Biology HL P3 TZ1

2009 May

School Level 12th IB Diploma

Programme

Board Exam

International Baccalaureate (IB

Board)

Solved

M09/4/BIOLO/HP3/ENG/TZ1/XX+

22096009

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

BIOLOGY
HIGHER LEVEL
PAPER 3

Thursday 7 May 2009 (morning)

1 hour 15 minutes

Candidate session number

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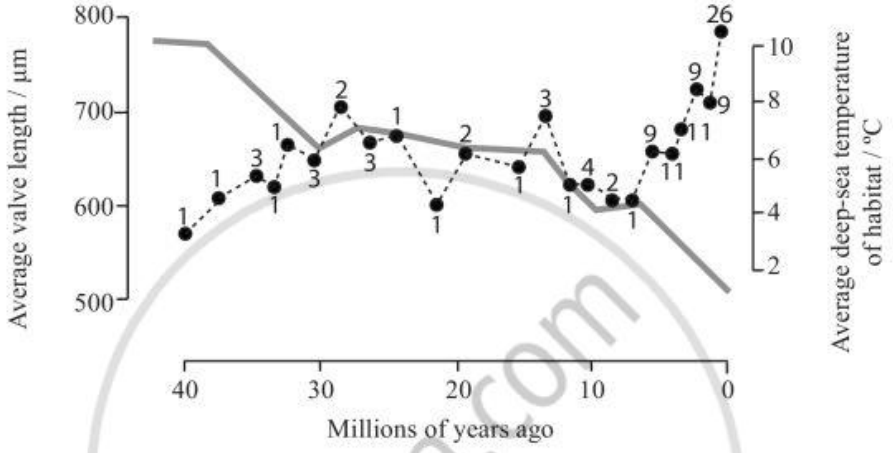
INSTRUCTIONS TO CANDIDATES

- 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.

22096009

Option D — Evolution

D1. There is evidence that body size of animals tends to increase over time. In this study, fossils and living species from the genus *Poseidonamicus*, deep-sea ostracods, were used to test this hypothesis. The numbers on the dotted line represent the number of different *Poseidonamicus* species found either as fossils or living. For each time period, the average valve length of all species studied is plotted. Valve length is an indication of total body size. The continuous line is the estimated temperature of their deep-sea habitat.



[Source: Gene Hunt and Kaustuv Roy, "Climate change, body size evolution, and Cope's Rule in deep-sea ostracodes", Proceedings of the National Academy of Sciences, Volume 103, Issue 5, January 31 2006, pp. 1347–1352: Figure 1C. Copyright 2006 National Academy of Sciences, USA.]

(a) Calculate the percentage increase in valve length between the species studied from 40 million years ago and the species from the present day. *[2]*

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(b) Suggest **two** reasons for the increase in the number of species of *Poseidonamicus* over time. *[2]*

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(This question continues on the following page)

(Question D1 continued)

(c) Evaluate the hypothesis that changes in size of *Poseidonamicus* are caused by changes in sea temperature. *[3]*

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D2. (a) State **one** process needed for the spontaneous origin of life on Earth. *[1]*

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(b) Outline the contribution of prokaryotes to the creation of an oxygen-rich atmosphere. *[2]*

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D3. (a) Outline allopatric and sympatric speciation. *[4]*

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(b) Explain the biochemical evidence for the common ancestry of living organisms. *[6]*

