

Biology HL P3 TZ2

2010 May

School Level 12th IB Diploma

Programme

Board Exam

International Baccalaureate (IB

Board)

Solved

**BIOLOGY
HIGHER LEVEL
PAPER 3**

Tuesday 18 May 2010 (morning)

1 hour 15 minutes

Candidate session number

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INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options in the spaces provided. You may continue your answers on answer sheets. Write your session number on each answer sheet, and attach them to this examination paper and your cover sheet using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the candidate box on your cover sheet and indicate the number of answer sheets used in the appropriate box on your cover sheet.



Option D — Evolution

- D1.** The HIV virus has a high rate of mutation. Scientists studied the evolution of this virus in a small group of men with a slow rate of disease progression for a period of 12 years. The viral divergence from the original viral population and the diversity within the populations were recorded over the years.

GRAPH REMOVED DUE TO COPYRIGHT REASONS.

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(Question D1 continued)

- (a) (i) Identify the pattern of divergence of the viral sequence from the original viral population. [1]

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- (ii) Identify the change in the pattern of diversity of the populations. [1]

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- (b) Estimate the percentage increase of the population diversity from the stage of the initial infection to the diversity 12 years later. [2]

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- (c) Using the data provided, suggest how the change in divergence and diversity of viral RNA may be of evolutionary benefit to the HIV virus. [2]

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D2. (a) Identify **two** processes needed for the spontaneous origin of life on Earth. [2]

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(b) Outline ideas about the pace of evolution according to gradualism and punctuated equilibrium. [2]

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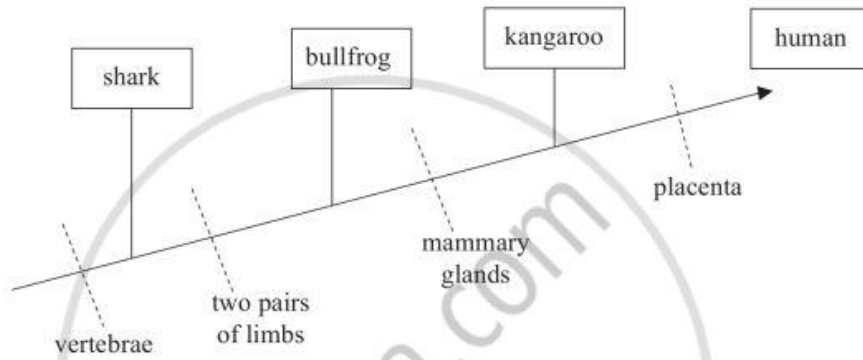


(Question D2 continued)

(c) (i) Define a *clade*. [1]

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(ii) Analyse the relationship between the organisms in the following cladogram. [3]

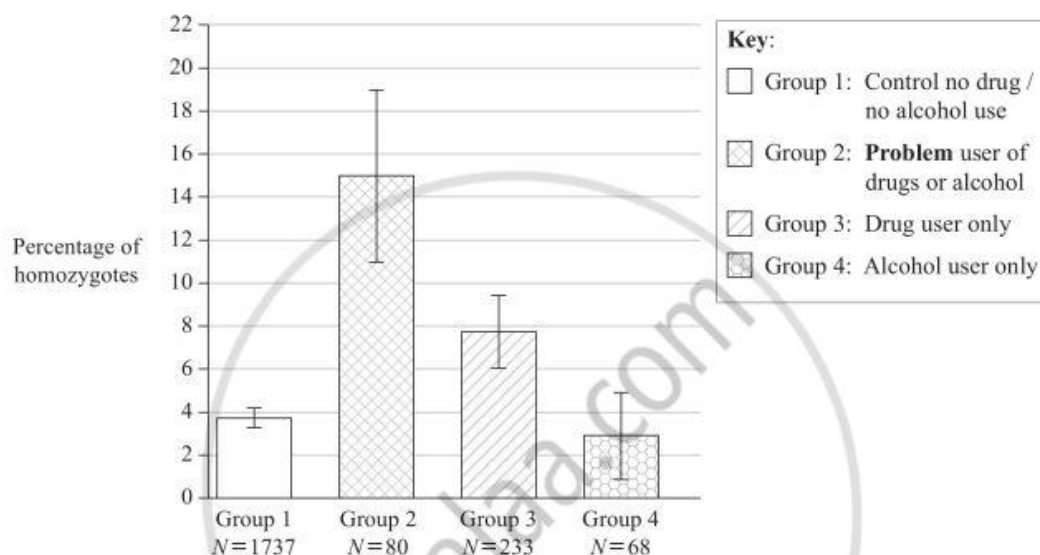


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Option E — Neurobiology and behaviour

E1. Drug abuse and alcohol abuse are neurobehavioural disorders of complex origin. A human gene has been identified that encodes the main enzyme (FAAH) for inactivating cannabinoid (THC). A mutation in this gene can occur and the homozygous mutation allows normal catalytic activity of FAAH but makes the FAAH more likely to be broken down. A study was conducted to test for the presence of the homozygous FAAH mutation in relation to drug and alcohol abuse. Four different groups were formed based on their use of drugs and alcohol.



