



MARKSCHEME

May 2009

BIOLOGY

Standard Level

Paper 3

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Subject Details: **Biology SL Paper 3 Markscheme**

Mark Allocation

Candidates are required to answer questions from **TWO** of the Options [**2 × 18 marks**].

Maximum total = [**36 marks**].

1. A markscheme often has more marking points than the total allows. This is intentional. Do **not** award more than the maximum marks allowed for part of a question.
2. Each marking point has a separate line and the end is signified by means of a semicolon (;).
3. An alternative answer or wording is indicated in the markscheme by a slash (/). Either wording can be accepted.
4. Words in brackets () in the markscheme are not necessary to gain the mark.
5. Words that are underlined are essential for the mark.
6. The order of marking points does not have to be as in the markscheme, unless stated otherwise.
7. 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 markscheme then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by writing **OWTTE** (or words to that effect).
8. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.
9. 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. Indicate this with **ECF** (error carried forward).
10. Only consider units at the end of a calculation. Unless directed otherwise in the markscheme, unit errors should only be penalized once in the paper. Indicate this by writing **-1(U)** at the first point it occurs and **U** on the cover page.

Option A — Human nutrition and health

- A1.** (a) legumes [1]
- (b) *similarities:*
 contribution to energy intake by legumes remained the same/very similar / very small decrease in both rural and urban areas;
 contribution to energy intake by fat increased over 10 years in both rural and urban areas;
 contribution to energy intake by animal sources increased in both;
 contribution to energy intake by cereals decreased in both;
- differences:*
 contribution to energy intake by tubers was unchanged in urban but decreased in rural; [3 max]
- (c) increased blood cholesterol levels;
 increased atherosclerosis;
 increased coronary heart disease;
 increased stroke;
 increased bowel cancer/constipation due to lower fibre intake; [3 max]
- A2.** (a) hormones produced by empty stomach / hormones (insulin) produced in pancreas/small intestine after eating / by adipose tissue (leptin) in response to fat storage;
 pass to appetite control centre of brain/hypothalamus;
 leads to a feeling of hunger/satiety; [2 max]
- (b) body weight is maintained at well below normal;
 avoidance of fattening foods;
 excessive exercise / using laxatives or diuretics / self-induced vomiting;
 fear of putting on weight / sufferers preoccupied with the shape or size of their bodies;
 may cause hormonal disturbances / women with anorexia nervosa may stop having periods / infertility;
 weaker physical strength due to excessive weight loss;
 loss of bone mass / leads to osteoporosis;
 leads to anxiety in family and friends;
 can be fatal; [2 max]

A3. (a) determine how much vitamin C a person must take in order to have a continuously elevated level of vitamin C in the urine / how often that dosage must be taken to provide a continuously elevated level;
measurement of blood plasma levels of vitamin C and excretion of by-products of vitamin C;
pharmacokinetic models of vitamin C absorption and excretion, based on existing published studies;

[3]

(b) vitamin C needed to prevent scurvy / has antioxidant function;
vitamin C is an essential vitamin in the (human) diet / it cannot be synthesized;
it cannot be stored / it is excreted in the urine;
variation in recommended dosage between health agencies;
dosage affected by body mass/metabolism;
40–100 mg day⁻¹ the accepted normal adult range;
mega doses (1000 mg day⁻¹) suggested by Linus Pauling to avoid colds/respiratory tract infections/cancer;
Pauling's recommendation was followed by many due to his public standing rather than evidence;
rebound malnutrition;

[4 max]

Option B — Physiology of exercise

- B1.** (a) 183 s/seconds (*units required*) [1]
 (Accept 181–185 s/seconds)
- (b) $\left(\frac{15}{130} \times 100\right) = 11.5\%$ (*units required*) [1]
 (Accept answers in the range 11–12%)
- (c) the longer the time spent swimming, the better the response time in group 3;
 after sixteen days there is no/little difference between both groups;
 by day 31 group 3 learned most effectively;
 after day 16 response time in group 2 drops slightly but group 3 increases further; [2 max]
- (d) day 2 results suggest that each group started with the same ability to learn;
 regular exercise resulted in increased learning;
 group 3 had the best learning after 31 days suggesting that daily exercise benefits learning;
 group 2 was second best in learning / control group was worst at learning, supporting the idea that exercise assists learning;
 numerical support for the above;
 increase in response time reflects greater learning and when exercise stops effect wears off; [3 max]
- B2.** (a) *vital capacity*: the maximum volume of air exhaled after maximum inhalation;
tidal volume: (normal) volume of air taken in (or out) with (each) inhalation (or exhalation)/in a single breath; [2]
- (b) ventilation rate at rest decreases (from 14 to 12 breaths per minute);
 maximum ventilation rate increases (from 40 to 45 or more breaths per minute);
 vital capacity may increase;
 blood supply to the lungs is increased;
 improved oxygen absorption (in alveoli);
 tidal volume can increase slightly at rest and more during exercise; [2 max]

