IB Diploma

BIOLOGY

HL P2

2017 — 2024

1 – (BIOLO/21_HL_Summer_2017_Q3) – *Cell Biology*

Pictured below are Louis Pasteur's original drawings of swan-necked flasks.

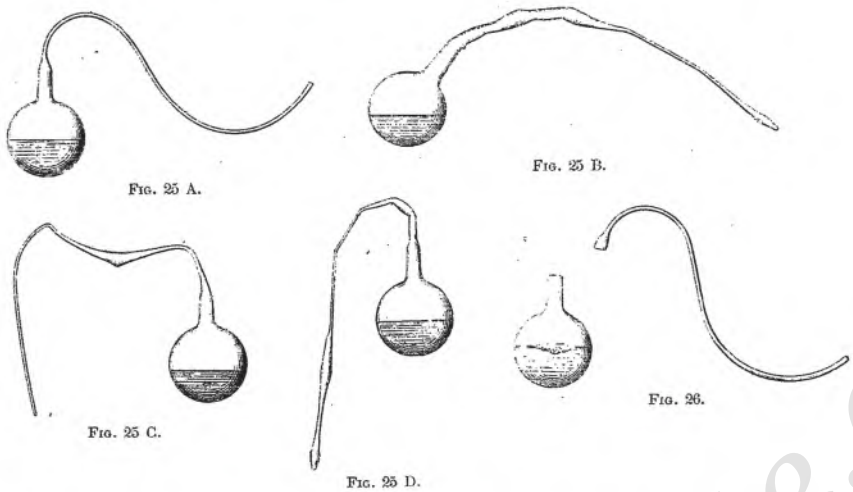

Fig. 25 A.

Fig. 25 B.

Fig. 25 C.

Fig. 25 D.

Fig. 26.

[Source: L Pasteur and L Pasteur Vallery-Radot, (1922), *Œuvres de Pasteur, Vol II Fermentations et générations dites spontanées*, pages 260–261]

(a) Describe how Pasteur's experiments provided convincing evidence to falsify the concept of spontaneous generation. [3]

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(b) State the function of life in *Paramecium* that is carried out by:

(i) cilia. [1]

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(ii) the contractile vacuole. [1]

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(c) Discuss the advantages and disadvantages of the use of adult stem cells. [3]

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2 – (BIOLO/22_HL_Summer_2017_Q3) – *Cell Biology*

(a) Outline the properties of water molecules that permit them to move upwards in plants. [2]

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(b) Define osmolarity. [1]

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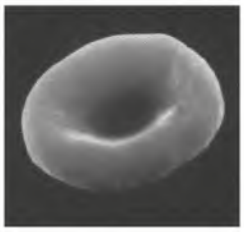
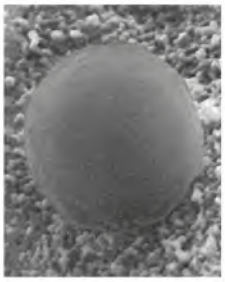
(c) This image shows a normal red blood cell.

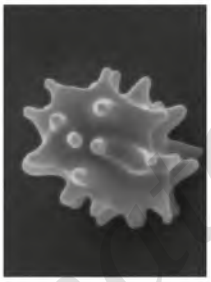


These images show two red blood cells that have been placed in solutions with different concentrations of solutes.

Red blood cell 1



Red blood cell 2



[Source: adapted from www.acbrown.com]

Deduce, with a reason, which red blood cell has been placed in a hypertonic solution. [1]

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(d) State what change there has been in the cell surface area to volume ratio in red blood cell 1. [1]

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3 – (BIOLO/22_HL_Summer_2017_Q8) – *Cell Biology, Genetics, Nucleic Acids (ahl)*

(a) Cells go through a repeating cycle of events in growth regions such as plant root tips and animal embryos. Outline this cell cycle. [4]

(b) Draw a labelled diagram of the formation of a chiasma by crossing over. [3]

(c) Explain the control of gene expression in eukaryotes. [8]

4 – (BIOLO/20_HL_Winter_2017_Q6) – *Cell Biology, Animal Physiology (ahl), Evolution & Biodiversity*

Cell biologists play an important role in research into disease, fertility, evolution and many other areas of science.