[Source: adapted from JC Sipe *et al.*, "A missense mutation in human fatty acid amide hydrolase associated with problem drug use" (2002) *PNAS*, 99(12), pages 8394–8399; Figure 1 (adapted). copyright 2002 National Academy of Sciences, USA]

(a) Identify the percentage of homozygotes among drug users only. [1]

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(b) Calculate the actual number of homozygotes in group 2. [2]

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(Question E1 continued)

- (c) Evaluate the evidence to support the hypothesis that the presence of the homozygous mutation is a risk factor in drug and alcohol use. [3]

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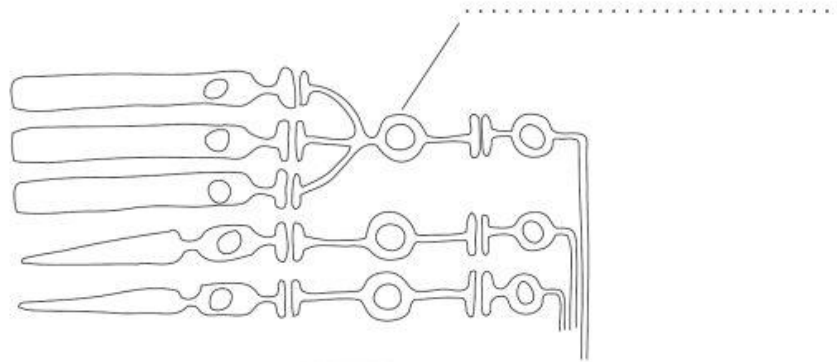
- (d) Suggest a reason for the high incidence of homozygotes among drug and alcohol users. [1]

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E2. (a) (i) Label the cell type indicated on the diagram below depicting part of the retina. [1]



(ii) Explain contralateral processing of visual stimuli. [2]

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(b) Outline an example of the effect of natural selection on animal responses. [2]

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(c) Using a **named** example, outline a rhythmical behaviour pattern with an adaptive value. [2]

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E3. Explain sympathetic and parasympathetic control of blood flow to the gut. [6]

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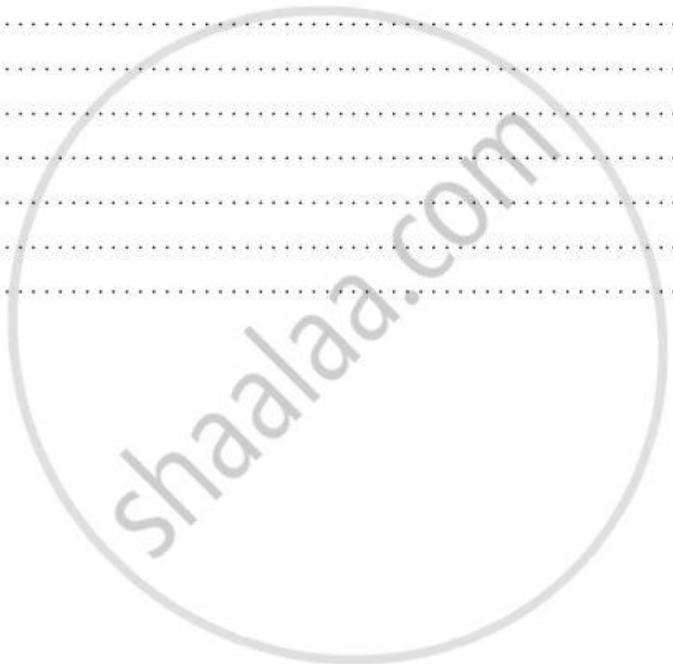
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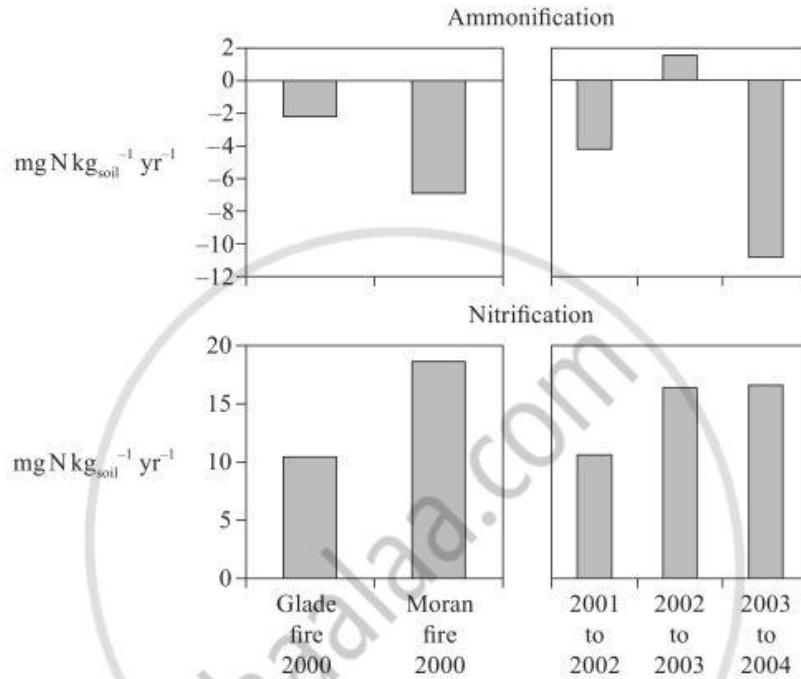
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Option F — Microbes and biotechnology

F1. In the year 2000, serious fires damaged two regions in Yellowstone National Park, USA. In the Glade fire there was destruction to the tops of trees while the Moran fire destroyed ground level species. After these fires, the overall nitrogen levels for ammonification (formation of ammonia) and nitrification in the soil were measured yearly.



