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MARKSCHEME

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BIOLOGY

Higher Level

Paper 3

13 pages

General Marking Instructions

Subject Details: Biology HL Paper 3 Markscheme

Mark Allocation

Candidates are required to answer questions from **TWO** of the Options **[2 × 20 marks]**.
Maximum total = **[40 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. 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.

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.

Option D — Evolution

D1. (a) 2 (%) *(units not required)* ***[1]***
Allow answers in the range of 2.0 to 2.1.

(b) 17.5% *(allow answers in the range of 17.3 to 17.7%)* ***[1]***

(c) both show range variation;

average genetic divergence of mtDNA much less than average nDNA; *Allow numerical comparison.*

greater range of genetic variation in nDNA than mtDNA / 18% in nDNA and 6.5% in mtDNA;
three of mtDNA have less than 1% genetic divergence while none of nDNA have less than 5%;
the highest divergence of mtDNA is similar to the lowest of nDNA;
mtDNA3 and nDNA8 have no (known) species with the same sequence divergence; ***[3 max]***

(d) mtDNA (appears to be) more stable (due to less genetic divergence) / converse;
mtDNA (likely) has fewer genes which could be a limit on the accumulation of mutations / converse;
mtDNA more stable as no meiosis/cross-over/chromosome re-assortment;
smaller range of genetic divergence may indicate that they had a common ancestor/are more closely related;
natural selection could put more pressure on nDNA / more evolutionary change;
problem in using mutations as an evolutionary clock / different genetic divergence / different rates of mutation depending on the genes examined;
the high rates of nDNA6 divergence could be neutral substitutions / no effect / intronic;
insufficient data to know the effects of these mutations; ***[3 max]***

D2. (a) cultural evolution involves passing of technology/language/customs from one generation to the next / does not affect the gene pool/change the genetic makeup while genetic evolution involves passing of genes/genetic mutations from one generation to another / *OWTTE*;
cultural evolution allows for faster changes than genetic evolution; ***[1 max]***
Accept any other valid difference.

(b) long stable periods / little change;
short periods of sudden/rapid evolution;
e.g. volcanic evolution/meteor impact causing sudden climatic/environmental changes / other valid examples; ***[2 max]***

D3. (a) *analogous*: ***[2 max]***
similar structures but different (evolutionary) origins / different basic structure but same function;
e.g. vertebrate and invertebrate eyes / insect and human legs;
Accept any other valid example.

homologous: ***[2 max]***
structures are of similar origin / same basic structure but different functions;
e.g. pentadactyl limbs in vertebrates; ***[4]***
Accept any other valid example.

(b) for two alleles of a given genetic characteristic, three possible genotypes exist; { *Accept examples of genotypes.*
predicts frequencies of dominant and recessive alleles of a given gene;
homozygous for each allele and heterozygous;
frequency of dominant allele = p, recessive/albino allele = q;
total frequency of both alleles $= 1$ *or* $p + q = 1$;
random mating, probability of receiving two dominant alleles is $p \times p$ *or* p^2;
probability of receiving two recessive alleles is $q \times q$ *or* q^2;
expected frequency of heterozygous genotype is $2pq$;
$p^2 + 2pq + q^2 = 1$;
assumes no mutations / large population / random mating / no selective pressure / no immigration nor emigration;
explains why recessive alleles do not disappear over several generations;
$q^2 = \frac{1}{20\,000}$ *or* $q = 0.007$ (frequency of recessive);
$p = 1 - 0.007$ *or* 0.993;
frequency of dominant $p^2 = 0.986$ *or* 98.6%;
frequency of heterozygotes $2pq = 0.014$ *or* 1.4%; ***[5 max]***
Accept values with more significant figures.

Option E — Neurobiology and behaviour

E1. (a) 15 s *(allow answers in the range of 14 s to 16 s)* ***[1]***

(b) lemon ***[1]***

(c) the greater the colour contrast, the shorter the search times / negative correlation ***[1]***

(d) hypothesis (seems to be) supported as in larger flowers (15 mm and 25 mm) colour contrast seems to be the strategy used to detect flowers;
hypothesis (seems to be) supported as in smaller flowers (8 mm) colour contrast does not affect search times / always long search times;
colour contrast is difficult to see in very small flowers from a distance;
so another strategy must be used (*e.g.* scent / green receptor signal);
lemon colour is an exception as always has low search time;
bumblebees receive stimulus in lemon coloured flowers not perceived in other colours / lemon coloured real flowers might have more sucrose;
density of flowers not known; ***[3 max]***

(e) innate behaviour (shown by most bumblebees) helps them find flowers (instinctively) with more food sources/camouflage better so survive better;
learned behaviour (taught by other bumblebees) helps them find flowers with more food sources/camouflage better/more adaptable to changing conditions so survive better; ***[1 max]***
Accept references to taxis and foraging behaviour.