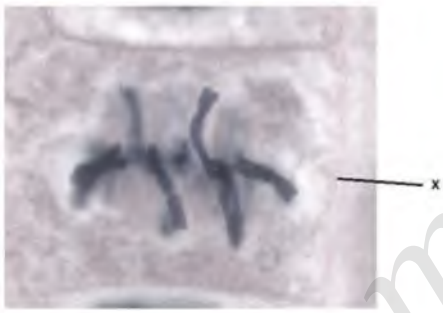
(a) Describe the origin of eukaryotic cells according to the endosymbiotic theory. [4]

(b) Compare and contrast the processes of spermatogenesis and oogenesis. [8]

(c) Outline the evidence for evolution provided by selective breeding. [3]

5 – (BIOLO/21_HL_Summer_2018_Q5) – *Cell Biology, Molecular Biology*

(a) The image shows a cell in a section of an onion root tip seen under a light microscope.



[Source: Adapted Dr. phil.nat Thomas Geier, Fachgebiet Botanik der Forschungsanstalt Geisenheim, https://commons.wikimedia.org/wiki/File:Allium-Mitose03-DM100x_BL28.jpg. Licenced under the Creative Commons Attribution-Share Alike 3.0 Unported license, https://creativecommons.org/licenses/by-sa/3.0/legalcode.]

(i) Identify the structure labelled X. [1]

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(ii) State the stage of mitosis of this cell. [1]

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(b) Compare and contrast the location of ATP synthase and the movement of protons during aerobic cell respiration and photosynthesis. [2]

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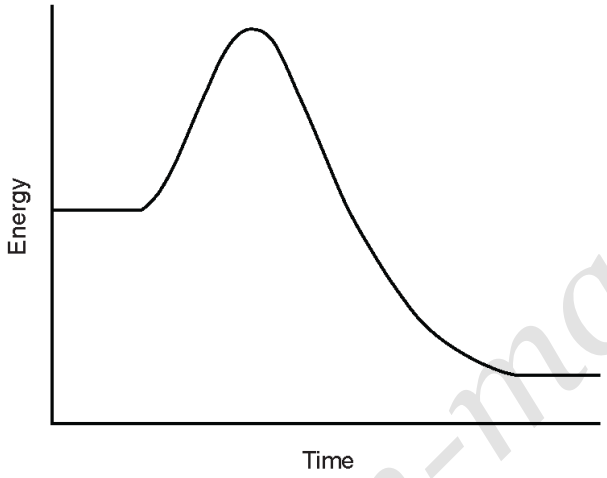
(c) Using the table, distinguish between the production of ATP, use of oxygen and release of CO_2 in aerobic cell respiration between the cytoplasm and the mitochondrion. [3]

	Cytoplasm	Mitochondrion
ATP production		
Use of oxygen		
Release of CO_2		

(d) The graph shows energy levels throughout an uncatalysed reaction. Draw a curve to show how the action of an enzyme would affect this reaction. [1]



6 – (BIOLO/21_HL_Summer_2018_Q6) – *Cell Biology, Human Physiology, Molecular Biology*

(a) Draw a labelled diagram to show the fluid mosaic model of the plasma membrane. [4]

(b) Outline how neurons generate a resting potential. [4]

(c) Hydrogen bonds can exist both within and between molecules in living organisms and have an impact on their structure and function. Explain the importance of hydrogen bonding for living organisms. [7]

7 – (BIOLO/22_HL_Summer_2018_Q5) – *Cell Biology, Plant Biology (ahl)*

Every cell is surrounded by a cell surface membrane which regulates the movement of materials into and out of the cell.

