

Markscheme

May 2023

Biology

Higher level

Paper 3

30 pages

© International Baccalaureate Organization 2023

All rights reserved. No part of this product may be reproduced in any form or by any electronic or mechanical means, including information storage and retrieval systems, without the prior written permission from the IB. Additionally, the license tied with this product prohibits use of any selected files or extracts from this product. Use by third parties, including but not limited to publishers, private teachers, tutoring or study services, preparatory schools, vendors operating curriculum mapping services or teacher resource digital platforms and app developers, whether fee-covered or not, is prohibited and is a criminal offense.

More information on how to request written permission in the form of a license can be obtained from <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

© Organisation du Baccalauréat International 2023

Tous droits réservés. Aucune partie de ce produit ne peut être reproduite sous quelque forme ni par quelque moyen que ce soit, électronique ou mécanique, y compris des systèmes de stockage et de récupération d'informations, sans l'autorisation écrite préalable de l'IB. De plus, la licence associée à ce produit interdit toute utilisation de tout fichier ou extrait sélectionné dans ce produit. L'utilisation par des tiers, y compris, sans toutefois s'y limiter, des éditeurs, des professeurs particuliers, des services de tutorat ou d'aide aux études, des établissements de préparation à l'enseignement supérieur, des fournisseurs de services de planification des programmes d'études, des gestionnaires de plateformes pédagogiques en ligne, et des développeurs d'applications, moyennant paiement ou non, est interdite et constitue une infraction pénale.

Pour plus d'informations sur la procédure à suivre pour obtenir une autorisation écrite sous la forme d'une licence, rendez-vous à l'adresse <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

© Organización del Bachillerato Internacional, 2023

Todos los derechos reservados. No se podrá reproducir ninguna parte de este producto de ninguna forma ni por ningún medio electrónico o mecánico, incluidos los sistemas de almacenamiento y recuperación de información, sin la previa autorización por escrito del IB. Además, la licencia vinculada a este producto prohíbe el uso de todo archivo o fragmento seleccionado de este producto. El uso por parte de terceros —lo que incluye, a título enunciativo, editoriales, profesores particulares, servicios de apoyo académico o ayuda para el estudio, colegios preparatorios, desarrolladores de aplicaciones y entidades que presten servicios de planificación curricular u ofrezcan recursos para docentes mediante plataformas digitales—, ya sea incluido en tasas o no, está prohibido y constituye un delito.

En este enlace encontrará más información sobre cómo solicitar una autorización por escrito en forma de licencia: <https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/>.

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.

Section A

Question		Answers	Notes	Total
1.	a	2.4 μm	<p><i>Allow 2.2 to 2.6 μm</i></p> <p><i>Accept correct answers in other SI units e.g. mm/cm</i></p> <p><i>Units required.</i></p>	1
	b	<p>a. cardiac muscle cell has a higher solute concentration/lower water potential than hypotonic solution</p> <p>OR</p> <p>(in osmosis) water moves from a solution with higher water potential to lower water potential</p> <p>OR</p> <p>(in osmosis) water moves from lower concentrated solution to higher concentrated solution;</p> <p>b. water entering (by osmosis) causes cell to be swollen/enlarged/burst;</p>	<p><i>Do not accept "solution moves..." instead of water moves..."</i></p>	2

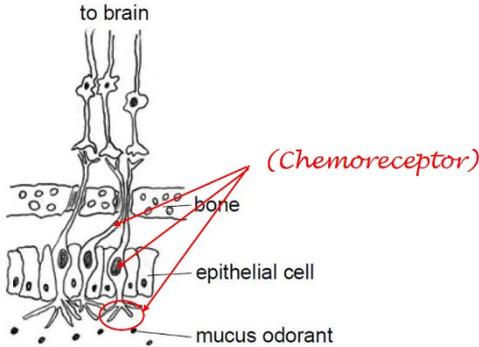
Question			Answers	Notes	Total
2.	a	i	enzyme/substrate/egg white concentration/volume/pH/temperature;	<i>Accept another reasonable variable.</i>	1
		ii	(with/without) ultrasound pretreatment / time;		1
	b		a. measure 10 g/parts egg whites; b. add to 90 g/parts of water;	<i>Accept use of volume instead of mass.</i>	2
	c		a. more reliable results; b. to identify outliers/anomalous results OR reduce random errors; c. assess the variability of the data OR allows statistical tests/calculation of mean/standard deviation/correlation;	<i>Mp a: do not accept "accurate".</i>	2 max
	d		it is not, as hydrolysis is higher without ultrasound pretreatment OR it is not, as hydrolysis is lower with ultrasound pretreatment;	<i>Do not accept numerical values only with no attempt to evaluate their importance.</i> <i>Do not accept increase/decrease instead of lower/higher.</i>	1

