IB DIPLOMA PROGRAMME
PROGRAMME DU DIPLÔME DU BI
PROGRAMA DEL DIPLOMA DEL BI

M04/412/S(3)

BIOLOGY
STANDARD LEVEL
PAPER 3

Candidate number

Wednesday 12 May 2004 (morning)

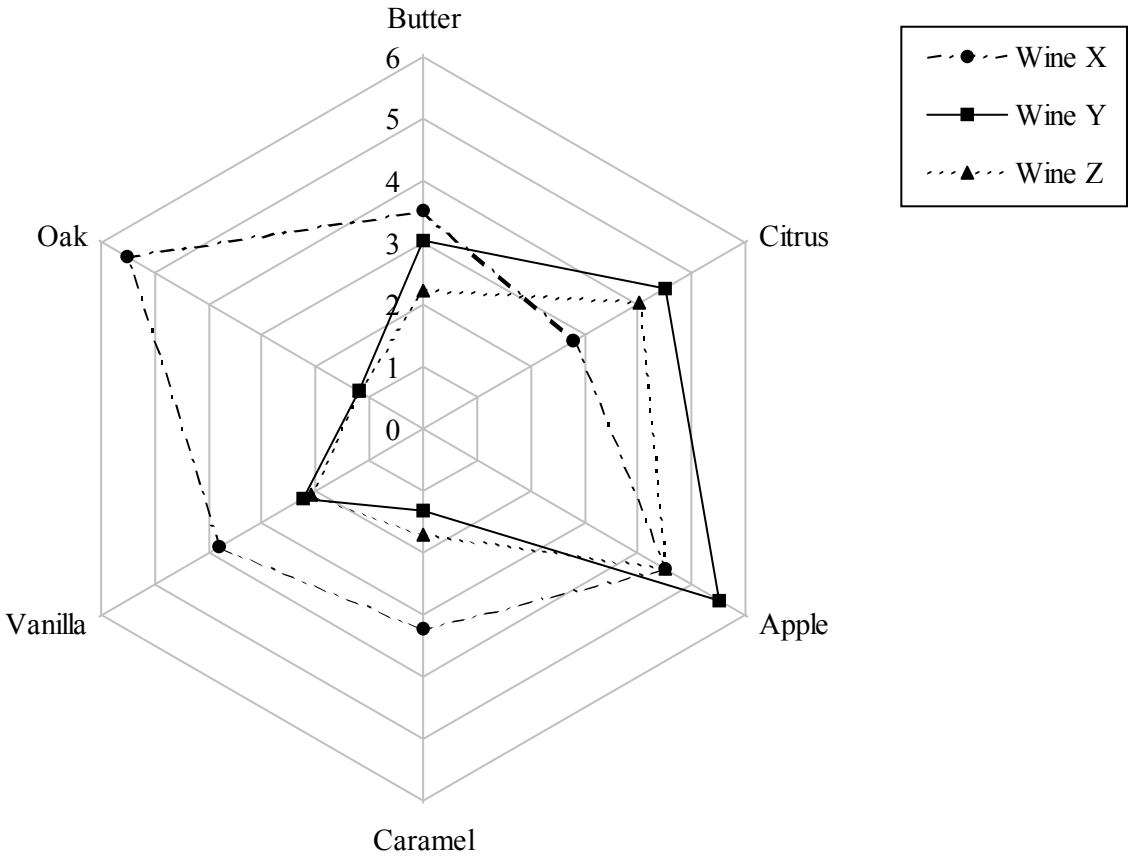
1 hour

INSTRUCTIONS TO CANDIDATES

- Write your candidate number in the box 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 candidate number on each answer sheet, and attach them to this examination paper 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 A – Diet and Human Nutrition

A1. The flavour of wines can be assessed quantitatively by a technique called descriptive analysis. Using this technique, judges can evaluate wines for the relative intensity of different flavours. The graph below shows flavour profiles for three inexpensive white wines. Relative intensities for six of the flavours are shown. The centre of this diagram corresponds to low intensity and the outer edge to high intensity.