(a) Discuss alternative models of membrane structure including evidence for or against each model. [8]

(b) Describe the processes involved in absorbing different nutrients across the cell membrane of villus epithelium cells lining the small intestine. [4]

(c) Outline the process used to load organic compounds into phloem sieve tubes. [3]

8 – (BIOLO/21_HL_Summer_2019_Q5) – *Cell Biology*

(a) Outline the functions of rough endoplasmic reticulum and Golgi apparatus. [3]

(b) Outline the control of metabolism by end-product inhibition. [5]

(c) Explain how hydrophobic and hydrophilic properties contribute to the arrangement of molecules in a membrane. [7]

9 – (BIOLO/20_HL_Winter_2019_Q4) – *Cell Biology, Metabolism,cell Respiration & Photosynthesis (ahl)*

(a) (i) State the property of amphipathic phospholipids that enables them to form a bilayer. [1]

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(ii) State the reason cis and trans fatty acids are said to be unsaturated. [1]

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(b) During photosynthesis plants use water in the conversion of light energy to chemical energy.

(i) State the name of this process. [1]

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(ii) Explain how water is used in photosynthesis. [3]

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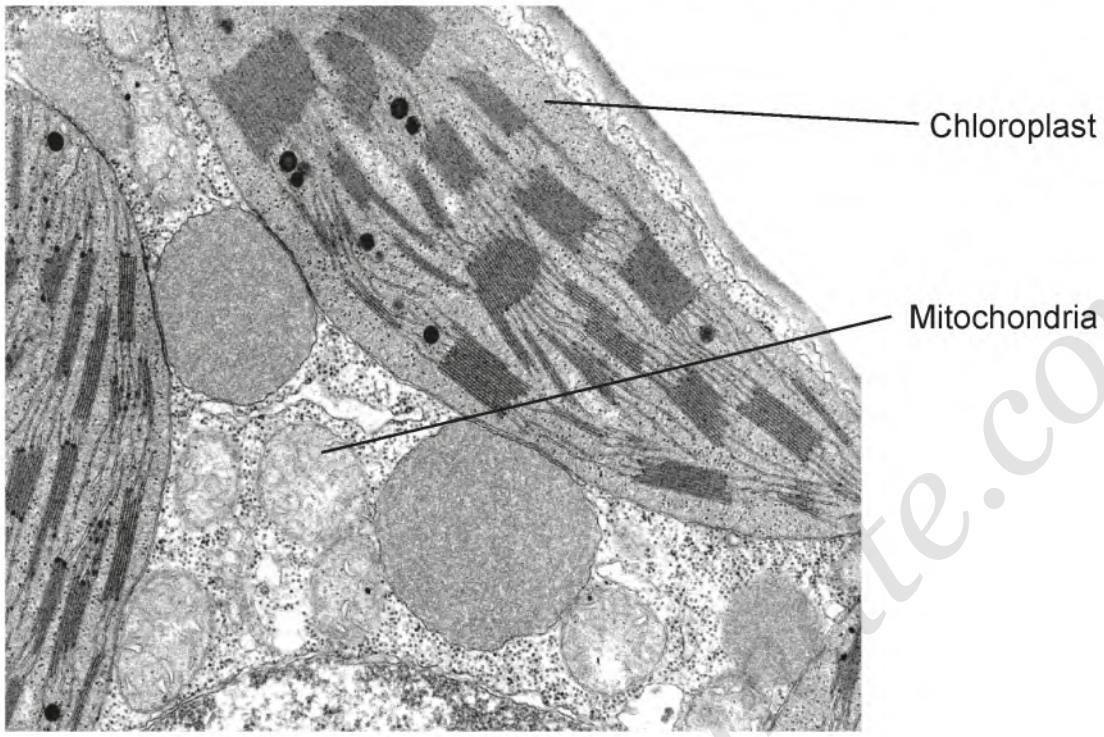
10 – (BIOLO/21_HL_Summer_2021_Q2) – *Cell Biology*

The image shows part of a plant cell with a chloroplast in close proximity to mitochondria.



(a) State **two** structural similarities between mitochondria and chloroplasts. [2]

1. .....

2. .....