Question		Answers	Notes	Total
3.	a	a. temperature; b. pH; c. minerals / salt concentration / conductivity; d. O ₂ (concentration); e. CO ₂ (concentration);		2 max
	b	environmentally safe/cheaper/control of variables easier;		1
	c	a. photosynthetic organisms/autotrophs/plants as producers; b. <u>light</u> (as energy source) for photosynthesis; c. nutrient/water recycling (by saprotrophs); d. decomposers/saprotrophs to breakdown (toxic) wastes;	<i>The question is "outline", so do not accept only a list of variables without a brief account.</i>	2 max

Section B

Option A — Neurobiology and behaviour

Question		Answers	Notes	Total
4.	a	<p><i>The statement seems justified as:</i></p> <p>a. data shows there are more synapses at an early age</p> <p>OR</p> <p>synapses decrease with age;</p> <p>b. more synapses allow for greater learning/cognitive activity;</p> <p>c. information from the sensory neurons (auditory and visual) used to perform higher order functions (such as learning);</p> <p>d. huge variability at very early age in the number of synapses might mean different children might have differences in learning;</p> <p>e. insufficient information / no standard deviation;</p>	<p><i>Do not accept “connection” instead of “synapse”.</i></p>	<p>2 max</p>
	b	<p>a. <u>neural/synaptic pruning</u>;</p> <p>b. (neural/synaptic pruning) involves the loss of neurons/dendrites/synapse:</p> <p>c. synapses that are not used do not persist;</p>	<p><i>Do not accept “connection” instead of “synapse”.</i></p>	<p>2 max</p>
	c	<p>animal experiments / lesions / fMRI;</p>	<p><i>“f” must be written in fMRI.</i></p>	<p>1</p>

Question		Answers	Notes	Total
5.	a	properly labelled chemoreceptor;	<p><i>Accept label with lines pointing directly to any part of a receptor cell.</i></p> 	1
	b	<p>a. odorants are small/volatile molecules (with different chemical formulae);</p> <p>b. olfactory chemoreceptors have receptors (proteins) on surface membrane;</p> <p>c. each odorant attaches to its specific receptor;</p>		2 max
	c	<p>a. photoreceptor;</p> <p>b. proprioceptor/mechanoreceptor;</p> <p>c. thermoreceptor;</p> <p>d. baroreceptor;</p>	<p><i>If more than two receptors are written, mark only the first two.</i></p>	2 max

Question		Answers	Notes	Total
6.	a	a. template/basis of the song is innate (as all have the same base); b. (variations) learned from listening to adults; c. repeating the songs / learn with experience;		2 max
	b	a. template/basis of the song remains the same (as it is innate); b. repeated/mimicked song learned from surrounding adults/parent birds; c. new variation/tutor song learned by offspring (as typical song is not heard) OWTTE ; d. learning of variation isn't perfect/exact;		2 max

Question		Answers	Notes	Total
7.	a	a. affect synapses/synaptic transmission; b. interfere in neural transmission OR interrupt/block neural transmission; c. cause a reversible loss of sensation/numbness/unconsciousness; d. act between sensory neurons/receptors and central/autonomic nervous system (CNS);		3 max
	b	pathways/autonomic functions are inhibited / synapses blocked OR PNS/CNS are depressed;	<i>If more than one reason is written, mark only the first one.</i>	1 max

