



# Markscheme

**May 2023**

**Biology**

**Higher level**

**Paper 3**

25 pages

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### Subject Details: Biology HL Paper 3 Markscheme

Candidates are required to answer **all** questions in Section A and **all** of the questions from **one** option in Section B. Maximum total = **45 marks**.

1. Each row in the “Question” column relates to the smallest subpart of the question.
2. The maximum mark for each question subpart is indicated in the “Total” column.
3. Each marking point in the “Answers” column is shown by means of a semicolon (;) at the end of the marking point.
4. A question subpart may have more marking points than the total allows. This will be indicated by “**max**” written after the mark in the “Total” column. The related rubric, if necessary, will be outlined in the “Notes” column.
5. An alternative word is indicated in the “Answers” column by a slash (/). Either word can be accepted.
6. An alternative answer is indicated in the “Answers” column by “**OR**”. Either answer can be accepted.
7. An alternative markscheme is indicated in the “Answers” column under heading **ALTERNATIVE 1** etc. Either alternative can be accepted.
8. Words inside brackets ( ) in the “Answers” column are not necessary to gain the mark.
9. Words that are underlined are essential for the mark.
10. The order of marking points does not have to be as in the “Answers” column, unless stated otherwise in the “Notes” column.
11. If the candidate’s answer has the same “meaning” or can be clearly interpreted as being of equivalent significance, detail and validity as that in the “Answers” column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by **OWTTE** (or words to that effect) in the “Notes” column.
12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.
14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the “Notes” column.

**Section A**

Question		Answers	Notes	Total
1.	a	activity of the enzyme is higher than normal enzymes (at temperatures over 30 °C);		1
	b	pH/concentration of enzyme/concentration of substrate;	<i>Do not accept temperature</i> <i>Do not accept "amount"</i>	1
	c	a. only 3 readings at each temperature may be insufficient; b. reliable as error bars are small;		1 max
	d	a. the graph shows the optimum temperature to be near 40 °C; b. choose smaller range of temperature (between 30 and 50 °C); c. smaller increments of temperature;	<i>c. Accept numbers such as 1 or 5 degrees.</i>	2 max

2.	a	to kill all microbes/bacteria in the flask; to sterilize the broth/flasks;		1 max
	b	kept a flask in similar conditions with no broken neck;		1
	c	a. observed microbe growth only in the flask without a neck <b>OR</b> microbes can't enter through curved/swan necked flask; b. microbes do not arise by spontaneous generation <b>OR</b> microbes/bacteria travel in the air;		2

Question		Answers	Notes	Total
3.	a	a. lowers evaporation of water; b. vents allow air to enter as water leaves the reservoir; c. allows for pressure changes in the reservoir as water flows to the flask;		1 max
	b	a. more water is lost during the day than at night; b. temperature is higher so more loss of water by evaporation; c. stomata are open for gas exchange/ photosynthesis (so more water can evaporate/transpire);		2 max
	c	parts of the shoot/leaves are removed/covered in petroleum jelly/Vaseline;	<i>Accept part wrapped in plastic</i>	1
	d	a. water uptake by shoot causes a decrease in reading for balance 2; b. water lost by the shoot would be total loss from the system;	OWTTE	2

**Section B**

**Option A — Neurobiology and behaviour**

Question		Answers	Notes	Total
4.	a	a. ectoderm forms a neural plate; b. neural plates start to infold; c. neural groove/crest forms; d. infoldings fuse to form (the structure of) the neural tube;		2 max
	b	a. cell division/differentiation in the neural tube leads to production of neurons; b. migration of (immature) neurons occurs as they move to their final location; c. axons grow from the neurons (in response to chemical stimuli); d. the developing neurons form multiple synapses; e. neural pruning eliminates unwanted synaptic connections/neurons; f. neural tube elongates to form brain and spinal cord;	a. <i>Accept neurogenesis</i>  d. <i>Accept synaptogenesis</i>	3 max
	c	unethical to carry out experimental procedures on brains in a group of humans and then see effects <b>OR</b> less complex/more visible/more accessible nervous systems are easier to study <b>OR</b> animal's brain can be locally stimulated to observe functions/changes in behaviour <b>OR</b> some brain diseases in animals are similar to humans' so useful to find treatments/cure;	<i>OWTTE</i>	1