(b) Compare and contrast mitochondria and chloroplasts in terms of the substrates they use and the products they produce. [2]

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(c) Outline how the compounds produced by chloroplasts are distributed throughout the plant. [3]

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ANSWERS

1 – (BIOLO/21_HL_Summer_2017_Q3) – *Cell Biology*

a		a. spontaneous generation is life appearing from nothing/from non-living/cells only come from pre-existing cells/life ✓ b. broth/culture medium «for bacteria» «used/placed» in flasks ✓ c. broth boiled/sterilized «in some flasks» to kill microbes ✓ d. no clouding/signs of bacteria growth/reproduction/microbes did not appear «in flasks of boiled broth» ✓ e. after necks of flasks snapped boiled broth became cloudy/growth «of microbes» ✓ f. because microbes from the air contaminated the «boiled» broth ✓ g. curved necks allowed exposure to air but prevented entry of microbes ✓	*Allow bacteria or organisms instead of microbes.*	3 max
b	i	movement / locomotion ***OR*** feeding/nutrition ✓	*If student has multiple answers do not accept the second answer if the first one is incorrect.*	1
	ii	homeostasis ***OR*** maintain osmotic balance / osmoregulation / expels «excess» water / maintains «cell» water content ✓	*If student has multiple answers do not accept the second answer if the first one is incorrect.*	1

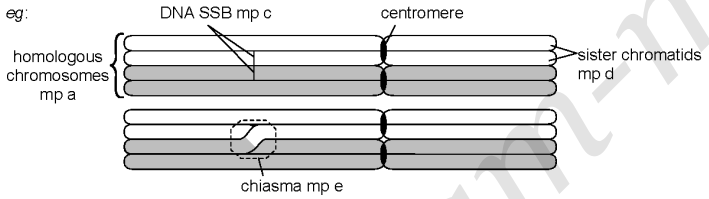
c		*Advantages* a. «adult stem cells» can divide «endlessly» / can differentiate ✓ b. «adult stem cells» can be used to repair/regenerate «tissues» ✓ c. fewer ethical objections «than with embryonic stem cells» ✓ d. adult source not killed / «source» would not have grown into new human / no death of embryos used to provide stem cells ✓ e. adults can give «informed» consent for use of their stem cells ✓ f. no rejection problems / patient's own cells used ✓ g. less chance of cancer/«malignant» tumor development «than with embryonic stem cells» h. most tissues in adults contain some stem cells ✓ *Disadvantages* i. difficult to obtain/collect/find in adult body/; ✓ j. some «adult» tissues contain few/no stem cells/very few available ✓ k. (adult stem cells) differentiate into fewer cell types «than embryonic cells»/WTTE ✓	*Maximum **[2]** if only advantages or only disadvantages are included.*	3 max

2 – (BIOLO/22_HL_Summer_2017_Q3) – *Cell Biology*

a		a. water molecules are polar ***OR*** can form hydrogen bonds ✓ b. cohesion between water molecules allows continuous water columns ***OR*** cohesion between water molecules allows transpiration stream «to form in xylem» ✓ c. adhesion of water to the walls of xylem vessel «helps water rise» ✓ d. water evaporates at environmental temperatures allowing transpiration pull ✓	*OWTTE*	2 max
b		«measurement of» solute concentration of a solution ✓	*OWTTE*	1
c		cell 2 because it has plasmolized/lost water/volume has decreased ✓		1
d		decreased ✓		1

3 – (BIOLO/22_HL_Summer_2017_Q8) – *Cell Biology, Genetics, Nucleic Acids (ahl)*

a		a. mitosis is the division of a nucleus to produce two genetically identical daughter nuclei ✓ b. consists of four phases: prophase, metaphase, anaphase, telophase ✓ c. cytokinesis occurs after mitosis ✓ d. interphase is the metabolically active phase between cell divisions ✓ e. the interphase consists of the S phase, G1 and G2 ✓ f. DNA replicates in the S phase ✓ g. cell growth ***OR*** preparation for mitosis ***OR*** duplication of organelles in G1 and G2 ✓	*OWTTE*	**4 max**