[Source: adapted from Monica G Turner: Inaugural Article "Inorganic nitrogen availability after severe stand-replacing fire in the Greater Yellowstone ecosystem" (2007) *PNAS*, **104**(12), pages 4782–89; Figure 3 copyright 2007 National Academy of Sciences, USA]

- (a) (i) Identify the years when the most ammonification occurred. [1]

- (ii) Calculate the net nitrogen level in the soil for the year of the Moran fire. [1]

- (b) State the name of **one** bacterium that could be responsible for nitrification levels. [1]

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(Question F1 continued)

- (c) Using the data, explain what could account for the low levels of ammonia after the Moran fire. [3]

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- F2. (a) (i) List **two** microscopic eukaryotes. [1]

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- (ii) Outline the diversity of microscopic eukaryotes. [3]

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- (b) State **two** microbes used for the production of **two named** foods. [2]

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- (c) Explain the use of bacteria in bioremediation for **one** specific substance contaminating soil **or** water. [2]

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F3. Discuss the origin and epidemiology of **one named** example of a pandemic. [6]

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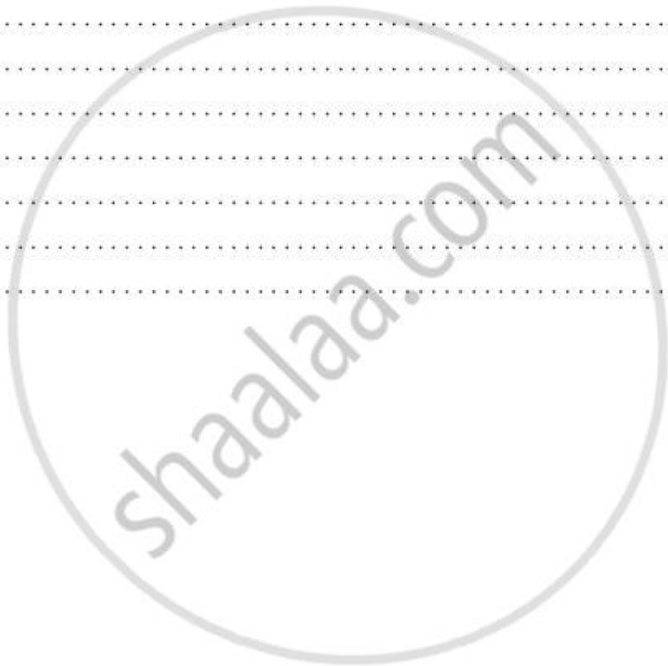
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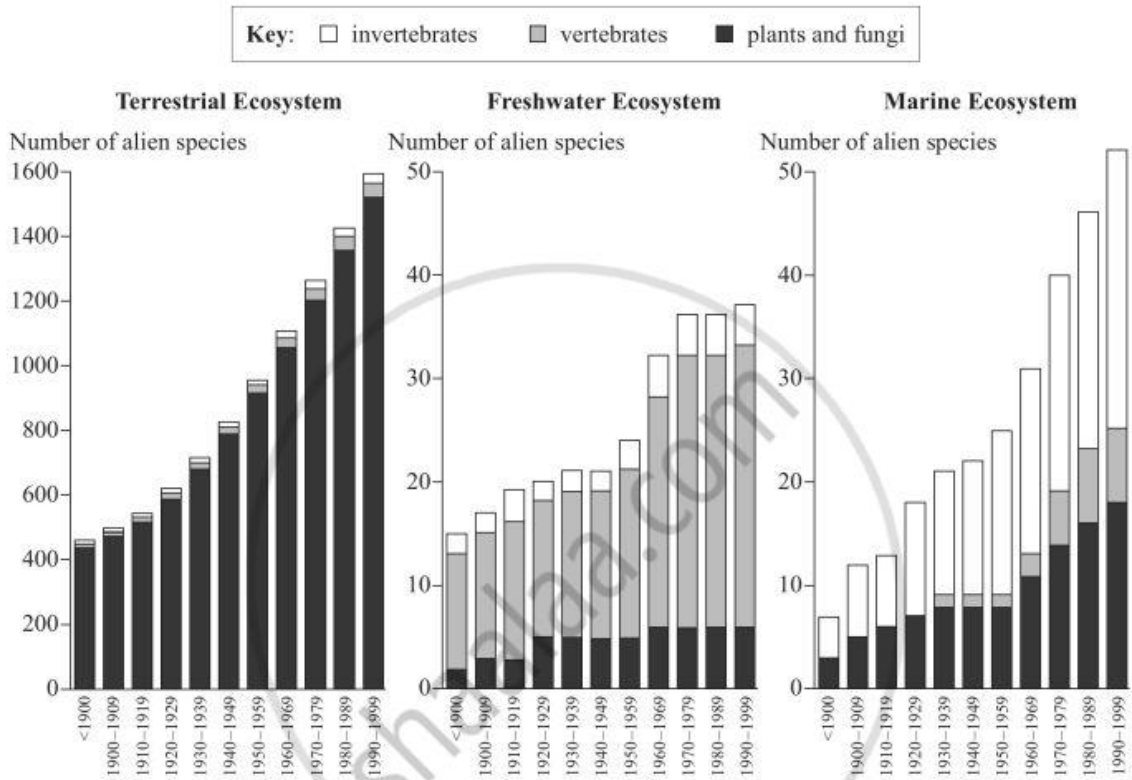
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Option G — Ecology and conservation