E2. (a) *Award **[1]** for any two of the following correct names.*
I. bones of middle ear / ossicles / malleus, incus and stapes;
II. auditory nerve/ cochlear nerve;
III. cochlea;
IV. eardrum / tympanic membrane / tympanum; ***[2]***

(b) animals learn to avoid dangerous situations/predators;
animals learn how to hunt/obtain food;
animals learn to adapt to changing environments;
e.g. birds learn to avoid the bad-tasting black and orange caterpillars of the cinnabar moth (by classical conditioning) and thus avoid possible poisoning; ***[2 max]***
Accept any other valid examples.

E3. (a) name of organism and behaviour;
adaptive value; ***[4 max]***

e.g. Baltic grey seal has diurnal activity;
allows them to find food;

e.g. shore crabs are inactive during low tide/active during high tide;
hunt organisms that come in on tide;
Accept any other valid examples.

(b) lesions (from accidents/birth) indicate effect of loss of area;
e.g. split brain patients/severed corpus callosum led to understanding different functional roles of left and right hemispheres / other valid examples;
many actions of the body involve different areas of the brain;
damage may be to several/many parts so results unclear;
difficult to interpret due to complexity of reactions;
fMRI gives a more specific knowledge of stimulated area/activation;
e.g. used to study/diagnose ADHD/dyslexia/recovery from strokes/music comprehension / other valid examples;
non-invasive / no damage to brain;
can study healthy subjects;
involves blood flow/supply/oxygenation;
not neuronal connections (so requires interpretation);
good spatial but poor temporal resolution;
problem of statistical interpretations of model; ***[5 max]***
*Award **[4 max]** if either brain lesions or fMRI alone are discussed.*

Option F — Microbes and biotechnology

F1. (a) (i) (non-denitrifying bacterium) 3 ***[1]***

(ii) *A. cycloclastes*/Ac ***[1]***

(b) (i) 0.57 arbitrary units *(allow answers in the range of 0.54 to 0.60)* ***[1]***

(ii) 68 (%) *(units are not required)* ***[1]***
Accept answers in the range of 68.0 to 68.5.

(c) *R. sphaeroides* strain c causes more inhibition in (all three non denitrifying bacteria) than *A. cycloclastes*/Ac;
both have less effect on (non denitrifying bacterium) 1 than on the other two;
each has approximately the same inhibitory effect on (non-denitrifying bacterium) 2 and (non-denitrifying bacterium) 3 (but *R. sphaeroides* strain c much greater than *A. cycloclastes*/Ac); ***[2 max]***

(d) *A. cycloclastes*/Ac ***[1]***

F2. (a) have DNA/RNA;
have single stranded/double stranded DNA/RNA;
e.g. mutation/genetic engineering/error in transcription; *(allow mechanisms)* ***[1 max]***

(b) named example (*e.g.* human insulin);
used for cloning DNA;
copies DNA from mature mRNA;
cDNA has no introns;
host bacteria have no means to remove introns;
used for diagnosing microbial diseases (rapidly); ***[3 max]***
*Award **[2 max]** if no examples provided.*

F3. (a) *named example*: *e.g.* botulism / neurotoxin from *Clostridium botulinum*;

To award the mark the response must be a specific agent/organism. No mark for "bacteria".

symptoms: *e.g.* paralysis of skeleton muscles / blurred vision / difficulty swallowing / difficulty speaking;
method of transmission: *e.g.* foodborne infection;
treatment: *e.g.* antitoxin / intensive respiratory care / immunoglobulin; ***[4]***

(b) *example 1*:
pasteurization is the use of mild heat to reduce the number of microorganisms in a product/food;
the time and temperature depend on killing potential pathogens;
unable to kill many pathogens;
may affect taste and appearance of food;

example 2:
irradiation with UV light/x-rays/microwaves usually destroys/distorts nucleic acids;
many spoilage organisms are easily killed by irradiation;
may increase shelf-life of fruits and vegetables greatly; ***[5 max]***
*Award **[3 max]** for each example.*
Accept other valid examples of methods using acids, high sugar or salt concentrations, sterilization, antiseptics, antibiotics, etc.

Option G — Ecology and conservation

G1. (a) $40\,mg\,(carbon)\,m^{-3}$ *(allow answers in the range of 39 to 41 mg (carbon) m^{-3})* ***[1]***

(b) correct calculations;
correct answer = 367%; ***[2 max]***

(c) warmer temperatures (in summer/spring) cause enzyme activation / converse;
more reproduction of organisms (so more food) / converse;
(more sun) more photosynthesis so more biomass (of autotrophs) (so more food for organisms);
in summer there are other organisms that feed on them;
ocean water movement could carry nutrients;
seasonal changes in the abundance of food causes difference; ***[3 max]***

G2. (a)

named biome	***temperature***	***moisture***
desert	high temperature/thermal amplitude in day and cold at night	dry / average rainfall less than $25\,cm\,year^{-1}$;
tropical rainforest	hot	damp / wet / average rainfall $225\,cm\,year^{-1}$;
tundra	cold / $-6^{\circ}C$ to $-12^{\circ}C$	dry / average rainfall $25\,cm\,year^{-1}$;

[2 max]

Both temperature and moisture are required for mark to be awarded. Accept other correct biomes.