[Source: modified from J Yegge and A C Noble, Proc. ASEV* 50th Anniversary Annual Meeting (2000), Davis]

* American Society for Enology and Viticulture

(a) State the relative intensity of butter flavour in wine X. *[1]*

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(b) Distinguish the flavours of wine X and wine Y. *[2]*

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(This question continues on the following page)

(Question A1 continued)

(c) Identify, giving reasons, which **two** wines are most similar in taste. *[2]*

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(d) Some wines contain food additives.

(i) State **two** uses for chemical additives. *[2]*

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2. . . . . .

(ii) State **one** possible harmful effect of chemical additives. *[1]*

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A2. Lipids are essential nutrients that must be included in the diet.

(a) State **one** food rich in lipids suitable for a vegan diet. *[1]*

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(b) Outline **two** functions of lipids in the body. *[2]*

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(c) Discuss the possible health problems associated with diets rich in lipids. *[4]*

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A3. Explain the importance of using hygienic methods to handle and prepare food. *[3]*

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Option B – Physiology of Exercise

B1. Since 1970 jogging has become an increasingly popular form of exercise, but the public concern over its harmful effects has been raised following reports of death during jogging.

A randomly selected group of 4658 men in Copenhagen, Denmark, between the ages of 20 and 79, attended two examinations – one in 1976 and the other in 1981. Jogging status was determined by asking the participants if they were joggers. The influence of jogging on the risk of death was measured. The results are shown in the table below. Factors, other than jogging, were also analysed.

Factor		Relative risk of death
Jogging at time of examinations	No or at only one examination	1.00
	At both examinations	0.39
Diabetes	No	1.00
	Yes	1.75
Smoking	No	1.00
	Yes	1.74
Income	Middle or high	1.00
	Low	1.21
Duration of education	< 10 years	1.00
	> 10 years	0.91
Alcohol consumption per week	< 21 drinks	1.00
	Abstainers	1.16
	> 21 drinks	1.35

[Source: P Schorn *et al*., *British Medical Journal*, 9 September 2000, **321**, pages 602-603]

(a) State the factor that causes the greatest risk of death in this group of men. *[1]*

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(b) Using only the data given, outline the type of man that has the least risk of death. *[2]*

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(This question continues on the following page)

(Question B1 continued)

(c) Discuss the hypothesis that regular jogging is not associated with increased mortality in men, using the results obtained in Copenhagen. *[3]*

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(d) Training affects the cardiovascular system, the lungs and the muscles. Explain how each of these is affected when training by jogging. *[3]*

(i) Cardiovascular system: . . . . . .

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(ii) Lungs: . . . . . .

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(iii) Muscles: . . . . . .

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B2. In the knee-jerk reflex, the stimulus is received by a receptor which passes an impulse to the sensory neuron. The effector is the muscle in the leg.

(a) Draw and label the structure of a sensory neuron. *[2]*

(b) Describe the movements at the knee joint during the knee-jerk reflex. *[2]*

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B3. (a) Outline the role of myoglobin in muscles. *[2]*

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(b) Explain the effect of adrenaline on muscles. *[3]*