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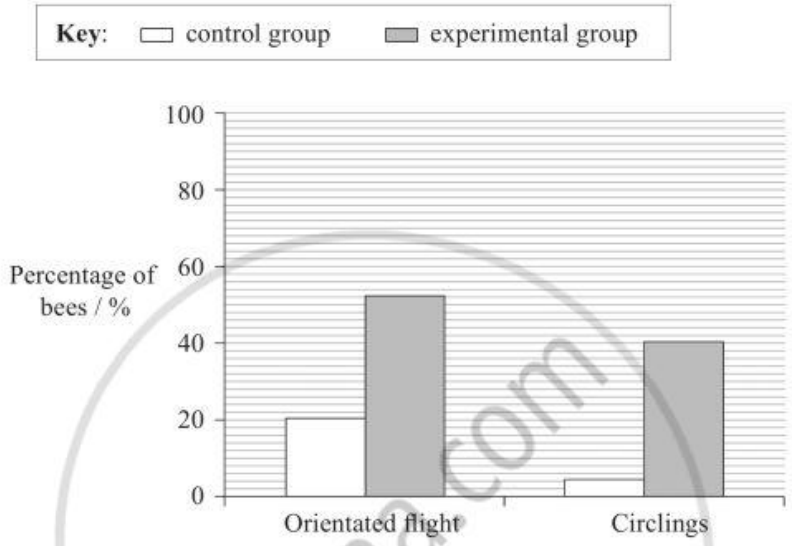
Option E — Neurobiology and behaviour

E1. Evidence suggests that the behaviour of bees is often a response to odours. Scientists placed bees 200 cm away from an attractive odour source. An experimental group of bees had previous exposure to the odour, a control group had no previous exposure. Both the percentage of bees flying towards (orientated flight) and the percentage circling the odour source were measured.



[Source: Antoine Chaffiol, David Laloi, and Minh-Hà Pham-Delègue, "Prior classical olfactory conditioning improves odour-cued flight orientation of honey bees in a wind tunnel", *Journal of Experimental Biology*, Volume 208, Issue 19, pp. 3731-3737 (Figure 3). Adapted with permission.]

(a) Describe the effect of previous exposure to the odour on the flight of bees. *[2]*

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(b) Outline the type of behaviour that the experimental group demonstrates. *[1]*

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(This question continues on the following page)

(Question E1 continued)

(c) Discuss the implications of this study for the survival of bees. *[3]*

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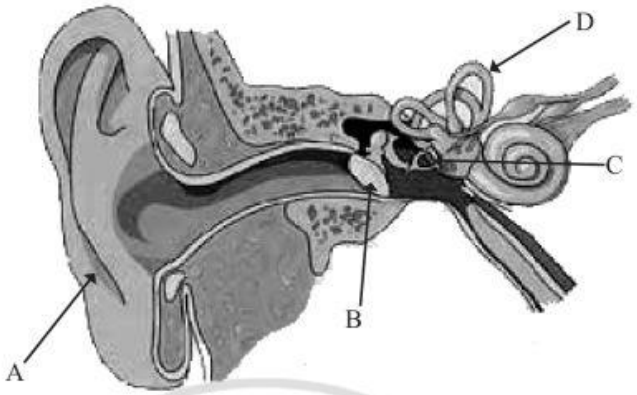
E2. (a) Label this diagram of the ear. *[2]*



A. .....

B. .....

C. .....

D. .....

(b) (i) Define *reflex*. *[1]*

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(ii) List **two** inhibitory psychoactive drugs. *[1]*

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2. .....

E3. (a) Describe an experiment investigating innate behaviour in invertebrates. *[4]*

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(b) Explain how fMRI (functional magnetic resonance imaging) scanning can be used in investigation of how the human brain functions. *[6]*

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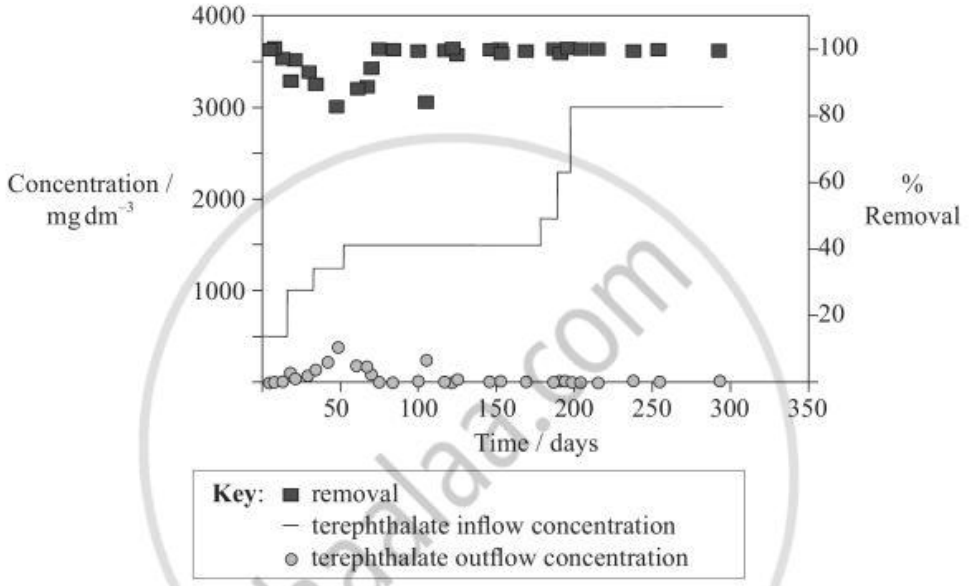
Option F — Microbes and biotechnology