G1. Invasion of alien species has become a serious issue in most environments of the world. This study of Nordic environments charts the presence of alien species over the last century. Relative proportions of invertebrates, vertebrates and plants and fungi are indicated in each bar.



[Source: adapted from I. R. Weidema (ed), *Introduced Species in the Nordic Countries*, © Nordic Council of Ministers 2000, Copenhagen, Nord 2000:013, ISBN 92-893-0489-8]

(a) (i) State the ecosystem in which the proportion of alien vertebrates is the greatest. [1]

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(ii) Describe the general pattern of the numbers of alien species in terrestrial and marine ecosystems. [1]

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(Question G1 continued)

- (b) Suggest a reason why alien plant and fungi invasion is greatest in the terrestrial ecosystem. [1]

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- (c) Identify how invasion of marine waters by alien invertebrates might occur. [1]

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- (d) Discuss the impact of alien species on ecosystems. [3]

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G2. (a) Distinguish between fundamental niches and realized niches. [2]

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(b) Outline the changes in species diversity and production during primary succession. [2]

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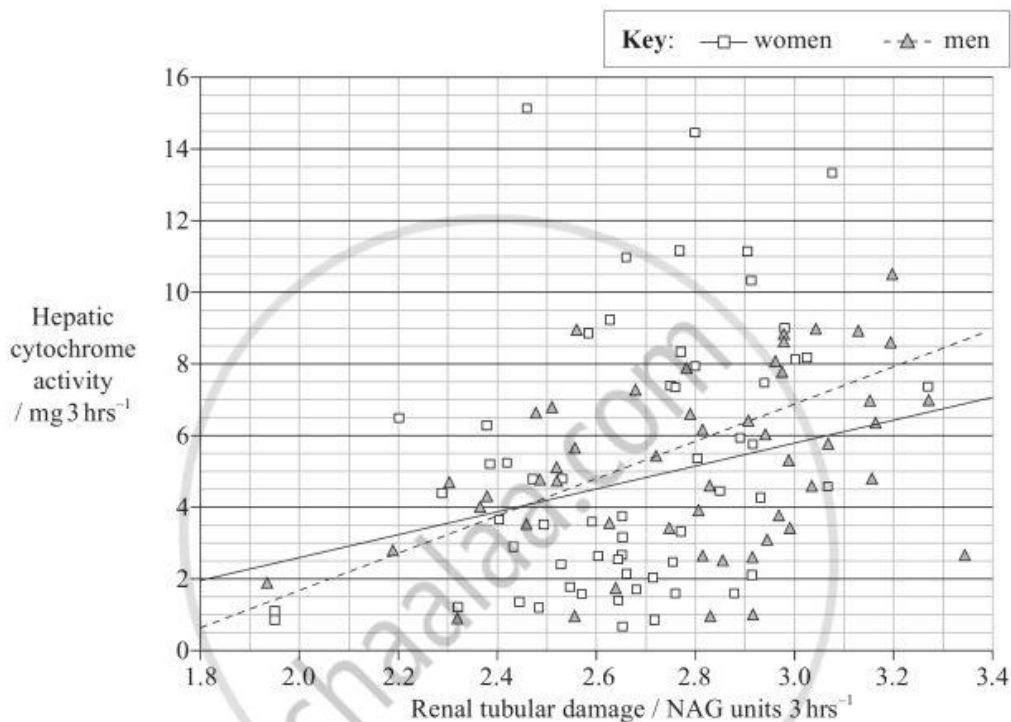
(c) Outline, using examples, the biogeographical features of nature reserves that promote the conservation of diversity. [3]

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Option H — Further human physiology

H1. A group of non-smoking men and women were studied for the effects of environmental contamination with cadmium, a toxic metal. A study was conducted to see the effect of cadmium exposure on the metabolism of the liver, as measured by the activity of a cytochrome enzyme that metabolizes drugs, and on renal tubular damage in the kidney as indicated by the excretion of a substance, NAG.