b		a. «crossing over/chiasmata shown between» homologous chromosomes ✓ b. centromere drawn and labelled ✓ c. single strand break «SSB»/DNA cut between homologous chromosomes ✓ d. non-sister chromatids labelled ***OR*** sister chromatids labelled ✓ e. chiasma between homologous chromosomes labelled «shown forming after SSB» ✓ *eg:*  	*Homologous chromosomes must be labelled and correctly drawn.* *It is likely that more than one diagram will need to be included to demonstrate the stages.*	**3 max**

c		a. mRNA conveys genetic information from DNA to the ribosomes «where it guides polypeptide production» ✓ b. gene expression requires the production of specific mRNA «through transcription» ✓ c. most genes are turned off/not being transcribed at any one time/regulated ***OR*** some genes are only expressed at certain times ✓ d. some genes are only expressed in certain cells/tissues ***OR*** «cell» differentiation involves changes in gene expression ✓ e. transcription factors/proteins can increase/decrease transcription ✓ f. hormones/chemical environment of cell can affect gene expression ✓ g. example of cell environment ✓ h. transcription factors/proteins may prevent or enhance the binding of RNA polymerase ✓ i. nucleosomes limit access of transcription factors to DNA/regulate gene expression/transcription ***OR*** activate or silence genes ✓ j. DNA methylation/acetylation appears to control gene expression «as epigenetic factor» ***OR*** methylated genes are silenced ✓ k. «some» DNA methylation patterns are inherited ✓ l. introns may contain positive or negative gene regulators ***OR*** gene expression can be regulated by post-transcriptional modification/splicing/mRNA processing ✓	*eg: auxin/insulin/cytoplasmic gradient in embryo*	**8 max**

4 – (BIOLO/20_HL_Winter_2017_Q6) – *Cell Biology, Animal Physiology (ahl), Evolution & Biodiversity*

a		a. mitochondria and chloroplasts are similar to prokaryotes ✓ b. «host» cell took in another cell by endocytosis/by engulfing «in a vesicle» ✓ c. but did not digest the cell/kept the «ingested» cell alive ***OR*** symbiotic/mutualistic relationship «between engulfed and host cell» ✓ d. chloroplasts and mitochondria were once independent/free-living «organisms» ✓ e. DNA «loop» in chloroplast/mitochondrion ✓ f. division/binary fission of chloroplast/mitochondrion ✓ g. double membrane around chloroplast/mitochondrion ✓ h. 70s ribosomes «in chloroplast/mitochondrion» ✓	*Allow "taking in" in place of "engulfing"* *Award up to **[2]** for evidence from mpe to mph*	**4 max**

b		a. both result in haploid cells/gametes ✓ b. both involve mitosis at the start/in the «germinal» epithelium ✓ c. both have cell growth «before meiosis» ✓ d. both involve «two divisions of» meiosis ✓ e. both involve differentiation to produce a gamete ✓ f. both are stimulated by hormones ***OR*** spermatogenesis stimulated by testosterone and oogenesis stimulated by FSH ✓	*A table is not required but both statements in one row of the table must either be explicitly stated or clearly implied to award the mark*	**8 max**

	Oogenesis	***Spermatogenesis***	
g.	in the ovaries	in the testes	✓
h.	starts «in germinal epithelium» during embryo/fetus development	starts during puberty/adolescence ***OR*** continuously starting «in germinal epithelium»	✓
i.	pauses occur in prophase I/prophase II/ metaphase II	no pauses	✓
j.	large quantity of cytoplasm in egg/ cytoplasm split unequally	small quantity of cytoplasm «per sperm»/equal division of cytoplasm	✓
k.	one cell/egg «per meiosis» ***OR*** some become polar bodies	four sperm «per meiosis» ***OR*** all cells become sperm	✓
l.	one «usually» at a time/per month/per menstrual cycle	many/far more/millions daily	✓
m.	released on about Day 14/in middle of menstrual cycle/at ovulation	released continuously «from testis» ***OR*** by ejaculation/intercourse	✓
n.	stops at menopause	goes on throughout adult life/until death	✓