F1. Wastewater from factories producing polyester fibres contains high concentrations of the chemical terephthalate. Efficient removal of this compound can be achieved by certain bacteria. The graph below shows what percentage of the compound can be removed from the wastewater in an experimental reactor. Researchers increased the amount of terephthalate entering the reactor stepwise over a 200 day period.



[Source: Jer-Horng Wu, Wen-Tso Liu, I-Cheng Tseng, and Sheng-Shung Cheng, "Characterization of microbial consortia in a terephthalate-degrading anaerobic granular sludge system", *Microbiology*, Volume 147 (2001), pp. 373-382, © Society for General Microbiology. Reprinted with permission.]

(This question continues on the following page)

(Question F1 continued)

(a) The reactor has a volume of 12 litres. Calculate the initial amount of terephthalate in the reactor. *[1]*

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(b) (i) Outline the relationship between terephthalate concentration in the outflow and percentage removal. *[2]*

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(ii) Suggest why the drop in removal percentage occurs. *[1]*

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(c) Deduce which bacteria can be used for the degradation of terephthalate. *[1]*

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(d) Evaluate the efficiency of the terephthalate removal. *[2]*

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F2. (a) State the roles of: *[1]*

Rhizobium: .....

Nitrosomonas: .....

(b) Outline the production of soy sauce. *[2]*

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F3. (a) Outline the diversity in structure of viruses. *[4]*

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(b) Discuss the origin and epidemiology of a pandemic. *[6]*

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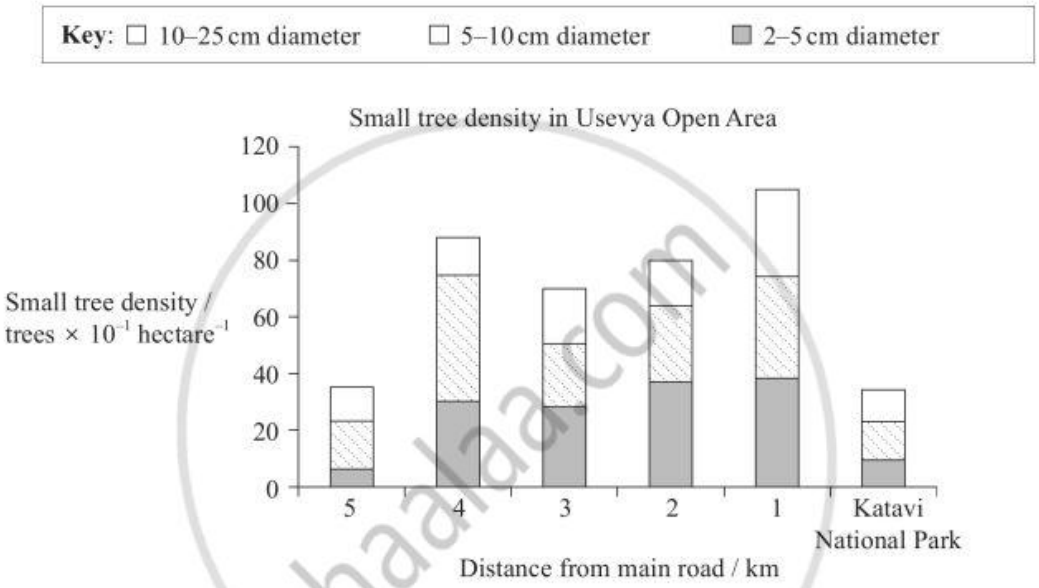
Option G — Ecology and conservation