Question			Answers	Notes	Total
8.	a	i	<p>a. the longer the migration, the lighter the colour / <i>vice versa</i>;</p> <p>b. too much variation so it is not possible to see a relationship;</p>		1 max
		ii	<p>a. camouflage to avoid predators (in different migratory routes);</p> <p>b. different diets (in different migratory routes);</p> <p>c. less migratory distance leaves more energy to produce pigments (in plumage);</p> <p>d. geographic isolation (due to different migratory routes) leads to different gene pools;</p>		2 max
	b		<p>a. behavioral variations within the population have a genetic basis;</p> <p>b. selection pressure creates competition;</p> <p>c. individuals that are best adapted to the environment have greater chances of survival;</p> <p>d. adapted organisms have greater chances of reproduction/produce more offspring;</p> <p>e. advantageous alleles/behavior is inherited by offspring;</p> <p>f. (the frequency of) the favourable alleles/behaviour increases in the population;</p>	<i>Do not accept "genes" instead of alleles</i>	3 max

Question	Answers	Notes	Total
9.	<p>a. neurotransmitters are (chemicals) released by exocytosis/vesicles (in the pre-synaptic neuron) after the arrival of a nerve impulse;</p> <p>b. neurotransmitters leave the presynaptic neuron;</p> <p>c. (neurotransmitters) attach to receptors in the postsynaptic neuron;</p> <p>d. neurotransmitters (in the synaptic cleft) are broken down/reabsorbed;</p> <p>e. fast-acting neurotransmitters attach to protein-ion channels (in postsynaptic membrane);</p> <p>f. slow-acting neurotransmitters activate second messengers (in postsynaptic membrane);</p> <p>g. slow-acting neurotransmitters affect more than one neuron;</p> <p>h. some neurotransmitters excite nerve impulses (in postsynaptic neuron) while others inhibit them;</p> <p>i. excitatory neurotransmitter causes generation of action potential;</p> <p>j. inhibitory neurotransmitter prevents threshold being reached (preventing action potential);</p> <p>k. summation of all excitatory / inhibitory neurotransmitters received in postsynaptic neuron;</p>	<p><i>Mp e and f: accept correct named example of fast-acting or slow-acting neurotransmitters.</i></p> <p><i>Mp i and j: Accept correct named examples of excitatory/inhibitory neurotransmitters.</i></p>	<p>6 max</p>

Option B — Biotechnology and bioinformatics

Question		Answers	Notes	Total	
10.	a			2 max	
	b	i	archaeans/methanogenic bacteria/methanogens;	<i>Accept named examples.</i>	1
		ii	substrate/reactant / source of nutrients / organic matter for bacteria;		1
	c		a. changes in temperature/heat affect metabolic rate/limit enzyme activity; b. production of CO ₂ /carbonic acid decreases pH/increase acidity which denatures enzymes; c. high levels of toxins/ammonia/sulphur inhibit growth; d. increase in salt/organic matter/ethanol concentration can affect osmotic potential/metabolism; e. lack of nutrients prevents reproduction / OWTTE ;		2 max

Question		Answers	Notes	Total
11.	a	successful as the bands in lanes 4 <u>and</u> 5 are the same size as in lane 2/positive control / same size as the gene;		1
	b	DNA from non-transformed/normal plant cells because they lack HBsAg gene/ <i>OWTTE</i> ;		1
	c	a. kanamycin resistance is used as a marker (gene); b. kanamycin kills non-transformed cells; c. cells are grown in a plate/medium containing kanamycin; d. growth indicates successful uptake (of gene) OR no growth means no uptake of gene/Ti plasmid;		3 max

Question		Answers	Notes	Total
12.	a	a. quorum sensing; b. high biomass density; c. low/no cell division; d. limited supply of nutrients; e. less penetration/diffusion of substances; f. emergent properties;		1 max
	b	<i>Supports</i> a. results show that DPA removed outer layers / reduced EPS (of biofilm); b. total surface area reduced after 84 min DPA; <i>Does not support</i> c. bacteria still present; d. it is only a simulation / needs to be investigate experimentally;		2 max
	c	no change/slight decrease;		1