Question		Answers	Notes	Total
5.	a	X: ear drum/tympanic membrane; Y: auditory nerve;	Y: Accept acoustic or cochlear nerve	2
	b	they are amplified / increase the force/strength of vibrations;		1
	c	a. sound waves cause movement of the fluid in the inner ear/cochlea; b. this causes hair cells/sensory hairs in the cochlea to move; c. low frequency sounds would travel further into the cochlea/more towards apex than high frequency sounds; d. impulses are sent from different hair cells/sensory hairs according to their frequency; e. the brain interprets these as different sounds;	<i>Accept vice versa.</i>	3 max

Question		Answers	Notes	Total
6.	a	decreases (concentration of dopamine)		1
	b	a. increase psychomotor arousal/alertness; b. increase transmission at synapses in the brain; c. they increase the concentration of dopamine/neurotransmitter; d. dopamine is involved in the brain's reward pathway <b>OR</b> stimulate pleasure areas of the brain; e. block re-uptake of dopamine/ block uptake transporters; f. high concentration of dopamine/neurotransmitter remains in the synapse so continues pleasure;		3 max
	c	benzodiazepines <b>OR</b> alcohol <b>OR</b> tetrahydrocannabinol/THC;	<i>Accept other valid example, no commercial names valid.</i>	1
	d	a. friends taking drugs may influence taking drugs for a feeling of belonging/peer pressure; b. certain cultures/locations have a greater incidence of drug use (so it may seem normal); c. low income increases the likelihood of addiction for escapism; d. poor knowledge of drug addiction/abuse; e. personal problems/illness/mental health issues /stress/emotional issues for escapism;		2 max



7.	a	1–5 mm;	<i>units required</i>	<b>1</b>
	b	making many journeys with a little food is energy expensive; better to carry one large insect than make many trips with small ones;	<i>OWTTE</i>	<b>1 max</b>
	c	a. bigger prey may not be possible for nestlings to eat/swallow (so the adults give them 16–30 mm prey); b. bigger prey may be difficult to carry to the nest; c: (16-30mm) Ideal size to nutrient content ratio for nestling to eat;		<b>1 max</b>
	d	a. foraging behaviour ensures adults and nestlings have enough food for survival <b>OR</b> natural selection favours this type of foraging; b. birds showing this behaviour will be more likely to reproduce; c. the genes responsible for this behaviour are passed to the offspring for their survival;		<b>2 max</b>

Question		Answers	Notes	Total
8.	a	<p>a. breathing is an automatic process/can occur without conscious intervention/is involuntary/ autonomic;</p> <p>b. voluntary/conscious factors can override automatic functions (for a limited time);</p> <p>c. control of the breathing comes from the respiratory centre;</p> <p>d. (respiratory centre) located in the medulla of the brain;</p> <p>e. exercise results in higher CO<sub>2</sub> levels in blood;</p> <p>f. breathing rate changes in response changes to blood pH/acidity/CO<sub>2</sub> level;</p> <p>g. medulla contains chemoreceptors</p> <p><b>OR</b></p> <p>chemoreptors in aortic/carotid bodies send signals to medulla;</p> <p>h. respiratory centre/medulla sends nerve impulses to diaphragm/intercostal muscles;</p> <p>i stimulates (the intercostal muscles/diaphragm) to control breathing rate/depth of inspiration/contraction;</p>		6 max

**Option B — Biotechnology and bioinformatics**

Question		Answers	Notes	Total
9	a	R;		1
	b	pH/temperature/oxygen level/foam;		1
	c	a. constant removal/harvesting of products results in higher production for continuous fermenter; b. the fed-batch fermenter would have a build-up of waste that would inhibit production <b>OR</b> for fed-batch addition of materials without removal uses up space in fermenter; c. conditions more likely to be monitored/kept at optimal levels/steady state in continuous culture;		2 max