G1. In south-central Africa trees are used for furniture production or building material by the local population. Large trees are cut down selectively. The densities of small trees were studied in Usevya Open Area where there are three settlements. Katavi National Park, where tree cutting is not allowed, is next to Usevya Open Area.

The graph below shows the density of three categories of small trees up to 25 cm in diameter at set distances from the main road.



[Source: M. W. Schwartz, T. M. Caro, "Effect of selective logging on tree and understory regeneration in miombo woodland in western Tanzania", *African Journal of Ecology*, Volume 41, Issue 1, pp. 75–82. Copyright Wiley-Blackwell. Reprinted with permission.]

(a) Identify the density of trees with a diameter between 5–10 cm in Usevya Open Area at a distance of 4 km from the main road. *[1]*

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(This question continues on the following page)

(Question G1 continued)

(b) In Usevya Open Area describe the relationship between distance from the main road and small trees. *[2]*

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(c) Outline the density of small trees in Usevya Open Area. *[1]*

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(d) Discuss the distribution of small trees in Katavi National Park with those at a distance of 5 km from the road. *[3]*

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G2. (a) Define *biomass*. *[1]*

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(b) Outline the effects of ultraviolet (UV) radiation on living tissues. *[2]*

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G3. (a) Describe the causes and consequences of a **named** example of biomagnification. *[5]*

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(b) Discuss conditions that favour K-strategies. *[5]*

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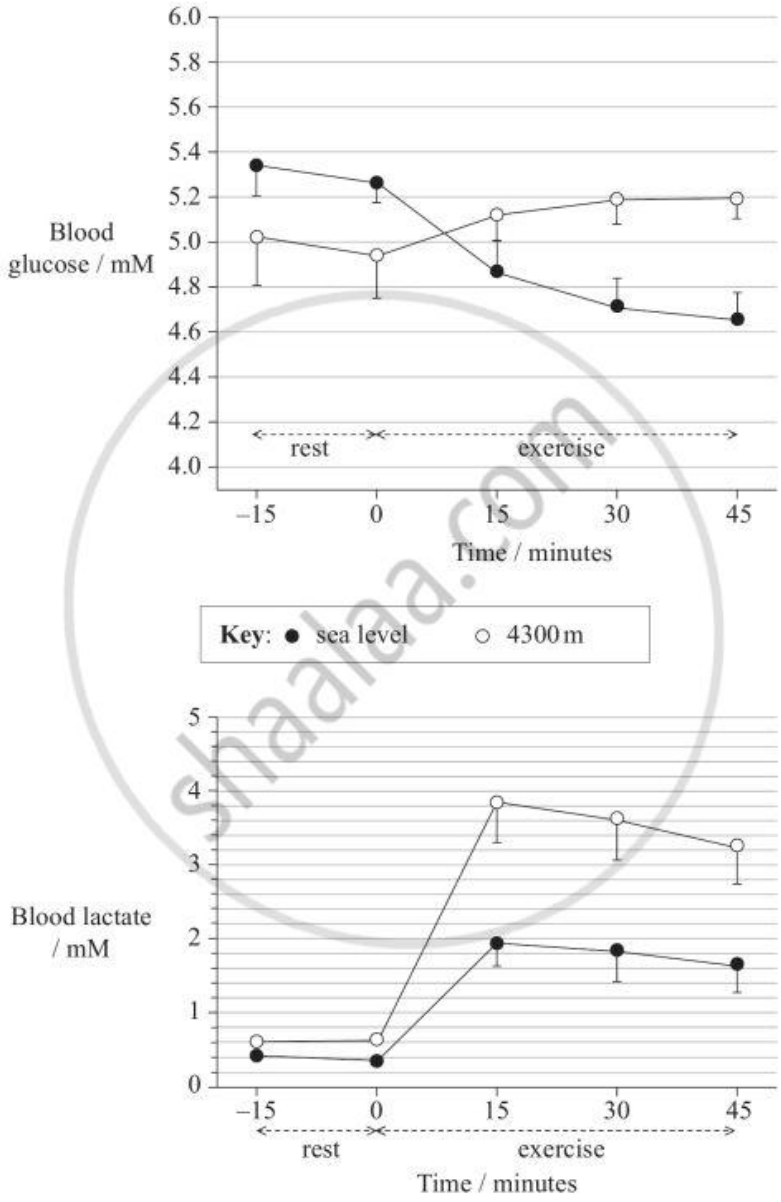
Option H — Further human physiology