Question		Answers	Notes	Total
13.	a	sequencing;		1
	b	a. karyotyping can only detect large chromosomal rearrangements OR karyotyping detects at low resolution/down to a million bps; b. microarrays can detect whole genome changes in a single assay/array OR microarrays identify genomic imbalance widely/down to kilobase pairs OR microarrays use probes to detect genome changes/specific sequences OR microarrays are quicker/safer/easier;		2
	c	a. short sequence of cDNA OR DNA obtained from mRNA (by reverse transcription); b. approximately 500 to 800 nucleotides; c. represent (a portion) of expressed genes OR can be used to identify potential genes;		2 max

Question		Answers	Notes	Total
14.	a	28		1
	b	a. amino acid sequence obtained (in FASTA format); b. (alignment obtained by) BLASTp/CLUSTAL W/COFFEE / any named software; c. (sequence alignment) allows comparison of sequences (from different organisms) OR similar sequences are aligned next to each other; d. the percentage sequence similarity can be calculated;	<i>"p" must be written in BLASTp.</i>	3 max

Question	Answers	Notes	Total
15.	<ul style="list-style-type: none"> a. glyphosate is an herbicide/weed killing substance; b. tumour-inducing/Ti plasmid as a vector; c. glyphosate resistance gene cloned into/added to Ti plasmid; d. together with marker gene/antibiotic resistance; e. Ti plasmid transformed to/inserted in bacteria/<i>Agrobacterium tumefaciens</i>; f. only antibiotic resistant bacteria selected; g. <i>A. tumefaciens</i> infects soybean cells; h. transgenic DNA integrated into soybean chromosomes; i. glyphosate resistance expressed by soybean; j. soybeans not killed when sprayed with glyphosate (only weeds are killed); 	<i>Allow other viable techniques</i>	6 max

Option C — Ecology and conservation

Question		Answers	Notes	Total
16.	a	sap beetles are herbivores/primary consumers of strawberry plants which are producers;	<i>Both required.</i>	1
	b	a. ripe/semi-ripe have more damage than green; b. supports that ripe/semi-ripe emit more chemicals (and attract more beetles) OR supports that green emit less chemicals (and attract less beetles); c. no data on error bars/standard deviation (makes support difficult);	<i>Do not accept values only, unless commented.</i>	2 max

Question		Answer	Notes	Total
17.	a	colonization of areas that were barren/not previously inhabited/not occupied by organisms;		1
	b	a. light limits photosynthesis OR daylength limits growth season; b. (low) temperature limits growth/slows metabolism OR (low) temperature slows activity of decomposers; c. (lack of) water due to frozen water/permafrost OR (lack of) water/rain limits photosynthesis/productivity; d. nutrients (in permafrost)/quality/depth of soil limit production of organic molecules / OWTTE OR insufficient soil / permafrost for tree growth;	<i>Award marks only for factors accompanied by a description.</i>	2 max
	c	a. weathering of rock accumulates matter (allowing pioneer species to grow); b. decay/decomposition of organisms increase organic matter/detritus/litter; c. increased soil allows larger/more plants to grow / roots preventing erosion; d. as more plants are decomposed, soil depth/amount of soil available increases;		2 max

Question			Answers	Notes	Total
18.	a	i	the higher the DDE concentration, the lower the thickness/higher the thinning OR negative correlation/inverse relationship;	<i>Accept vice versa.</i>	1
		ii	more risk of predation/ eggs break more easily/fewer chicks hatch;	OWTTE	1
	b		a. California, as most eggs have a high level of DDE / most eggshells are thinning; b. (California as) less chicks hatching (results in smaller population size) OR (California as) birth rate less than death rate (so decrease in population);		2
	c		a. DDE accumulates in (fat tissues of) organisms/bioaccumulation; b. (brown) pelicans/birds feed on fish/organisms (that have accumulated DDE); c. (DDE) is not excreted; d. (DDE) concentration <u>increases</u> as trophic level increases; e. (brown) pelicans are in a high trophic level (so have a high accumulation);		3 max