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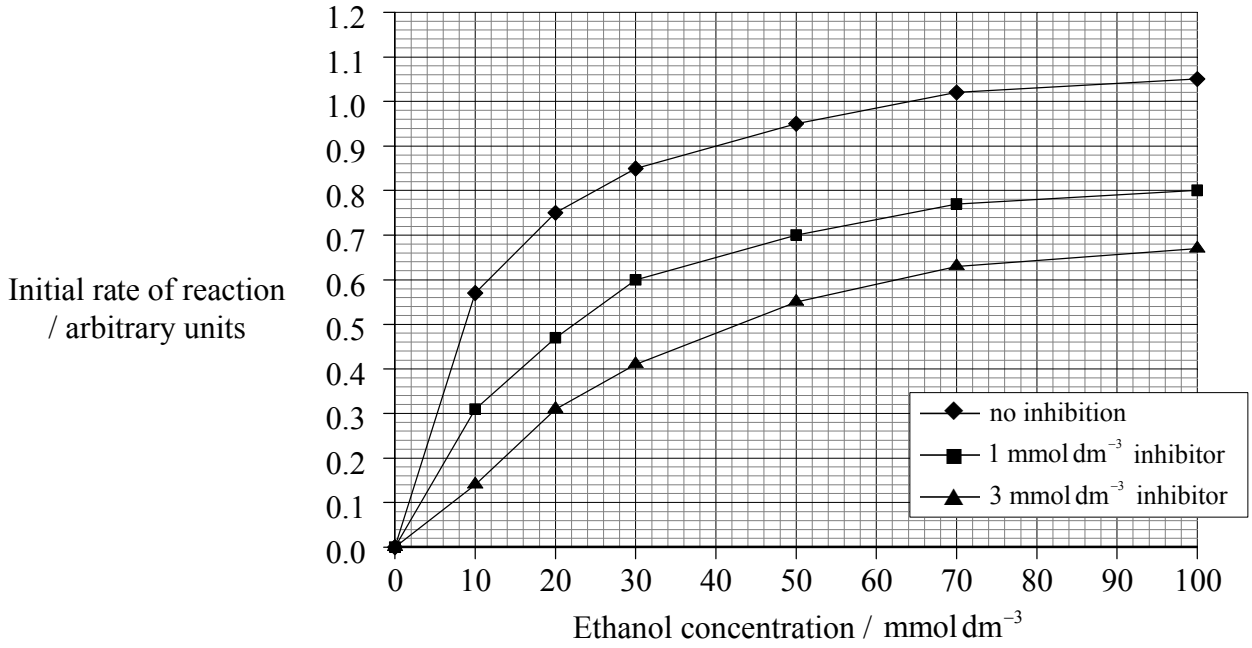
Option C – Cells and Energy

C1. Alcohol dehydrogenase is an enzyme that catalyses the reversible reaction of ethanol and ethanal according to the equation below.

$$\underset{\text{ethanol}}{NAD^+ + CH_3CH_2OH} \rightleftharpoons \underset{\text{ethanal}}{CH_3CHO + NADH + H^+}$$

The initial rate of reaction can be measured according to the time taken for NADH to be produced.

In an experiment, the initial rate at different concentrations of ethanol was recorded (no inhibition). The experiment was then repeated with the addition of $1\,\text{mmol}\,\text{dm}^{-3}$ 2,2,2-trifluoroethanol, a competitive inhibitor of the enzyme. A third experiment using a greater concentration of the same inhibitor ($3\,\text{mmol}\,\text{dm}^{-3}$) was performed. The results for each experiment are shown in the graph below.



[Source: R Taber, *Biochemical Education*, (1998), **26**, pages 239-242]

(a) Outline the effect of increasing the substrate concentration on the control reaction (no inhibition). *[2]*

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(This question continues on the following page)

(Question C1 continued)

(b) (i) State the initial rate of reaction at an ethanol concentration of 50 mmol dm^{-3} in the presence of the inhibitor at the following concentrations. *[1]*

1 mmol dm^{-3}: . . . . . .

3 mmol dm^{-3}: . . . . . .

(ii) State the effect of increasing the concentration of inhibitor on the initial rate of reaction. *[1]*

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(c) Explain how a competitive inhibitor works. *[3]*

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C2. Anaerobic respiration occurs in the absence of oxygen while aerobic respiration requires oxygen.