Question		Answers	Notes	Total
10	a	the enzyme PPO was absent/deactivated/inhibited/replaced;		1
	b	they allow scientists to know that the (trans)gene has been added (correctly/successfully);	<i>OWTTE</i>	1
	c	a. host cells are in solution with calcium chloride at low/cold temperatures; b. the temperature of the solution is quickly raised/heat shock; c. chemical method to enhance plasmid/DNA uptake by (bacteria) cells <b>OR</b> induces competence for transformation;	<i>OWTTE</i>	2 max

11.	a	allows bacteria to stick together/to the surface/retains water/protection/structural stability;		1
	b	<p>a. emergent properties are those in the biofilm that may not be present in individual cells/are outcomes of interactions of the elements of a system;</p> <p>b. resistance to antibiotics due to reduced cell division rates;</p> <p><b>OR</b></p> <p>resistance to antimicrobials due to physical barriers to penetration;</p> <p>c. social cooperation as cells organize to form a complex structure</p> <p><b>OR</b></p> <p>release of signaling molecules leads to gene expression to develop biofilm;</p> <p>d. cells use matrix to move, leading to (whole) colony moving;</p> <p>e. formation of channels for water flow inside a colony;</p>	<i>Accept other valid examples with descriptions</i>	2 max
	c	<p>a. (trickling filter) system/bed uses support medium/rocks/ stones/rubber/plastic on which biofilm develops/ grows;</p> <p>b. sewage trickled/sprinkled/dripped/sprayed over the medium to provide aeration/oxygen;</p> <p>c. biofilms feed off/digest organic matter in the sewage to obtain energy/for growth;</p> <p>d. resulting sludge removed may be used as fertilizer;</p>		3 max

Question		Answers	Notes	Total
12.	a	fluorescent/coloured to be identified later;		1
	b	cDNA/copy DNA;		1
	c	a. (single strand) DNA molecules /sequences/probes attached to a slide/small surface; b. there are numerous sequences of DNA/genes in one microarray; c. probes bind to/hybridize with cDNA which has been coloured/labelled; d. the microarray is scanned to detect different colours OR colours show which genes have been expressed;		3 max

Question		Answers	Notes	Total
13.	a	BLAST(p) / Clustal W / T-Coffee;		1
	b	the genetic code is degenerate/each amino acid has more than one codon;		1
	c	a. evolved from a common ancestor with a given amino acid sequence (for histone protein); <b>OR</b> (accumulation of) mutations over time may lead to new species/ evolution; b. Least number of differences in (amino acid) sequence shows closer relationship; c. human sequence in the data is more similar to the chimp than other species/mouse/rat/cow; d. humans and chimp have a more recent common ancestor;	b. <i>Accept vice versa.</i> c. <i>Accept vice versa.</i>	3 max

14.		a. bioremediation involves using microorganisms to return a polluted environment to its natural state; b. <i>Pseudomonas</i> can be used in the treatment of oil spills (in marine environments); c. the bacteria are sprayed directly onto the oil; d. the bacteria use the hydrocarbons in crude oil as carbon/energy source/for respiration; e. breaking them down into carbon dioxide and water; f. process can be accelerated by providing the bacteria with essential nutrients/nitrates; g. mercury released into aquatic ecosystems by industrial processes/coal-fired power plants/ in garbage dumps in paints/light bulbs; h. can be converted into methyl mercury; i. methyl mercury runs off into / bioaccumulates in aquatic systems; j. <i>Pseudomonas</i> can break down methyl mercury to elemental mercury and methane gas;	a. <i>OWTTE</i>	6 max
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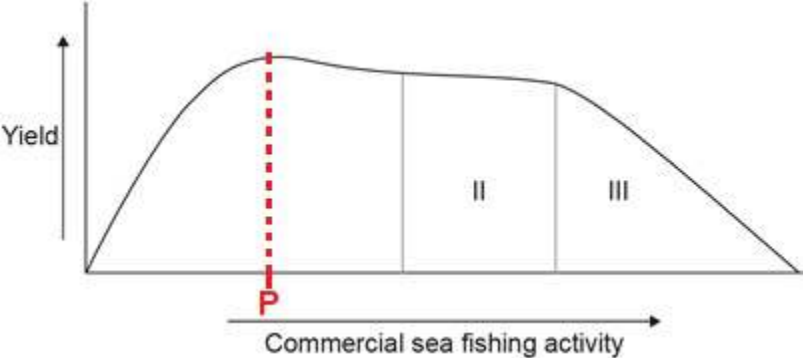
**Option C — Ecology and conservation**