c		a. crop plants/domesticated animals/livestock produced by selective breeding ✓ b. specific example of a domesticated animal/crop plant and the wild species from which it was developed ***OR*** specific example of a domesticated animal/crop plant and the features in it which have been improved «compared with the wild species» ✓ c. artificial selection/crossing selected varieties/eliminating undesirable varieties ✓ d. «selective breeding/artificial selection can cause» significant/rapid change over time/from the original wild species ✓ e. «changes due to selective breeding/artificial selection» shows natural selection can cause change/evolution «in a species» ✓	*For example dogs have been developed from wolves*	**3 max**

5 – (BIOLO/21_HL_Summer_2018_Q5) – *Cell Biology, Molecular Biology*

	a	i	cell wall ✓		**1**
	a	ii	metaphase ✓		**1**
	b		***location of ATP synthase*** a. cristae/inner mitochondrial membrane versus thylakoid membranes ✓ ***movement of protons*** b. protons moved/pumped as a result of electron flow/electron transport in both ✓ c. (pumped by the electron transport chain) from the matrix to the intermembrane space versus from the stroma to the thylakoid space ✓ d. through ATP synthase/synthetase in both (respiration and photosynthesis) ✓ e. protons move (through ATP synthase/synthetase) down the concentration gradient in both ✓ f. move (down concentration gradient) from the intermembrane space to the matrix versus from the thylakoid space to the stroma ✓		**2 max**

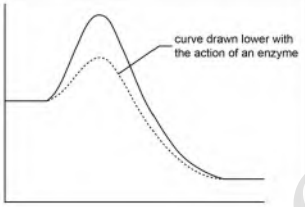
c

	Cytoplasm	Mitochondrion
ATP production	small gain / 2 per glucose / substrate level / by glycolysis	larger gain / more than 30 per glucose / chemiosmosis / by oxidative phosphorylation ✓
use of oxygen	none / × / no	required/used (as terminal electron acceptor) / ✓ / yes ✓
release of CO_2	none / × / no	waste product /produced (by link reaction and Krebs cycle) / ✓ / yes ✓

3

d

curve starting and ending at the same energy level but rising to a lower peak ✓



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6 – (BIOLO/21_HL_Summer_2018_Q6) – *Cell Biology, Human Physiology, Molecular Biology*

a

Draw a labelled diagram to show the fluid mosaic model of the plasma membrane.

Do not award the mark unless the structure is labelled with the underlined name.

a. two correctly orientated layers of phospholipids/phospholipid bilayer shown with heads facing in opposite directions ✓
b. phospholipids shown with two parts labelled hydrophilic/phosphate head ***AND*** hydrophobic/hydrocarbon tail ✓
c. protein (any) shown as a globular structure embedded in one/both layers of phospholipid ✓
d. peripheral protein shown as globular structures at the surface of the membrane ***AND*** integral protein shown as embedded globular structures ✓
e. glycoprotein shown as embedded globular structure with antenna-like carbohydrate protruding
OR
carbohydrate shown as branched/antenna-like structure attached either to a protein or to a phospholipid ✓
OR
channel protein(s) shown with a pore passing through it
OR
pump protein shown as a transmembrane globular structure ✓
f. cholesterol shown in between adjacent phospholipids ✓

4 max

b

Outline how neurons generate a resting potential.

a. sodium-potassium pump ✓
b. sodium /Na^+ out and potassium /K^+ in ✓
OR
sodium/Na^+ concentration higher outside and potassium/K^+ higher inside ✓
c. three Na^+ pumped for every two K^+ (hence negative inside) ✓
OR
inside of axon holds negative ions/Cl^- ions/negatively charged proteins/organic anions (hence negative inside) ✓
d. by active transport / using ATP ✓
e. inside (of axon/neuron) is negative in comparison to outside ✓
OR
electrochemical concentration/charge difference (across the membrane) is the resting potential ✓
f. resting potential is -70mV ✓