(a) State **one** final product of anaerobic respiration. *[1]*

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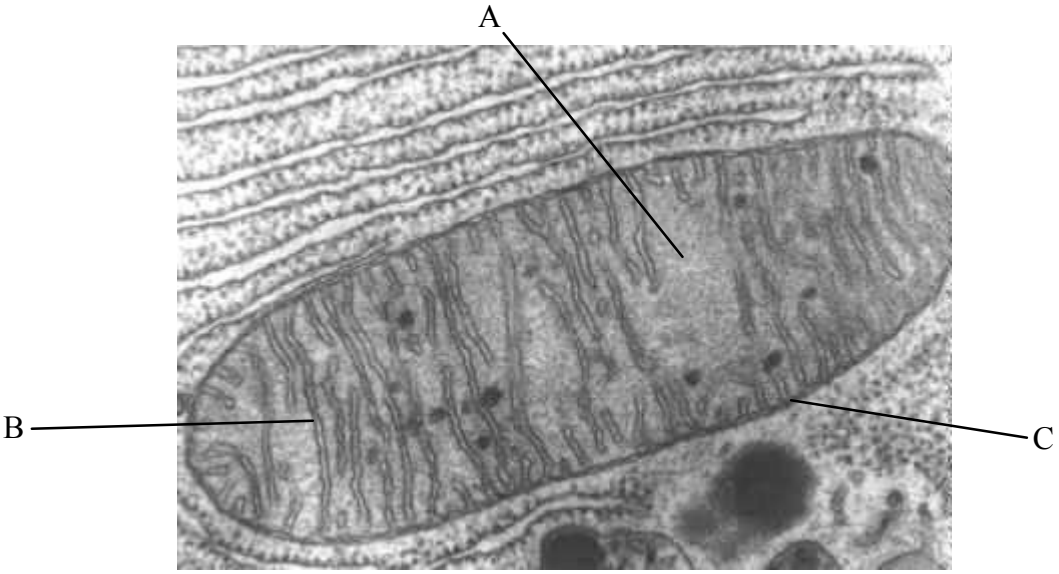
(b) Complete the table showing the differences between oxidation and reduction. *[2]*

	Oxidation	**Reduction**
Electrons gained or lost		
Oxygen or hydrogen gained or lost		

(c) The structure of a mitochondrion is shown in the electron micrograph below.



Name the parts labelled A, B and C and state the function of each. *[3]*

Part A: Name: . . . . . .

Function: . . . . . .

Part B: Name: . . . . . .

Function: . . . . . .

Part C: Name: . . . . . .

Function: . . . . . .

C3. (a) State the site of the light-independent reactions in photosynthesis. *[1]*

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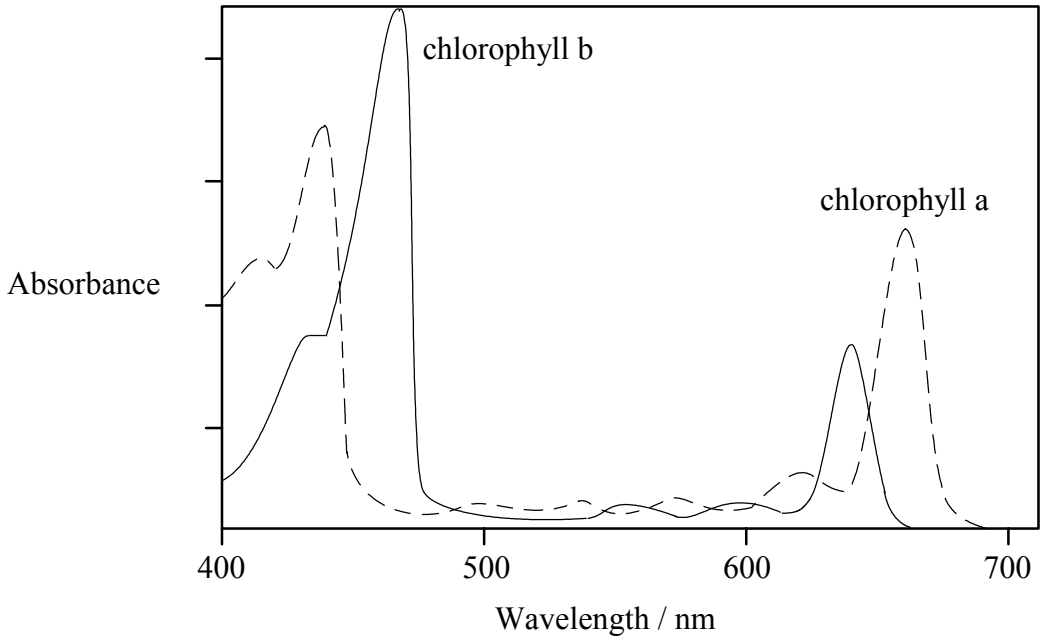
The absorption spectrum of chlorophyll a and chlorophyll b are shown in the graph below.