[Source: adapted from S. Satarug *et al.*, "Evidence for concurrent effects of exposure to environmental cadmium and lead on hepatic CYP2A6 phenotype and renal function biomarkers in nonsmokers", *Environmental Health Perspectives*, 2004, **112**(15), pages 1512-1518, Figure 2. Reproduced with permission from Environmental Health Perspectives]

(a) (i) Identify the highest hepatic cytochrome activity value in women. [1]

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(ii) Identify the lowest renal tubular damage value in men. [1]

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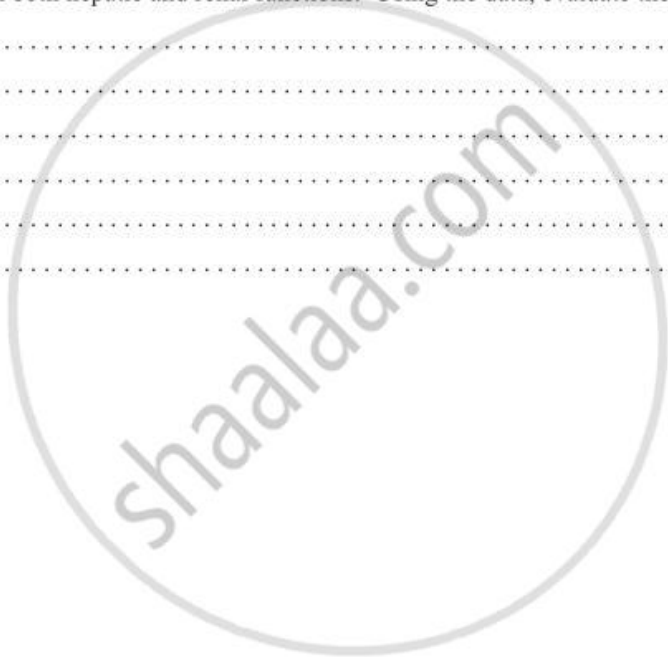
(Question H1 continued)

- (b) Compare the correlation between hepatic and renal functions for men and for women. [2]

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- (c) The scientists who conducted the study hypothesized that exposure to cadmium causes toxicity in both hepatic and renal functions. Using the data, evaluate the hypothesis. [2]

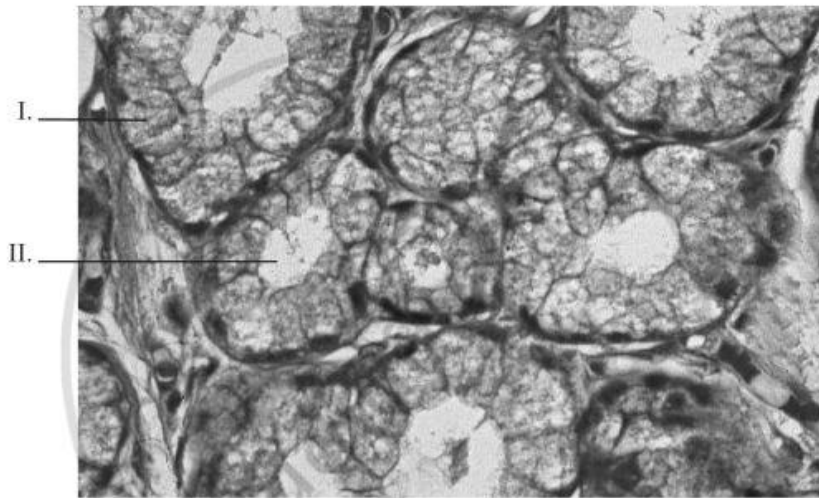
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H2. (a) Distinguish between the mode of action of protein hormones and steroid hormones. [2]

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(b) Label the indicated structures in the micrograph of exocrine gland cells below. [2]



[Source: www.pathguy.com/histo/074.jpg. Reprinted with the permission of Ed Friedlander, Kansas City University of Medicine and Biosciences.]

I.
II.

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(Question H2 continued)

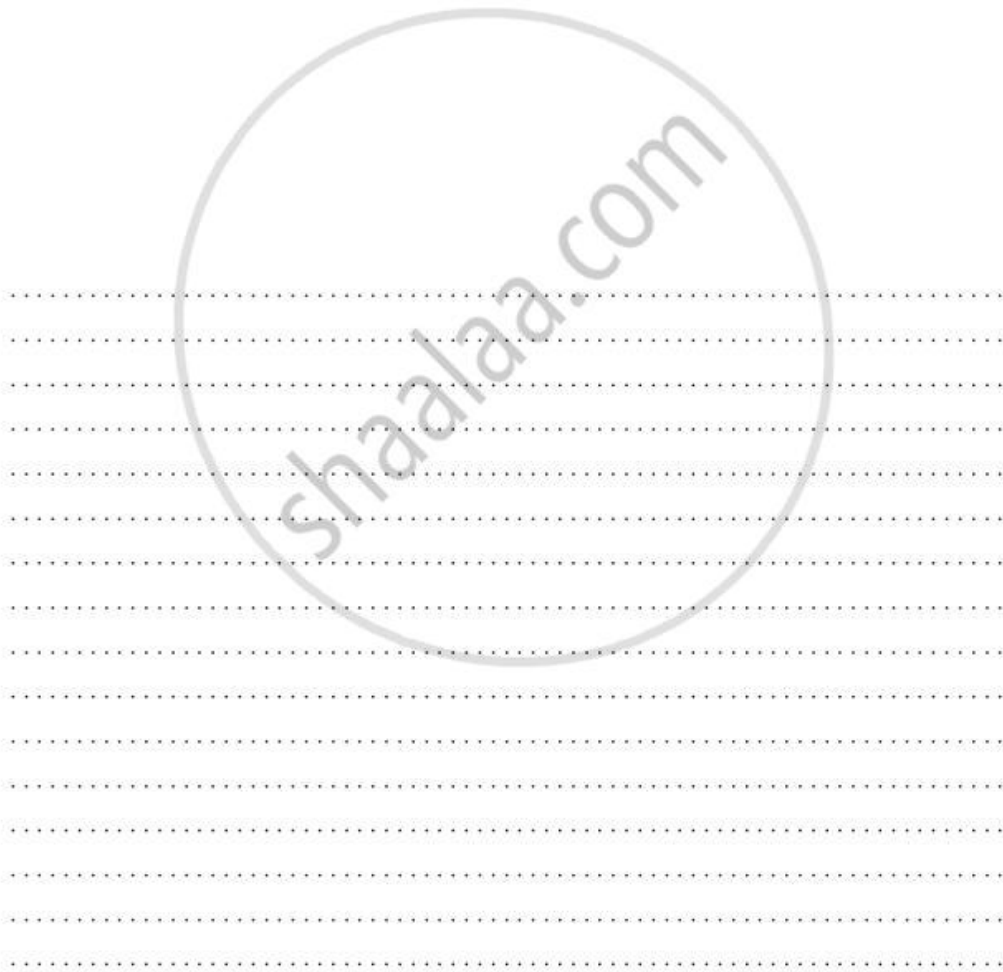
- (c) Outline the control of the secretion of gastric juice by nerves and hormones. [4]