H1. Sixteen women were studied to evaluate blood glucose and blood lactate levels while exercising at sea level and at high altitude, 4300 m above sea level.



[Source: Figure 6 from Barry Braun, Jacinda T. Mawson, Stephen R. Muza, Shannon B. Dominick, George A. Brooks, Michael A. Horning, Paul B. Rock, Lorna G. Moore, Robert S. Mazzeo, Steven C. Ezeji-Okoye, and Gail E. Butterfield, "Women at altitude: carbohydrate utilization during exercise at 4,300 m", *J Appl Physiol* 2000 88: 246-256, © The American Physiological Society]

(This question continues on the following page)

(Question H1 continued)

(a) (i) Calculate the percentage increase in blood lactate concentration after 30 minutes of exercise at 4300 m. *[1]*

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(ii) Suggest a reason for the difference in blood lactate concentration between women exercising at sea level and at high altitude. *[1]*

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(b) Describe the variation in the blood glucose and lactate concentrations in the women at sea level. *[2]*

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(c) Analyse the effect of high altitude on the blood glucose and lactate levels. *[3]*

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H2. (a) Outline mechanisms used by the ileum to absorb amino acids. *[2]*

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(b) State **two** materials which are not absorbed in the ileum. *[1]*

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H3. (a) Outline factors that affect the incidence of coronary heart disease. *[5]*

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(b) Discuss the roles of gastric acid and *Helicobacter pylori* in the development of stomach ulcers and cancers. *[5]*

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MARKSCHEME

May 2009

BIOLOGY

Higher Level

Paper 3

15 pages

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. 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.

D3. (a) speciation is the formation of a new species by the splitting of an existing species;
allopatric speciation caused by geographical separation;
sympatric speciation occurring within the same habitat caused by different niches / caused by courtship/feeding differences/behavioural differences;
both processes lead to isolation of sub-populations;
isolation favours certain genetic variations (within a species);
over time this leads to genetic barriers/speciation; ***[4 max]***
Both allopatric and sympatric speciation must be mentioned. ***[3 max]*** *if only one mentioned.*

(b) all organisms have DNA as the genetic material;
all organisms use (approx.) 20 different (L) amino acids;
genetic code is (nearly) universal;
mechanism for protein synthesis is similar;
metabolic pathways are similar;
if parts of DNA (genes) are shared between organisms then it denotes (close) relationship;
the greater the percentage of genes shared, the closer the genetic relationship;
mitochondrial DNA is maternally inherited in most organisms/phospolipid membranes/ATP common in most (all) organisms;
conserved genes have similar function; ***[6 max]***

Option E — Neurobiology and behaviour

E1. (a) 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.

(b) the bees associate the odour with food, and this is learned/conditioning behaviour ***[1]***
Do not accept taxis or simply learned behaviour or conditioning.

(c) 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 – pinna
B – eardrum/ tympanic membrane
C – bone of middle ear / stapes/stirrup/ossicles/oval window
D – semicircular canal ***[2]***
*Award **[1]** for every two correct labels – four correct labels required for **[2]**.*

(b) (i) reflex is a rapid unconscious/involuntary response ***[1]***
Answer must include either unconscious or involuntary.