(b) On the graph above, draw the action spectrum of photosynthesis for a green plant *[1]*

(c) Explain photophosphorylation in terms of chemiosmosis. *[3]*

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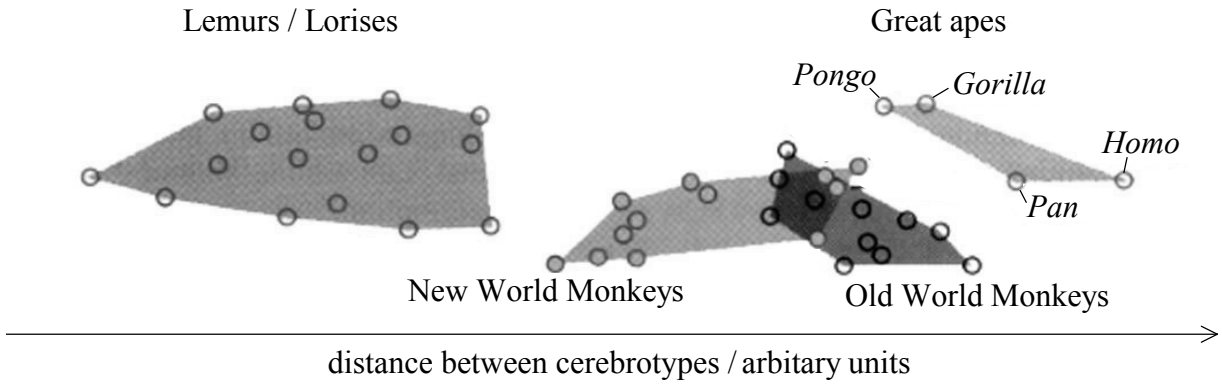
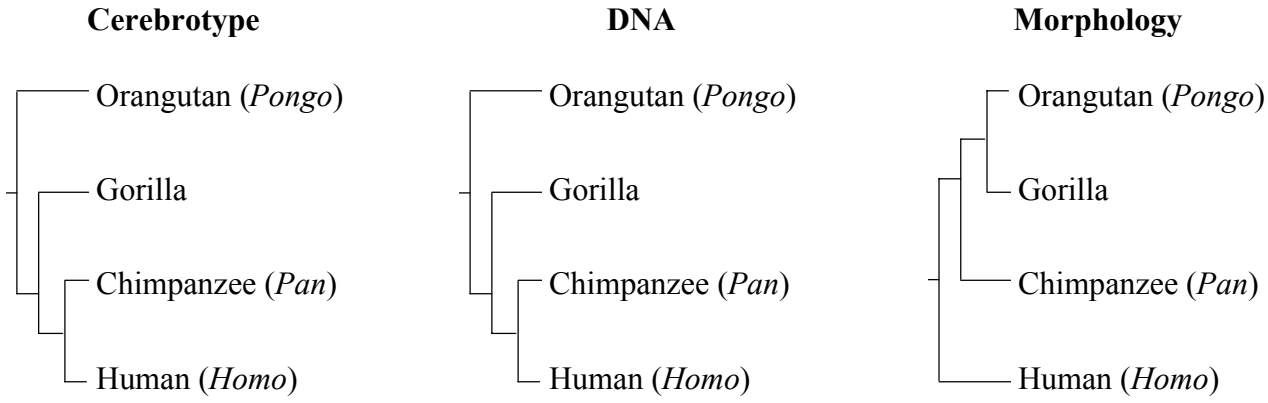
Option D – Evolution

D1. Comparison of mammalian brain areas has often focused on the differences in absolute size. However, in an experiment, scientists compared the sizes of 11 different brain areas relative to the total brain size for various primate species. A *cerebrotype* was then defined for each species, which reflected the relative sizes of different brain areas. The diagram below shows the clustering of cerebrotypes within primates.