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H3. Explain, with the use of a diagram, the role of the Bohr shift in the supply of oxygen to respiring heart muscle.

[6]





MARKSCHEME

May 2010

BIOLOGY

Higher Level

Paper 3

13 pages

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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. 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.
9. 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) (i) increases and then levels off [1]
- (ii) increases and then decreases [1]
- (b) at 12 years approximately 8 times larger (than initial);
 $\frac{39-5}{5} \times 100$ / calculation of percentage increase;
 about 680% increase; (*allow answers in the range of 600% to 760%*) [2 max]
- (c) mutations cause variability in viruses;
 greater diversity and divergence leads to variation in viruses;
 the most successful forms are naturally selected;
 those that survive reproduce more;
 more difficult for production of new T-cells/lymphocytes/reaction of immune system; [2 max]
- D2.** (a) synthesis of simple organic molecules/nucleotides/aminoacids;
 assembly of these molecules into polymers/DNA/protein;
 origin of self-regulating molecules that made inheritance possible;
 packaging of molecules into membranes (with internal chemistry different from surroundings); [2 max]
- (b) gradualism is the slow change from one form to another / stable conditions lead to low levels of natural selection making it a long, gradual process;
 punctuated equilibrium implies long periods without much change and short periods of fast changes / mass extinction promotes rapid change/new species; [2]
- (c) (i) a group including an ancestral species and all the descendents from that species / a group of organisms that evolved from a common ancestor [1]
- (ii) all four organisms have vertebrae;
 shark is the oldest/furthest from human/other examples of relationships between the four organisms;
 human only one with all four characteristics;
 appearance of legs separated others from shark;
 appearance of mammary glands, separated kangaroo and human from bullfrog;
 appearance of placenta, separated human from kangaroo;
 both kangaroo and human are mammals; [3 max]

D3. DNA/genetic code is universal;

same four bases adenine, cytosine, guanine and thymine;

To award the mark full names of all four are required.

always pairing of A – T and G – C;

same structure of double helix of complementary strands;

use the same 20 amino acids in their proteins;

all left-handed;

same/similar enzymes in processes of replication/transcription/translation;

small differences in DNA/proteins show closer relationships;

e.g. hemoglobin/cytochrome C/gene structures show relationships among organisms;

humans have the same biochemistry as all organisms so part of same evolution/ common ancestry;

mitochondrial DNA used to determine maternal lines / y chromosome used to determine paternal lines;

endosymbiotic theory/mitochondria/chloroplast structures indicate common lines of evolution;

[6 max]



Option E — Neurobiology and behaviour

- E1.** (a) 7.8% (allow answers in the range of 7.7% to 7.9%) [1]
- (b) $\frac{15}{100} \times 80$;
= 12; [2]
- (c) group 1/control and group 4/alcohol users have small differences;
supports that the homozygous condition is not a risk factor in alcohol use;
group 1/control and group 2/problem users have large difference;
group 2/problem users have more chance of being homozygotes for the mutation;
group 1/control small difference with group 3/drug users only;
homozygous condition appears to be a risk factor in group 2/problem users of
alcohol or drugs and in group 3/drug users;
numbers are very different in each population / small percentages; [3 max]
- (d) Homozygotes cannot inactivate cannabinoids/THC well, thus increased needs for
drug or alcohol intake/chances of addiction [1]
- E2.** (a) (i) bipolar cell / neuron [1]
- (ii) both retinas receive information/stimuli from left and right fields of vision;
left and right optic nerves cross in optic chiasma;
neurons from both eyes carrying impulses from left field of view go to right
hemisphere/side of brain / *vice versa*;
allowing brain to have perception of depth, distances and sizes; [2 max]
- (b) named animal and traditional behaviour;
natural selection pressure with resulting animal response; [2]
e.g. blackcap/warbler migrates to Spain but some now to UK;
warmer winters in UK / more food resulting in selection of those migrating to UK
/ increased numbers / greater survival;
Accept common or general names of organisms.
- (c) named example and behaviour;
adaptive value; [2]
e.g. coral with coordinated spawning;
permits maximum results of fertilization/reproductive success/survival of species;
Accept common or general names of organisms.
- E3.** sympathetic and parasympathetic nervous systems are part of the autonomic system;
have antagonistic actions;
smooth muscle in blood vessels/arterioles controlled by sympathetic and
parasympathetic nerves;
sympathetic system release norepinephrine/noradrenaline;
constricting blood vessels/arterioles to gut;
decreasing blood flow to gut;
parasympathetic system release acetylcholine;
dilating blood vessels/arterioles to gut;
increasing blood flow to gut; [6 max]