(ii) benzodiazepines / alcohol/ethanol / THC ***[1]***
*Two needed for **[1]**.*

E3. (a) place the invertebrates/animals in a controlled environment;
observe the behaviour to see which stimuli elicit a response;
choose one stimulus that appears to change behaviour;
ensure that other factors do not have an effect on the response;
state an appropriate method to measure the response;
ensure sufficient numbers of trials/animals to ensure reliability of data;
ensure that ethical standards are met; ***[4 max]***
Full marks could be obtained by describing an experiment using a named organism e.g. woodlice.

(b) it records changes in blood flow;
active parts of the brain have increased blood flow;
but not all brain activity is detected by MRI;
a subject is given a stimulus which is designed to stimulate brain activity;
links stimulus with certain part of the brain;
brain activity visualized by coloured images;
degree of activity can be represented (by different colours);
temporal activities can be recorded as well;
allowing sequential use of the brain to be visualized;
collaboration between brain parts;
non invasive; ***[6 max]***

Option F — Microbes and biotechnology

F1. (a) $(12\,dm^3 \times 500\,mg\,dm^{-3} =) 6000\,mg$ ***[1]***

(b) (i) at approx. 50 days into the experiment there is a decline in the removal percentage;
removal percentage stable for most of the experiment / at nearly 100 %;
decrease in removal percentage linked to increase in teraphthalate outflow concentration/they are inversely related; ***[2 max]***

(ii) bacterial seeding culture has a lag phase;
bacterial culture has to adapt to reactor; ***[1 max]***

(c) chemoheterotroph ***[1]***

(d) removal is close to 100 % over the course of the experiment;
at the highest teraphthalate concentration removal is 100 %;
despite increasing teraphthalate inflow concentration, its concentration in the outflow is close to $0\,mg\,dm^{-3}$;
so removal is very efficient; ***[2 max]***

F2. (a) *Rhizobium*: nitrogen fixation / N_2 to NH_3
Nitrosomonas: nitrification / NH_3 to NO_2^- ***[1]***
*Both required for **[1]**.*

(b) main ingredients are salt, soybeans, and water;
(crushed) mixture treated with *Aspergillus oryzae*;
carbohydrate/starch is broken down to glucose/lactic acid/ alcohol;
proteins broken down to peptides and amino acids;
fermented for 6–8 months; ***[2 max]***

F3. (a) a virus is a non-cellular structure;
viruses consist of a protein coat and genetic material;
genetic material can be DNA or RNA;
may be ds or ss;
some are +/– RNA viruses;
some viruses are covered in a membranous bilayer/enveloped capsid/naked capsid;
some viruses/retroviruses have a reverse transcriptase component; ***[4 max]***

(b) pandemic is a widespread epidemic affecting large geographical areas (such as continents);
may be caused by a single mutation in the pathogen;
to which humans have no/reduced immunity;
virus/bacterium may mutate and cross the species barrier;
frequent contact between humans and animals is a necessity;
RNA viruses more prone to mutations;
reverse transcriptase is prone to production of mutations;
spread/infectivity by droplets/other bodily fluids;
link between economically developing countries and origin of pandemics;
link between economically developed countries and origin of multiple resistant bacteria;
longer incubation time lowers chance of detection and enables spread;
high density of population facilitates spread;
modern travel makes spread fast and efficient; ***[6 max]***

Option G — Ecology and conservation

G1. (a) 45 trees × 10^{-1} hectare^{-1} / 4.5 trees hectare^{-1} / per hectare *(units required)* ***[1]***
(Accept answers in the range 41–47 trees × 10^{-1} hectare^{-1})

(b) total number of small trees is lowest furthest from the main road;
from 1–4 km number of trees 5–10 / 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) the total dry mass of organic matter in living organisms/ecosystems ***[1]***

(b) UV radiation may cause damage to nucleic acids/proteins/lipids;
give rise to increase in skin cancer rates/glaucoma/cataracts/skin ageing;
may negatively affect plant/phytoplankton productivity;
small amount beneficial *e.g.* vitamin D synthesis;
used to kill microbes/water purification;
used to treat jaundice in newborn infants; ***[2 max]***