Question		Answers	Notes	Total
15.	a	secondary consumer / third trophic level/ trophic level 3 / 3;		1
	b	a. energy content in biomass/all organisms of each trophic level; b .size of study area included; c. over period of time / per year;		2 max
	c	orca is in different trophic levels depending on its food source;		1
	d	a. the efficiency by which an organism uses food is the feed conversion ratio/FCR <b>OR</b> FCR = mass of food taken in/production of biomass; b. fish have low respiration rate/body temperature so need less food/lose less energy;		2



16.	a	<p>a. they can become an invasive species because they lack predators  <b>OR</b>                      uncontrolled population growth due to lack of predators;                      b. compete with local/endemic species for nutrients/habitat;                      c. may cause (endemic) species to become extinct/reduction in numbers;</p>		2 max
	b	<p>a. (before 2002) the cactus moth had abundant food so the population grew exponentially;                      b. (after 2002) the population size fell as the amount of cactus plants decreased  <b>OR</b>                      from 2003 low population of moths corresponds with low number of cladodes/cactus plants;</p>		2
	c	<p><i>benefits: [1 max]</i>                      a. introduced/biological control species are selective/specific  <b>OR</b>                      no build-up of toxins/harmful chemicals (in food chains)  <b>OR</b>                      inexpensive;</p> <p><i>risks: [1 max]</i>                      b. control species may itself become a pest  <b>OR</b>                      takes a long time to control the pest due to reproduction times;</p>		2

Question		Answers	Notes	Total
17.	a	a. deforestation/forest fires; b. clearing land for houses/farming/growth of cities;		1 max
	b	a. the amphibians are kept in their natural habitat; <b>OR</b> preserves habitat/resources for amphibians; b. area can be actively managed <b>OR</b> pollution/predators/alien species can be controlled in the area;		2
	c	richness is how many species are in an area, evenness considers the relative number of each species;		1
	d	a. indicator species used to assess a specific environmental condition; b. they are tolerant/sensitive to certain levels of pollutant; c. their presence/absence allows the level of pollution to be estimated <b>OR</b> relative numbers of indicator species used to calculate biotic index;		2 max

18.	a	<p>label P on <math>x</math>-axis below the peak yield;  <i>Dotted line for guidance, not required in answer.</i></p> 	<p><i>Do not accept if P is <b>only</b> on the curve</i></p>	1
	b	<p>fish are being caught faster than they can reproduce;</p>		1
	c	<p>a. requires agreements/policies/enforcement between countries;                  b. commercial companies compete to increase profit;</p>		1 max
	d	<p>a. random sample is captured and marked/tagged (in a manner that will not harm fish);                  b. captured sample is released and allowed to mix with general population                  OR                  captured sample is released then wait a few days/weeks;                  c. second sample is captured and both the total number and the number of marked fish counted;                  d. ratio of recaptured marked fish to number in second sample = the ratio of the number in the first sample marked and released to the population size  <b>OR</b>                  Population Size = <math>\frac{n_1 \times n_2}{n_3}</math>  <math>n_1</math> = number in first sample marked  <math>n_2</math> = number in second sample  <math>n_3</math> = number of recaptured individuals marked</p>		3 max

Question	Answers	Notes	Total
19.	a. (saprophytic) bacteria decompose the dead remains of plants/animals; b. convert nitrogenous compounds/wastes to ammonia/NH <sub>3</sub> ; c. nitrifying bacteria/ <i>Nitrobacter</i> / <i>Nitrosomonas</i> (in the soil) convert ammonia to nitrites/nitrates; d. nitrogen fixation is the conversion of atmospheric nitrogen to ammonia; e. <i>Rhizobium</i> have a mutualistic relationship with the plants; f. ( <i>Rhizobium</i> ) bacteria in root nodules of legumes/peas/clover/beans fix nitrogen; g. free-living bacteria/ <i>Azotobacter</i> in the soil fix nitrogen; h. nitrates absorbed/assimilated/used by plants; i. denitrifying bacteria (in the soil) convert nitrates to nitrogen gas;		6 max