- B3.** (a) a person's ability to perform specific physical activities *[1]*
- (b) fast muscle fibres require more oxygen (than slow muscle fibres);
fast muscle fibres have less myoglobin (than slow muscle fibres);
fast muscle fibres provide maximum work over a shorter period/used for higher intensity short-term exercise;
fast muscle fibres have fewer mitochondria / respiration often anaerobic / slow fibres have more mitochondria/aerobic; *[2 max]*
- (c) taken by body builders as it is reputed to increase muscle mass;
some suggest that mass gains are due to increased water retention;
high intensity anaerobic sports report performance enhancement;
less certain results for swimming and running;
upper limit to amount body can store;
supplementation not recommended for adolescents/people with kidney dysfunction;
supplementation may suppress the body's natural synthesis;
CP supplements not suitable for enhancing aerobic exercise performance; *[4 max]*

Option C — Cells and energy

- C1.** (a) (i) 10.3 mU mg⁻¹ protein [1]
 (Accept answers in the range 10–10.5 mU mg⁻¹)
- (ii) 3 mM [1]
 (Accept answers in the range 3–5 mM)
- (b) as pyruvate increases so does peak enzyme activity;
 rate of decrease after the peak becomes less with increasing pyruvate concentration;
 at 12 mM activity is maintained at just over 14 mU per mg protein; [2 max]
- (c) presence of pyruvate stimulates pyruvate dehydrogenase activity (because increasing pyruvate causes increased activity);
 as pyruvate increases, more probability of collisions with active site of enzyme so higher activity;
 at lower pyruvate concentrations substrate quickly used up so rate/activity decreases;
 at high concentration of pyruvate there is enough substrate to saturate all active sites on enzyme and maximal activity is maintained; [3 max]
- C2.** (a) I – outer membrane (Accept inter mitochondrial space)
 II – matrix
 III – rough endoplasmic reticulum
 IV – crista(e)/inner membrane [2]
 Two structures required for [1]. All four structures required for [2].
- (b) cristae form a large surface area for the electron transport chain/oxidative phosphorylation;
 small space/volume between inner and outer membranes/intermembrane space for accumulation of protons;
 fluid matrix contains enzymes of the Krebs cycle/link reaction;
 ATP synthase/synthetase present on inner membrane;
 mitochondrion exhibits compartmentalisation to allow different respiratory processes to be controlled/regulated; [2 max]

- C3.** (a) ribulose biphosphate carboxylase / RuBP carboxylase / Rubisco (*Accept ATPase*) [1]
- (b) enzyme and substrate join;
enzyme active site changes shape to fit the substrate;
allows some enzymes to bind to/catalyze several substrates;
conformational change of active site; [2 max]
- (c) presence of product inhibits process;
product acts as non-competitive inhibitor/binds to allosteric site;
inhibition (usually) of the first enzyme;
suitable example *e.g.* enzyme pathways in glycolysis;
end product changes structure of active site;
making binding of substrate more difficult;
process is an example of negative feedback;
suitable example *e.g.* inhibition of threonine dehydrate by isoleucine; [4 max]

Option D — Evolution

- D1.** (a) $\frac{790-570}{570} \times 100 = 39\%$; (units required) [2]
 (Accept answers between 37–41% with the corresponding correct calculation. No marks if just difference (790–570) calculated.)
- (b) from earlier periods less fossil evidence available;
 because of more niches available at lower sea temperature / species spreading over greater depth / they evolved so more species/more time for adaptive radiation (speciation);
 modern classification methods recognize more species than previous methods;
 more research done at greater depths; [2 max]
- (c) valve length increases over time while average sea temperature decreases / there is an inverse/negative correlation between shell size and sea temperature;
 evolution of new species was slow up to approx. 5 million years ago when sea temperature was highest / evolution of new species was faster in last 5 million years when sea temperature was lower;
 depth of habitat not assessed for extinct species;
 conclusions unreliable because of lack of data from earlier time periods / conclusions unreliable because temperature relatively constant between 30 and 10 million years ago but the range of valves varies by about 100 µm; [3 max]
- D2.** (a) non-living synthesis of simple organic molecules;
 from mixture of **any three** of methane, ammonia, water vapour and hydrogen;
 assembly of these organic molecules into polymers;
 the origin of self-replicating molecules that made inheritance possible;
 the packaging of these molecules into membranes with an internal chemistry different from their surroundings;
 binary fission of cell; [3 max]
- (b) endosymbiosis theory states that eukaryotes are formed from prokaryotes;
 symbiosis is an association between two or more species;
 mitochondria of eukaryotes evolved from aerobic bacteria;
 chloroplasts evolved from primitive autotrophic prokaryotes;
 taken into larger heterotrophic cells by endocytosis;
 eukaryotes formed membranes that could contain the prokaryotes;
 mitochondria/chloroplasts have DNA/RNA similar to prokaryotes;
 mitochondria/chloroplasts have double membrane; [3 max]