G3. (a) biomagnification is a process in which chemical substances become more concentrated at each trophic level;
certain toxins will accumulate in the body;
fat soluble toxins have a longer half life/will accumulate in body tissues;
examples are: DDT/TBT/organophosphates/mercury/other;
effects of toxins can be magnified up the food chain;
top predators/consumers/carnivores have highest concentrations stored in their body;
For named example include:
source of toxin *e.g.* TBT anti-fouling paint used on ships;
how it enters food chain *e.g.* taken up by filter feeders;
links in food chain;
effect on top consumer;
ecosystem/community affected; ***[5 max]***

(b) K-strategists require more resources;
are long-lived;
are large, therefore need large habitats;
slow maturation, therefore require longer protection from predators;
more care for offspring / small number of offspring;
require stable habitat;
usually have stable population size;
perform better in an environment with high levels of competition/no vacant niches;
examples are: elephants / parrots / whales / Arctic tern / tortoise / other correct example; ***[5 max]***

Option H — Further human physiology

H1. (a) (i) $\frac{3.6-0.6}{0.6}\times 100 = 500\%$ *[1]*

(ii) increased anaerobic respiration at high altitude/4300 m due to low partial pressure of oxygen *[1]*

(b) glucose concentration starts to fall after the start of the exercise then levels off/decrease slows down/ glucose drops from 5.35 mM to 4.65 mM;
lactate concentration increases then levels off/then decreases/ lactate increase from 0.4 mM to1.9 mM;
changes in lactate are the inverse of those in glucose; *[2 max]*

(c) initial glucose concentration was lower at high altitude / glucose concentration increases only slightly/stays level (during exercise) at high altitude;
lactate concentration rises more sharply at high altitude / but initial concentration of lactate was similar;
less efficient use of glucose under anaerobic conditions / sharper increase in lactate concentration caused by increase in anaerobic metabolism; *[3]*

H2. (a) active transport: against concentration gradient and requires ATP and protein pumps/transport proteins;
facilitated diffusion: along concentration gradient, is passive/no ATP required and requires carrier/transport proteins;
simple diffusion: passive/no ATP required and along concentration gradient and through protein channels;
endocytosis: invagination of the cell membrane making a vesicle; *[2 max]*

(b) *Two of the following needed for* ***[1]****.*
cellulose/fibres
lignin
bile pigment
bacteria
intestinal cells *[1 max]*

H3. (a) *Named factors correctly outlined.*
genetic – some people predisposed for high cholesterol levels / high blood pressure;
age – older people greater risk / less elasticity in arteries;
sex – males at greater risk of heart disease than (pre-menopausal) women as estrogen protects against heart disease;
smoking – constricts blood vessels / increases blood pressure/heart-rate / decreases oxygenation of heart muscle;
diet – increased fat/cholesterol/LDL in blood leads to plaque formation in arteries;
exercise – helps reduce high blood pressure / exercise reduces the rate of fatty deposits building up in the inner lining of arteries/thickens the heart muscle walls so they pump blood more efficiently;
obesity – increase in blood pressure / leads to plaque formation in arteries; ***[5 max]***
Accept any other factor with brief account e.g. diabetes, atherosclerosis.
Do not award a mark for the name of a factor and simply that it leads to CHD.

(b) *H. pylori* is a bacterium which causes gastritis;
stomach ulcers are open sores in the stomach wall;
prolonged presence of ulcers may lead to the formation of tumours;
cancer of the stomach is a malignant tumour in the stomach wall;
about 80 % of gastric ulcers are caused by *H. pylori*;
H. pylori survives in the stomach mucosa;
producing urease;
which neutralizes gastric acid;
colonization by *H. pylori* opens up/weakens the (protective) (mucosal/mucus) lining;
for digestive attack by gastric acid/HCl causing ulcers;
linking *H. pylori* to stomach ulcers was a paradigm shift in medicine;
cause was previously thought to be stress/lifestyle/diet;
H. pylori now thought to be primary cause / now treated as infectious disease; ***[5 max]***