Option F — Microbes and biotechnology

- F1.** (a) (i) 2002 to 2003 [1]
- (ii) $18 - 7 = 11 \text{ mg N kg}_{\text{soil}}^{-1} \text{ yr}^{-1}$ (allow 10 to 12 $\text{mg N kg}_{\text{soil}}^{-1} \text{ yr}^{-1}$) [1]
- (b) *Nitrobacter*;
Nitrosomonas; [1 max]
- (c) ammonia used for nitrification so less ammonia at the end of a year;
decomposers (especially fungi) would have been destroyed (in a surface fire);
(leguminous) plants would have been destroyed (in a surface fire);
destruction of lower vegetation by the surface fire of the Moran site would not be available for ammonification;
lack of animal feces/decomposing plants and animals would reduce the available raw materials for ammonification; [3 max]
- F2.** (a) (i) Award [1] for any two of the following.
Saccharomyces / *Amoeba* / *Plasmodium* / *Paramecium* / *Euglena* / *Chlorella*
Accept any other valid example. [1]
- (ii) may be autotrophic/autotrophs/have chloroplasts or heterotrophic/
heterotrophs;
locomotion may be with pseudopods or cilia or flagella;
cell wall may be present or absent; [3]
- (b) *Saccharomyces* for beer/wine/bread;
Aspergillus sp for soy sauce;
Lactobacillus for yogurt; [2 max]
Accept any other correct examples with genus.
- (c) name of bacteria and contaminating substance;
action of bacteria to remove environmental contaminants from water or soil; [2]
e.g. some *Pseudomonas* used to clean oil spills;
uses crude oil for energy / breaks down crude oil;
e.g. *Geobacter sulfurreducens*/*G. sulfurreducens*/*Geobacter* sp used to remove uranium;
changes it to a (insoluble) form so that it can be harvested/collected;

- F3.** definition;
 named example;
 cause of occurrence;
 mode of transmission;
 symptom;
 effect;
 health measure;
 another health measure;
 international factors;
 TOK consideration/correlation and cause;

[6 max]

e.g. definition:

a pandemic is a widespread epidemic affecting a large geographical area/continent;

named example:

(Spanish) influenza (in 1918);

cause of occurrence:

occurs when a new viral strain emerges / crossing of a species border / immune system without defence to new strain;

mode of transmission:

spreads by coughing and sneezing / drop contamination;

symptom:

high fevers / breathing difficulties / sneezing / coughing / aching body;

effect:

susceptibility to secondary infections;

health measure:

analyse strain / vaccines / preparation for extensive medical care/ hospitals/medications / develop strategies to prevent transmission / restrict travel / quarantines;

another health measure:

a second example from the above measures

international factors:

transmission much wider due to travel / monitored by international cooperation by health experts/WHO;

TOK consideration/correlation and cause:

many variables to identify cause/correlation / problems of controlled experiments / information to the public may help limit epidemic/*vice versa*;

To award a mark each marking point requires a complete discussion or definition (not just a list of characteristics).

Option G — Ecology and conservation

- G1.** (a) (i) freshwater (ecosystem) [1]
- (ii) the rate is increasing (exponentially) [1]
Do not accept answers containing only numerical statements.
- (b) plants are purposely transported by people to new places for their use;
the ecosystem is changing/warming so new kinds of plants are now able to survive/compete with native plants;
only a few plants are aquatic so few would be expected in water;
fungal spores/seeds can travel more easily in air;
terrestrial ecosystems provide more suitable habitats; [1 max]
- (c) accidental transport of organisms (*e.g.* by vessels/boats);
purposeful importation for commercial reasons; [1 max]
- (d) *pros:*
may control a pest species (in an ecosystem);
economic/social benefits *e.g.* reforestation to reduce soil erosion / other reasonable examples;
cons:
competition reduces survival of native species;
upsets the balance between predators and prey;
leads to extinction of native species / reduces biodiversity; [3 max]
Accept the above points in a discussion of particular examples.
To award [3 max] responses require at least one pro and one con.