- D3.** (a) forward facing eyes/binocular vision;
large brains;
flexible shoulder joints / shoulder blades on the dorsal side of the thorax;
manual dexterity / power grip / opposable thumb / grasping limbs;
finger pads / nails not claws;
skull adapted for upright posture;
pronation / rotating hand; **[2 max]**
- (b) fossilization is an exceptionally rare occurrence;
most components of formerly living things tend to decompose relatively quickly following death;
fossilization tends to favour hard body parts;
fossilization favours species that were widespread/lived for a long time;
paleoanthropology is an inductive/data-poor science (a relatively small amount of data is used to draw conclusions);
many of the conclusions that have been drawn on limited data have not stood for long;
exposed fossils are soon destroyed/weathered, reducing the chance of them being found;
new discoveries regularly come to light, leading scientists to re-interpret previous assumptions in the light of the new data;
examples *e.g.* the Dmansi site, Georgia, discoveries have led to a re-evaluation of previous theories of human evolution; **[3 max]**

Option E — Neurobiology and behaviour

- E1.** (a) $\frac{52-20}{20} \times 100 = 160\%$ (*units required*) [1]
- (b) bees with previous exposure/experimental group fly around the source more than the control group;
 bees with previous exposure/experimental group fly towards the source more than the control group;
 bees with previous exposure/experimental group circle more than the control group;
 in bees with previous exposure, orientated flight is greater than circling; [2 max]
Accept vice versa statements.
- (c) the bees associate the odour with food, and this is learned/conditioning behaviour [1]
Do not accept taxis or simply learned behaviour or conditioning.
- (d) previous exposure leads bees to fly to food source more directly;
 giving them an advantage in finding food;
 increasing their chance of survival;
 and passing their genes to the next generation;
 less energy expended finding food;
 more direct flight/less flight time reduces chance of predation; [3 max]
- E2.** (a) A: cone
 B: rod
 C: bipolar cell
 D: ganglion cell [2]
Two structures required for [1]. All four structures required for [2].
- (b) arrow drawn from bottom of diagram pointing upwards [1]
- (c) *A direct comparison must be made.*
 rod cells more effective in low light/night than cone cells; *Accept converse*
 rod cells detect a broad range of wavelengths/colours whereas cone cells are sensitive to a specific wavelength/specific colours;
 groups of rod cells pass impulses to a single nerve fibre whereas a single cone cell passes impulses to a single nerve fibre / rods give less visual acuity;
 both are photosensitive;
 rod cells more sensitive to movement whereas cone cells give higher visual acuity/sharpness;
 rod cells respond more slowly to light whereas cone cells respond more rapidly; [3 max]

- E3.** (a) *Award [1] for any two of the following:*
benzodiazepine (also known as valium/diazepam) / alcohol / tetrahydrocannabinol (THC) **[1]**
Accept any correct alternatives.
- (b) *definition/explanation of addiction: [1 max]*
addiction is dependence on a substance (such as alcohol or other drugs) or an activity;
stopping is very difficult and causes severe physical/mental reactions/complex behaviour;
- reference to genetic factors: [1 max]*
predisposition may be determined by polygenic inheritance;
significant role of environmental factors;
- discussion of dopamine action: [3 max]*
dopamine released in response to reward/e.g. food / associated with pleasure pathways;
some drugs/heroin/cocaine enhance dopamine activity;
abuse of drugs hypothesized to lead to down-regulation of dopamine receptors;
requires increasing amounts to achieve same effect; **[4 max]**

Option F — Microbes and biotechnology

- F1.** (a) $(12 \text{ litres} \times 3 \text{ mg dm}^{-3}) = 36 \text{ mg}$ (*units required*) [1]
- (b) inverse relationship;
 approximately the same rate for decrease in terephthalate concentration and increase in methane production;
 linear degradation of terephthalate and methane production;
 at day 12 methane production starts to level out/plateaux/terephthalate concentration is at zero; [2 max]
- (c) anaerobic methanogenic bacteria / chemoheterotroph [1]
- (d) breakdown rate is (approximately) constant;
 terephthalate concentration decrease and methane concentration increase are linked;
 concentration of 3 mg l^{-1} is non-lethal for these bacteria;
 breakdown is very efficient/is 100%;
 breakdown is slow (as it takes 12 days); [2 max]
- F2.** (a) gene therapy involves the replacement of defective genes;
 viral vector (genetically) modified for (safe) use;
 insertion of desired gene/allele into viral genome/retrovirus;
 an example is the use in SCID/lack of enzyme ADA in SCID; *Accept other example e.g. cystic fibrosis*
 removal of somatic cells;
 introduction and insertion of the desired gene into the target cell;
 the cells are replaced in the patient so that the desired gene can be expressed; [3 max]
- (b) at present gene therapy treatment effects may be short lived / process may need to be repeated/fails;
 reintroduction of cells/introduction of viral vector to the patient risks immune response;
 viral vectors may inadvertently infect the patient;
 insertion of DNA may lead to tumours;
 risk of death; [2 max]