4 max

	c		**Explain the importance of hydrogen bonding for living organisms.** a. cohesion in water/water molecules stick together (due to hydrogen bonds) ✓ b. cohesion helps transport under tension of water/sap in xylem / transpiration stream✓ c. adhesion between water and cell walls/cellulose/polar molecules ✓ d. adhesion/capillary action helps water to rise in plants/stems/xylem / helps keep leaf walls moist ✓ e. solvent properties (due to hydrogen bonds) with polar/hydrophilic molecules ✓ f. solvent properties exemplified by glucose/other example of a polar solute ✓ g. high latent heat of evaporation / (much) energy required for evaporation so water useful as coolant/for sweating ✓ h. high (specific) heat capacity so water temperature changes less ✓ i. base pairing between bases/nucleotides/strands in DNA by hydrogen bonding ✓ j. base pairing between bases in RNA and DNA for transcription/between codon and anticodon for translation ✓ k. proteins have hydrogen bonding in secondary structure/α helix/β pleated sheet ✓ l. proteins have hydrogen bonding between R groups/in tertiary structure/to maintain conformation ✓ m. habitats because water is liquid due to high boiling point/due to water freezing on the surface ✓ n. habitats on water surface due to surface tension ✓		**7 max**

7 – (BIOLO/22_HL_Summer_2018_Q5) – *Cell Biology, Plant Biology (ahl)*

	a		a. early evidence showed membranes are partially permeable ***AND*** organic solvents penetrate faster than water ✓ b. suggests they have non-polar regions ✓ c. chemical analysis showed membranes consist mainly of proteins and lipids ✓ d. layer of phospholipids spread over water, orientate themselves into monolayer with nonpolar/hydrophobic tails out of water and polar/hydrophilic heads in water surface ✓ e. when shaken with water form micelles/particles with tails inwards away from water ✓ f. Davson–Danielli model proposed phospholipid bilayer coated with protein molecules on both surfaces ✓ g. evidence from electron microscopy «supported Davson–Danielli model» ✓ h. three-layered structure/ sandwich/railway tracks/two dark bands with a light band between ✓ i. model could not account for hydrophobic proteins / artifacts due to low resolution ✓ j fluorescent labelling / freeze fracturing later used to investigate membrane structure ✓ k. led to Singer-Nicholson / fluid mosaic model of protein molecules floating in fluid lipid bilayer ✓ l. shows particles/proteins project partially and sometimes right through lipid bilayer ✓ m. indicates peripheral and integral proteins present ✓	*Accept any of the points clearly explained in an annotated diagram.*	**8 max**

	b		a. (simple diffusion) of nutrients along/down a concentration gradient ✓ b. example of simple diffusion *eg* fatty acids ✓ c. facilitated diffusion of nutrients involves movement through channel proteins ✓ d. example of nutrient diffusion *eg* fructose ✓ e. active transport of nutrients against a concentration gradient / involving protein pumps ✓ f. example of active transport, *eg* (iron) ions/glucose/amino acids ✓ g. endocytosis / by means of vesicles ✓ h. example of nutrient for endocytosis, *eg* cholesterol in lipoprotein particles ✓		4 max
	c		a. active transport/loading of sucrose/amino acids/organic metabolites ✓ b. sucrose moves by apoplastic / symplastic routes ✓ c. «loading» at source into companion cells «of sieve tubes» ✓ d. movement «of sucrose» through plasmodesmata ✓ e. high concentration of solutes in phloem leads to water movement by osmosis ✓		3 max