[Source: Damon A Clark *et al*., *Nature* (2001), **411**, pages 189-193]

The relationship among hominoids was constructed using the cerebrotype data and is shown below. The evolutionary trees derived from DNA sequence and bone and tooth structure (morphology) are also shown.



(a) Deduce, using the cluster diagram, which group of primates is the least related to the Great apes. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(b) Compare the cerebrotypes of the New World monkeys and the Old World monkeys. *[2]*

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(c) Explain, using the data, which evolutionary tree the cerebrotypes support. *[2]*

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(d) In order to build the morphology tree, some of the fossilized bones and teeth had to be dated. Outline a method for such dating. *[2]*

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D2. (a) Outline the experiments of Miller and Urey into the origin of organic compounds. *[2]*

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(b) (i) State **two** conditions thought to be present in pre-biotic Earth. *[2]*

1. . . . . .

2. . . . . .

(ii) Discuss the possible roles of RNA in the origin of life. *[3]*

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(c) Draw a line to join each of the following theories of the origin of species with its definition. *[1]*

Special creation	arrived from outer space
Panspermia	created from inorganic matter
Spontaneous generation	life made by God

D3. Discuss the possible habitat of *Australopithecus* and the ecological changes that might have prompted its origin. *[3]*

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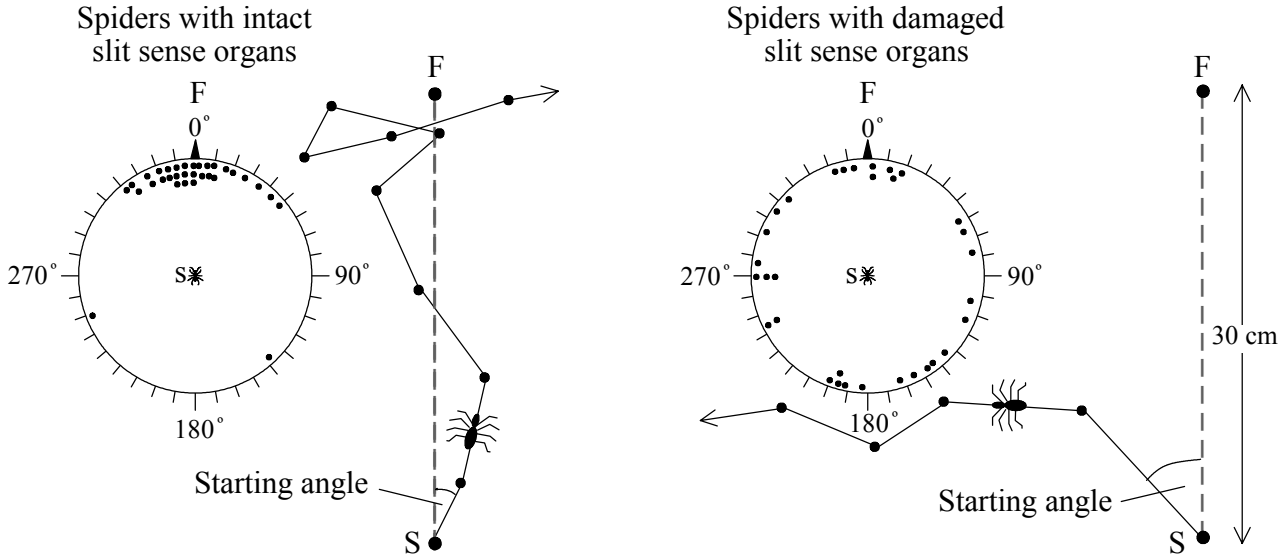
Option E – Neurobiology and Behaviour

E1. To move in the correct direction, wandering spiders *(Cupiennius salei)* depend on slit sense organs in their exoskeletons. In an experiment to show the importance of these organs, two groups of 32 spiders were used. One group had their slit sense organs intact and the other group had them temporarily damaged. Both groups were temporarily blinded so that so they could not see where they were going.