- F3.** (a) weak acid may lower intracellular pH of micro-organisms / prevents growth of micro-organisms;
e.g. acetic acid is used to pickle onions; *Accept other example*
salt may be used to create high osmotic potential drawing out water, killing microbes;
e.g. salted meat; *Accept other example*
sugar may be used to create high OP drawing draw out water, killing microbes
e.g. preserved fruits; *Accept other example*
lye (sodium hydroxide) may raise intracellular pH of micro-organisms / prevents growth of micro-organisms;
e.g. lye is used to produce hominy and lutefisk; *Accept other example* **[4 max]**
- (b) named example *e.g.* *Salmonella*; (*Accept typhoid/cholera with correct symptoms and treatment*)
symptoms: vomiting, abdominal pain, diarrhoea, fever;
treatment: rehydration therapy, anti-vomiting/anti-diarrhoea medication; **[3]**
Symptoms must be matched to treatment. Need reference to treatment for [3].
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Option G — Ecology and conservation

- G1.** (a) $45 \text{ trees} \times 10^{-1} \text{ hectare}^{-1} / 4.5 \text{ trees hectare}^{-1} / \text{per hectare}$ (*units required*) **[1]**
 (Accept answers in the range 41–47 trees $\times 10^{-1} \text{ hectare}^{-1}$)
- (b) total number of small trees is lowest furthest from the main road;
 from 1–4 km number of trees 5–10 cm/2–5 cm fairly stable;
 number of trees 10–25 cm highest 1 km from main road; **[2 max]**
- (c) small tree density generally declines (but with an increase at 4 km);
 drop in density of small trees furthest from the main road; **[1 max]**
- (d) distribution of small trees similar between Katavi National Park and Usevya Open Area;
 Katavi National Park – no logging so has more large trees;
 Usevya Open Area (at 5 km from road) distance too great for logging of trees;
 small tree density in both areas low because number of large trees is higher/
 highest small tree densities near the road;
 no information given on density of large trees; **[3 max]**
- G2.** (a) *Appropriate example: [1 max]*
 impact on specified ecosystem;
e.g. Cane toad introduction to Australia; (Accept rats to New Zealand, etc.)
Check with Google for validity of other examples.
 impact on specified ecosystem;
 competes with local toads/frogs to displace them;
 poisons local mammals; **[3 max]**
Allow [1 max] if valid discussion of impact in general terms without an example.

- (b) correctly named biome *e.g.* temperate deciduous forest;
 temperature range / *e.g.* warm/15–18°C summers and cold/3–7°C winters /
 significant annual temperature variation;
 dominant plant/ecosystem characteristics *e.g.* dominant plants are broad leaf trees
 (that lose leaves annually) / significant diversity of understanding plants;

Biome	Temperature	Vegetation
desert	hot (30°C+) in day and cold (below zero) at night	xerophytes / succulent / sparse low-lying bushes adapted to water conservation;
savanna	hot (20–30°C)	grasslands with widely spaced trees;
tropical rain forest	very hot (25–30°C)	epiphytes / trees and wide leaf plants in undergrowth / huge diversity / tall mature trees of many species;
temperate deciduous forest	warm/mild (5–20°C)	trees that lose leaves in winter;
taiga	cold (around zero)	coniferous/evergreen trees densely packed (few species);
tundra	minus temps for most of the year	small and close to ground / red leaves / grasslands with a few small trees (perennial herbs grow in summer);

[2 max]

Allow [1] for either temperature or vegetation if biome correctly named.

- G3.** (a) the total dry organic matter of living organisms/ecosystems [1]
- (b) organism/sample is cleaned of any other material (*e.g.* plant is pulled free of soil and roots washed);
 measure wet mass of organism/sample;
 organism/sample is dried in an incubator/drying oven to constant mass;
 biomass calculated based on wet mass of sample; [2 max]
- (c) biomass is largest in lowest trophic level / lowest in highest trophic levels /
 decreases from lower to higher trophic levels;
 only 10–20% organic material/biomass passes up each trophic level;
 organic material used for respiration / activity / lost as heat; [3]
Accept suitable examples to illustrate answer.