8 – (BIOLO/21_HL_Summer_2019_Q5) – *Cell Biology*

a		**Outline the functions of rough endoplasmic reticulum and Golgi apparatus.**		
		a. ribosomes on RER synthesize/produce polypeptides/proteins ✓ b. proteins from RER for secretion/export/use outside cell/for lysosomes ✓ c. Golgi alters/modifies proteins/example of modification ✓ d. vesicles budded off Golgi transport proteins «to plasma membrane» ***OR*** exocytosis/secretion of proteins in vesicles from the Golgi ✓	*Accept "for use inside and outside the cell" for mpb.*	**3 max**
b		**Outline the control of metabolism by end-product inhibition.**		
		a. metabolism is chains/web of enzyme-catalyzed reactions ***OR*** metabolic pathway is a chain of enzyme-catalyzed reactions ✓ b. end product/inhibitor is final product of chain/pathway ✓ c. inhibits/binds to/blocks the first enzyme in chain/pathway ✓ d. non-competitive inhibition ✓ e. end-product/inhibitor binds to an allosteric site/site away from the active site ✓ f. changes the shape of the active site/affinity of the active site «for the substrate» ✓ g. prevents intermediates from building up ***OR*** prevents formation of excess «end» product/stops production when there is enough ***OR*** whole metabolic pathway can be switched off ✓ h. negative feedback ✓ i. binding of the end product/inhibitor is reversible ***OR*** pathway restarts if end product/inhibitor detaches/if end product concentration is low ✓ j. isoleucine inhibits/slows «activity of first enzyme in» threonine to isoleucine pathway ✓	*Allow mark points shown in clearly annotated diagrams.* *To gain mpd, mpe and mpf the answer must be in the context of end-product inhibition, not enzyme inhibition generally.*	**5 max**

c		**Explain how hydrophobic and hydrophilic properties contribute to the arrangement of molecules in a membrane.**		
		a. hydrophilic is attracted to/soluble in water and hydrophobic not attracted/insoluble ✓ b. hydrophilic phosphate/head and hydrophobic hydrocarbon/tail in phospholipids ✓ c. phospholipid bilayer in water/in membranes ✓ d. hydrophilic heads «of phospholipids» face outwards/are on surface ✓ e. hydrophobic tails «of phospholipids» face inwards/are inside/are in core ✓ f. cholesterol is «mainly» hydrophobic/amphipathic so is located among phospholipids/in hydrophobic region of membrane ✓ g. some amino acids are hydrophilic and some are hydrophobic ✓ h. hydrophobic «amino acids/regions of» proteins in phospholipid bilayer «core» ✓ i. hydrophilic «amino acids/regions of» proteins are on the membrane surface ✓ j. integral proteins are embedded in membranes due to hydrophobic properties/region ***OR*** transmembrane proteins have a hydrophobic middle region and hydrophilic ends ✓ k. peripheral proteins on are on the membrane surface/among phosphate heads due to being «entirely» hydrophilic ***OR*** «carbohydrate» part of glycoproteins is hydrophilic so is outside the membrane ✓ l. pore of channel proteins is hydrophilic ✓	*Allow mark points shown in clearly annotated diagram.* *In any part of the answer, accept polar instead of hydrophilic and non-polar or apolar instead of hydrophobic.*	**7 max**

9 – (BIOLO/20_HL_Winter_2019_Q4) – *Cell Biology, Metabolism,cell Respiration & Photosynthesis (ahl)*

	a	**i**		have both a hydrophilic and a hydrophobic region **OR** have both a polar and a non-polar region ✓		**1**
		ii		they have a double bond between carbon/C «atoms» **OR** they could hold more hydrogen ✓	*Accept clearly annotated diagrams to that effect.* *Do not accept double bonds between C and any other atom.*	**1**
	b	**i**		photolysis / light-dependent «reactions/stages» / photophosphorylation ✓		**1**
		ii	***a***	water is split/broken «up»/lysed/undergoes photolysis ✓	*For mpa, reject "water is cut in half".* *For mpa, accept photolysis only if the context shows that water is being split.* *For mpc, do not accept just chlorophyll.* *For mpe, reject pumping of protons into the thylakoid as photolysis produces them inside the thylakoid.*	**3 max**
			b	producing/providing electrons ✓		
			c	replaces electrons lost by Photosystem II / PSII / P680 / chlorophyll a ✓		
			d	allows electrons «to continue» to pass along the electron transport chain ✓		
			e	provides protons/H^+ «inside thylakoid» to help generate a «proton» gradient/maintain high concentration inside thylakoid ✓		