(b) named example;
definition of biomagnification;
cause;
consequence; ***[3 max]***

e.g.
name: DDT / pesticide to control mosquitoes of malaria;
definition of biomagnification: chemicals accumulate along the food chain;
cause: as fat soluble, it accumulates in fatty tissue;
consequence: becoming more concentrated at each trophic level / increasingly more toxic / ultimately leading to death of organism up in food chain;

G3. (a) name;
use; ***[4]***

example 1:
name: zoos;
captive breeding of animals / permits assisted reproductive methods / use of modern technology;

example 2:
name: botanic gardens;
allows for protected growth of plants / protected from extreme climatic conditions / provision of all necessary conditions;
*Award **[1]** for name and **[1]** for its use.*
Accept other suitable examples.

(b) *r*-strategies involve many offspring, short life-span / early maturity, reproducing only once;
K-strategies involve longer life-span, late maturity / likely to involve parental care, the production of few offspring, and reproducing more than once;
most organisms have life histories that are intermediate;
in unstable environment *r*-strategies efficient;
better to produce as many offspring as quickly as possible;
r-strategies favoured when ecological disruption/in primary communities (in succession);
such as pathogens and pest species;
K-strategies efficient in stable environment / maximizes fitness/in climax communities;
pays to invest resources in long-term development and long life;
some populations (*e.g. Drosophila*) switch strategies depending on environmental conditions; ***[5 max]***
*Award **[3 max]** if only one strategy is discussed.*

Option H — Further human physiology

H1. (a) 0 m/at sea level/in Copenhagen and hypoxia ***[1]***

(b) correct calculation;
decreases by 28.57 % *(allow 28.6 %)* ***[2]***

(c) at altitude 5260 m and normoxia there is greatest power output per kilogram of body mass;
altitude has little effect as the values for 0 m normoxia and 5260 m normoxia are very similar / normoxia is the (more) important factor (at both altitudes);
O_2 levels are significant as values for 0 m hypoxia and 5260 m hypoxia are very similar/much lower than for normoxia;
O_2 levels are more significant than altitude in allowing for greater power out (per kg body mass); ***[2 max]***

(d) more hemoglobin permits the carrying of more O_2 / greater carrying capacity of O_2 / *OWTTE*;
body acclimatises to hypoxia/lower O_2 partial pressure/concentration; ***[1 max]***

(e) lung capacity can increase so that O_2 intake becomes more efficient per breath;
heart rate can increase so that the available O_2 is circulated around the body more quickly to counter the reduced O_2 availability;
increased number of red blood cells allow greater carrying capacity (greater amount of hemoglobin);
muscles produce more myoglobin to bind more O_2; ***[2 max]***
Accept any other valid adaptations.

H2. (a) steroid hormones enter cell while protein hormones bind to specific membrane receptors / steroid hormones can pass through cell membranes while protein hormones cannot;
steroid hormones interact directly with genes/receptor proteins in the cytoplasm while protein hormones achieve their effects by causing the release of secondary messenger into the cell; ***[2]***

(b) causes increased acid secretion / produces toxins / forms pores in epithelial cell membrane / produces urease which produces ammonia (which is toxic) / resides in gastric mucous protected from immune system reactions but cause inflammation and increase acid production / destroys mucus lining exposure to acid/causing inflammation ***[1]***

H3. (a) *Award **[1]** for a factor and **[1]** for its effect.*

Accept any two of the following factors with its associated effect:
e.g.: genetic predisposition / age / being male / obesity / eating too much saturated fat and cholesterol / lack of exercise / smoking / diabetes (melitus) / hypertension / stress.
Accept converse statements of factors decreasing risk.

e.g. *factor*: genetic predisposition;
effect: some synthesise more cholesterol/LDL than others;

e.g. *factor*: being male;
effect: women before menopause appear to be protected by higher blood estrogen levels which men do not have;

e.g.: *factor*: obesity;
effect: excess weight raises blood pressure/blood cholesterol/triglyceride levels / lowers HDL/good cholesterol levels; ***[4]***

(b) can cause inflammation/fatty liver/cirrhosis of the liver from alcohol abuse;
usually from prolonged/excessive drinking / *OWTTE*;
products of alcohol metabolism toxic to cells / alcohol consumption reduces antioxidant activity;
replacement of healthy liver cells with fibrous/scar tissue;
blocks blood flow through liver / loss of functional liver cells / blocks normal metabolic carbohydrates/fats/proteins;
decreased ability to remove toxins (through bile)/bacteria / production of bile and blood proteins;
nutritional deprivation / susceptible to infection/hepatic viruses; ***[5 max]***