**Option D — Human physiology**

Question		Answers	Notes	Total
<b>20</b>	<b>a</b>	a. both have increased CHD with increasing cholesterol; b. men always higher incidence CHD than women at each level (of cholesterol);	<i>Accept vice versa</i>	<b>2</b>
	<b>b</b>	a. depends on the type of cholesterol/ratio of HDL to LDL/some types of cholesterol do not increase the chance of CHD; b. may not indicate CHD if <i>lack</i> other risk factors for CHD;		<b>1 max</b>
	<b>c</b>	a. (excess) cholesterol is converted to bile salts; b. hemoglobin is broken down into heme and globin; c. heme is broken down to produce bilirubin and iron; d. bilirubin and bile salts combine to produce bile;		<b>3 max</b>
	<b>d</b>	neurological/brain damage /deafness / cerebral palsy;		<b>1</b>

Question			Answers	Notes	Total
21.	a		intestine		1
	b		a. toxins bind to (cell membrane) receptors /cascade of reactions causing activation of ion channels; b. (open channels) cause the loss of $\text{Cl}^-/\text{Na}^+/\text{K}^+/\text{HCO}_3^-$ ions from cells; c. (the build-up of ions outside the cell) causes water to be drawn out by osmosis; d. this causes diarrhoea /excessive water loss from the body; e. water passes from blood into cells to replace lost fluid causing dehydration <b>OR</b> water lost faster than can be replaced causing dehydration;	c. <i>OWTTE</i>  e. <i>OWTTE</i>	3 max

Question			Answers	Notes	Total
22.	a		0.4 s;	<i>units required</i>	1
	b		P;		1
	c		a. atrioventricular/AV valves closed; b. semi-lunar valves open;		2
	d		a. many mitochondria for aerobic respiration; b. cells are branched allowing for faster transmission/allow impulse to spread; c. cardiac muscle is myogenic so does not require the CNS to initiate contraction; d. cells are not fused together/are connected by gap junctions/intercalated discs (which) allows easier transmission between cells;		3 max

Question		Answers	Notes	Total
23.	a	lungs/alveoli;		1
	b	a. fetal hemoglobin has a higher affinity for oxygen than normal hemoglobin; b. oxygen will pass from normal/maternal/mother's hemoglobin to fetal hemoglobin (in the placenta);		1 max
	c	to left of the curve for fetal hemoglobin;	<i>Do not accept above the curve.</i>	1
	d	a. help smokers to quit smoking as smoking worsens emphysema; b. pulmonary rehabilitation/learning special breathing techniques to reduce breathlessness; c. use inhaler/bronchodilator/medications to open the air passages in the lungs <b>OR</b> steroids can help relieve symptoms of emphysema associated with asthma/bronchitis; d. patients may require a device that gives them supplemental oxygen; e. lung transplantation may be an option for some patients with emphysema; f. lung volume reduction surgery to remove damaged lung tissue may be recommended; g. AAT/alpha-1 antitrypsin to slow progression of lung damage (in patients with AAT deficiency);		3 max



Question	Answers	Notes	Total
24.	<p>a. growth hormone is produced by the pituitary gland;                      b. hormone travels in blood plasma to the target organ/muscle;                      c. (peptide) hormone binds to receptor/protein on the surface of the cell;                      d. triggers cascade/series of reactions inside cell;                      e. reactions mediated by secondary messengers;                      f. secondary messengers allow amplification of the signal from the hormone;                      g. cascade can involve activating/inhibiting enzymes;                      h. secondary messengers cause a specific cell response in the nucleus of the cells  <b>OR</b>                      trigger gene expression;                      i. growth hormone stimulates protein synthesis/mineralization of bone/increase in cartilage cells;</p>	<p><i>Do not accept increase muscle mass or performance as that is in the stem.</i></p>	<p><b>6 max</b></p>