Question	Answers	Notes	Total
19.	a. high growth rate (before day 6) depleted nutrients; b. overcrowding/competition for resources; c. (intraspecific) <u>competition</u> slows growth rate; d. carrying capacity has been reached/stabilized; e. intoxication from excretion limits growth;	<i>mp b: Accept resources examples such as CO₂, nutrients, light, space, etc.</i>	3 max

Question		Answers	Notes	Total
20.	a	a. excess nutrients/eutrophication; b. excessive growth of algae/algal blooms; c. blocking of sun prevents photosynthesis; d. increased decomposition of algae/organisms; e. increased biochemical oxygen demand/BOD; f. other organisms/fish die due to lack of oxygen;		3 max
	b	the higher the elevation, the greater the nitrogen content OR positive relationship;		1
	c	a. pitcher plants consume more insects (at different sampling sites); b. larger insects contain more nitrogen; c. more nitrogen concentration in soil OR more nitrifying bacteria in the soil OR water-logged soil has less nitrogen; d. use of N/NPK fertilizers OR leaching of N in different sites; e. more litter at different sites;		2 max

Question	Answers	Notes	Total
21.	<p>a. biogeographic features are combinations of species, habitats and physical features;</p> <p>b. richness is the number of different species present (in an area);</p> <p>c. evenness refers to relative abundance of the different species (in an area) / OWTTE;</p> <p>d. large nature reserves/large islands (potentially) have greater biodiversity / richness / evenness;</p> <p>e. large areas (tend to) have more species/populations/habitats/richness OR large areas have more stability/higher biodiversity index OR have less chances of loss of a species;</p> <p>f. connected areas/nature reserves have more diversity than isolated ones OR corridors between (small) areas/ reserves increases richness/biodiversity;</p> <p>g. the greater the surface:perimeter ratio, the greater the biodiversity;</p> <p>h. edges are transition areas OR have greater richness/lower evenness OR are less stable;</p> <p>i. circular shape has more biodiversity than rectangular shape;</p> <p>j. biodiversity measured by Simpson's / diversity index;</p> <p>k. one additional abiotic factor affecting biodiversity;</p>	<p><i>e.g. precipitation, soil quality/content, temperature, etc.</i></p>	<p>6 max</p>

Option D — Human physiology

Question			Answers	Notes	Total
22.	a	i	(relatively) low risk as a few/5% have vit C below RDA;		1
		ii	high risk, as many/90% have low intake of iron;		1
	b	i	a. constipation OR slow intestinal transport/transit; b. increased chances of diabetes/cancer/hemorrhoids/appendicitis/obesity; c. higher blood glyceemic index;		1 max
		ii	low bone mineralization/rickets/osteomalacia/osteoporosis;		1
	c		a. <u>essential</u> fatty acids missing; b. not enough energy/calories (for organs); c. not enough phospholipids (for cell membrane production); d. not enough myelin for neurons; e. not enough steroid/named steroid hormone produced; f. low levels/absorption of fat-soluble vitamins; g. insufficient HDL/LDL/cholesterol;	<i>Accept the definition or an example of essential fatty acid instead.</i> <i>Reject insulation</i> <i>No mark if the named hormone is not a steroid.</i>	1 max

Question		Answers	Notes	Total
23.	a	a. controlled by nervous <u>and</u> hormonal mechanisms; b. hydrochloric acid is secreted; c. secreted by parietal cells/stomach wall/lining; d. achieved by a proton pump / H ⁺ -K ⁺ ATPase; e. H ⁺ from the cytoplasm exchanged for K ⁺ in lumen;	<i>Accept details to that effect, e.g. gastrin.</i>	2 max
	b	a. proton pump inhibitors (PPI) used; b. PPIs activated by acid; c. PPIs bind irreversibly to pump OR prevent stomach cells from pumping acid into stomach;		2 max
	c	a. drugs/PPI will decrease risk of duodenal cancer as acid production will decrease; b. drugs/PPIs will increase/not affect risk of gastric cancer as it is related to low acid production; c. antibiotics will decrease risk of duodenal cancer as they kill <i>H. pylori</i> , thus reduce acid production;		1 max