- G2.** (a) a niche is the place where an organism lives and the roles that it plays in its habitat;
fundamental niche of a species is the potential mode of existence while realized niche of a species is the actual mode of existence;
fundamental niche depends on species' adaptations while the realized niche also depends on competition with other species; **[2 max]**
- (b) one/few species/lichens/moss at the start;
pioneer community slowly increases in species diversity;
production gradually increases as more soil develops/better conditions/more diversity; **[2 max]**
- (c) size;
edge effect;
example of edge effect;
habitat corridor;
example of habitat corridor;
habitat/niche diversity;
human management; **[3 max]**
- e.g. size:*
large reserves usually promote diversity more effectively than small ones;
- edge effect:*
cause different ecology of central areas compared to edges;
- example of edge effect:*
cowbird lays eggs in nests of other birds near edges of forests / fragmentation of forests increased cowbirds as more edges;
- habitat corridor:*
permit organisms to move between different parts of a fragmented habitat;
- example of habitat corridor:*
tunnels under roads;
- habitat/niche diversity:*
functioning reserve requires a diversity of niches to support the ecosystem structure;
- human management:*
banning hunting/lumbering/petroleum exploitation;
- To award [1] each marking point requires a complete discussion or definition.*

- G3.** require international agreement/cooperation;
difficulties of enforcing agreements / to determine maximum sustainable yield / to obtain and interpret data / monitor populations/stocks;
economic consequences for livelihood of fishermen/associated trades;
total ban on fishing in threatened areas/endangered species/exclusion zones;
limiting size of fish caught / limits on size of net mesh / ban on drift nets / indiscriminate in species of fish caught;
limiting size to total allowable catch/quotas;
limiting fishing to non-productive periods of fish / closed seasons banning fishing during breeding season;
reducing fishing days at sea / fixing number and type of vessels authorized to fish;
regulation on pollution of bodies of water;
use of fish farms;

[6 max]

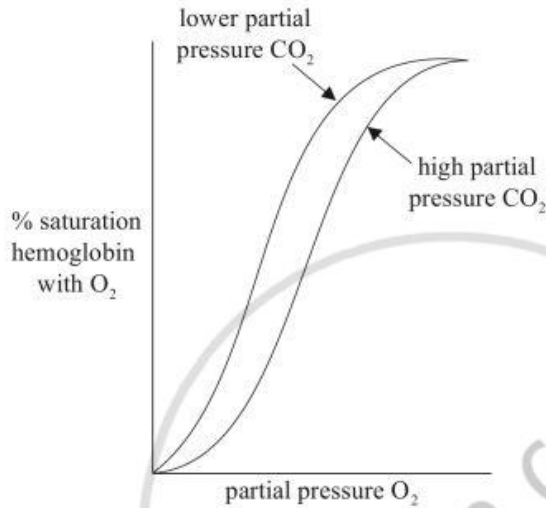


Option H — Further human physiology

- H1.** (a) (i) 15.2 mg 3 hrs⁻¹ (allow answers in the range of 15.0 to 15.4) [1]
- (ii) 1.93 NAG units 3 hrs⁻¹ (allow answers in the range of 1.92 to 1.95) [1]
- (b) both have a positive relationship;
values very scattered for both;
more positive correlation/steeper gradient for men than for women;
more scattered in women/greater range in hepatic activity / more scattered/ greater range in men in renal activity; [2 max]
- (c) people with more renal damage have more cytochrome activity;
positive correlation between both increased hepatic activity and renal damage so supports the hypothesis;
greater hepatic effect in women than in men / greater renal effect in men than women / gender differences in effects;
very wide range of data makes it very difficult to evaluate / possibly statistically invalid;
from this data it is impossible to establish a causal relationship / no control group / other factors may be involved; [2 max]
- H2.** (a) steroid hormones enter cell whereas protein hormones bind to receptors in membranes / steroid hormones can pass through cell membranes while protein hormones cannot;
steroid hormones interact directly with genes/receptor proteins in cytoplasm whereas protein hormones cause release of secondary messenger in cell;
steroid hormones control whether or not particular enzymes or proteins are synthesized whereas protein hormones change the cell's activity usually by activating or inhibiting enzymes; [2 max]
- (b) I: acinus cell/secretory cell/secretory vesicles;
II: duct/lumen; [2]
- (c) sight/smell of food initiate release of gastric juice;
before food reaches stomach, gastric juice already secreted by reflex action;
chemoreceptors/stretch receptors detect food in stomach;
impulses (from these receptors) are sent to brain, which sends impulses to release more gastric juice;
impulses also sent to endocrine glands to release gastrin;
gastrin stimulates stomach wall to increase secretions/release acid/gastric juices/pepsinogen;
low pH of stomach (and hormones) inhibits gastrin; [4 max]

H3. *diagram with correct labels:*

- partial pressure O_2 /percentage O_2 saturation on x -axis and percentage saturation hemoglobin with O_2 on y -axis;
- exponential shape curve at lower partial pressure/concentration of CO_2 ;
- curve shifted to right (and lower) for higher partial pressure/concentration of CO_2 ;



hemoglobin carries (up to) four oxygen molecules;
 Bohr shift promotes the release of oxygen in respiring heart muscle;
 active respiration releases CO_2 ;
 partial pressure of CO_2 increases;
 increases acidity/lower pH/increase lactic acid;
 hydrogen ions bind to hemoglobin / which decreases hemoglobin's affinity for O_2 ;
 so O_2 is released (from the oxyhemoglobin);
 allosteric effect / conformational change in hemoglobin which releases O_2 more readily; **[6 max]**
Award [4 max] if no diagram provided.