawn with correct link to (C5 of) ribose and labelled P/phosphate;
d. two (or more) ribonucleotides drawn with correct link (C3 to C5)



b.

a. synthesis of RNA/mRNA / transcription of DNA to RNA;
b. RNA nucleotides linked together to form a strand/chain;
c. RNA strand assembled on DNA template/antisense strand / copy made of sense strand;
d. RNA polymerase carries out transcription/links RNA nucleotides;
e. uncoiling/separation of DNA strands;
f. 5' end of nucleotides linked to 3' end of (growing RNA) strand;
g. complementary base pairing (is the basis of copying the base sequence);
h. uracil instead of thymine in RNA;
i. starts at/RNA polymerase binds to a promoter;
j. regulated by transcription factors/DNA binding proteins/nucleosomes;
Annotated diagrams can be used.

c.

	continuous variation	***discrete variation***
a	no distinct categories / intermediates / many possible phenotypes	distinct categories / non-overlapping classes / few possible phenotypes;
b	multiple genes/polygenic	one/few influencing genes;
c	environmental influences	not influenced by environment;
d	height/weight/skin colour/intelligence/other example	blood groups/number of eggs/ other example;

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a.
a.anaphase;
b.the (replicated) chromosomes/chromatids are separating/moving to opposite poles of the cell;
OWTTE

a.ii
50 µm = 27/28/29 mm, Y = 8/9/10 mm
OR
50 x 9 /27
OR
16.7 µm (accept answers in the range of 14.8 µm to 17.2 µm)
Award [1] for correct ratios not precise measurements in the work or [1] for correct answer with correct unit.

a.iii
a.(group of regulatory proteins that) control/regulate the cell cycle;
b. activate cyclin-dependent kinases (which control cell cycle processes);

b.i
a.prokaryotes (usually) have one chromosome while eukaryotes have numerous chromosomes;
b.prokaryotes have a circular chromosome while eukaryotes have linear ones;
c.eukaryotes' chromosomes are associated with histones/proteins but prokaryotes/Eubacteria have naked DNA vs eukaryote DNA associated to proteins/histones;

Accept only differences. **Differentiating terms expected;**

b.ii
a.Cairns grew prokaryotes/E. coli in radioactive thymidine/thymine/thymine containing tritium;
b.contents of cell put on photographic film/surface (for several weeks) / used autoradiography and electron microscopes;
c.measured the length of the DNA molecule and photographed it / produced image of DNA;
d. could show the new strands were all labelled with thymidine/thymine;