Question	Answers	Notes	Total
24.	<p>a. raised blood pressure damages arteries/coronary/cerebral blood vessels (manifesting as heart attacks and strokes);</p> <p>b. smoking tobacco causes greater platelet aggregation (increases risk of thrombosis/CHD due to atherosclerosis)</p> <p>OR</p> <p>smoking tobacco lowers oxygen supply / greater oxygen demand (so heart works more)</p> <p>OR</p> <p><u>nicotine</u> (in smoking tobacco) causes vasoconstriction/raises blood pressure (that can damage arteries);</p> <p>c. high glucose causes stronger contraction of blood vessels/raised blood pressure (causing damage to arteries/ coronary/cerebral blood vessels);</p> <p>d. physical inactivity prevents return of venous blood from the extremities;</p> <p>e. overweight and obesity causes greater risk of clot/plaque formation</p> <p>OR</p> <p>overweight and obesity raises blood pressure/vasoconstriction;</p> <p>f. high cholesterol promotes plaque formation/blockage of arteries (which increases risk of thrombosis/CHD due to atherosclerosis);</p>	<p><i>If more than two factors written, mark only the first two descriptions.</i></p> <p><i>Award only if descriptions are included.</i></p>	<p>2 max</p>

Question		Answers	Notes	Total
25.	a	a. nursing/suckling stimulates prolactin production OR (prolactin production) starts to increase during breast feeding; b. prolactin produced by the <u>anterior</u> pituitary; c. regulated by hypothalamus / estrogen; d. prolactin promotes milk production (by mammary glands);		2 max
	b	oxytocin;		1

Question		Answers	Notes	Total
26.	a	<ul style="list-style-type: none"> a. oxygen binds to hemoglobin; b. oxygen is bound to iron/heme; c. carbon dioxide is carried bound to hemoglobin/as carboxyhemoglobin (in red blood cells); d. carbon dioxide is transformed (in red blood cells) into hydrogen carbonate ions; 		3 max
	b	<ul style="list-style-type: none"> a. less oxygen/lower pO₂ in the air at high altitude; b. difficult for hemoglobin to become saturated; c. (low oxygen) necessitates more hemoglobin; d. increase in red blood cell production increases total hemoglobin; e. more hemoglobin can transport more oxygen; 		3 max
	c	<ul style="list-style-type: none"> a. phagocytosis/engulfed (of red blood cells) by Kupffer cells/macrophages; b. hemoglobin split into globin and heme group; c. amino acids (from the globin) recycled; d. heme group broken down into iron and bilirubin; 		3 max

Question	Answers	Notes	Total
27.	<p><i>Adaptations for absorption:</i></p> <ul style="list-style-type: none"> a. epithelial cells are one cell layer thick which facilitates transport (from the lumen to blood vessels); b. (epithelial cells) joined by tight junctions prevents leakage/<i>OWTTE</i>; c. (each cell has) microvilli/brush border to increase absorption surface <p>OR</p> <ul style="list-style-type: none"> microvilli provide large surface area:volume ratio to increase absorption rate; d. epithelial cells close to capillaries for transport/<i>OWTTE</i>; e. epithelial cells rich in mitochondria to provide energy/ATP (for active transport); f. membranes contain protein channels used for co-transport/facilitated diffusion of substances; g. vesicles in large numbers for absorption of larger molecules (by endocytosis); <p><i>Storage in liver:</i></p> <ul style="list-style-type: none"> h. glucose is stored as glycogen (in the liver/hepatocytes); i. fatty acids/fats stored in hepatocytes; j. excess Vitamin A/D stored in hepatocytes; k. iron/minerals stored in hepatocytes; l. detoxification/breakdown of toxins; 	<p><i>Allow maximum of 5 marks for absorption.</i></p> <p><i>Accept correct examples.</i></p> <p><i>Accept correct examples.</i></p>	<p>6 max</p>