The spiders were briefly presented with a housefly which was then removed. The spiders were placed in the centre of a grid and the starting angle that each spider took to find the housefly again was recorded, with 0° leading directly to the housefly and 180° being in the opposite direction to the housefly.



Key: S = starting point of the spider F = position of the housefly

[Source: modified from S Zill and E Seyfarth, *Scientific American* (July 1996), pages 70–74]

(a) Calculate the percentage of spiders that walked with a starting angle within 30° in either direction of the housefly in the two groups of spiders.

(i) Spiders with intact slit sense organs. . . . . *[1]*

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(ii) Spiders with damaged slit sense organs: . . . . . *[1]*

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(b) Compare the effect of damaging the sensors in the two groups of spiders. *[2]*

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(This question continues on the following page)

(Question E1 continued)

(c) Discuss whether the spiders were showing innate or learned behaviour in this experiment. *[3]*

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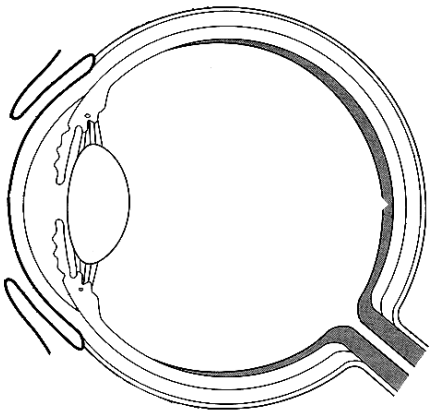
E2. (a) Label the diagram of the eye to indicate the following parts: lens, cornea, retina and optic nerve. *[2]*



(b) Explain the importance of a named reflex to humans. *[3]*

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E3. (a) State the name of the process described by Lorenz where animals followed the first object they saw at birth. *[1]*

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(b) Outline Skinner´s experiments into operant conditioning. *[2]*

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(c) State and explain an example of communication in a named bird **or** mammal (other than humans). *[3]*

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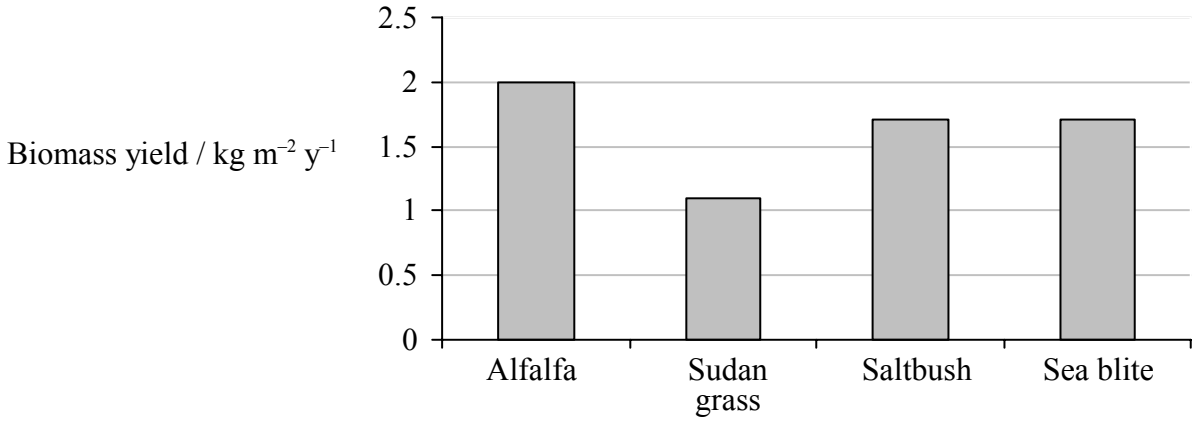
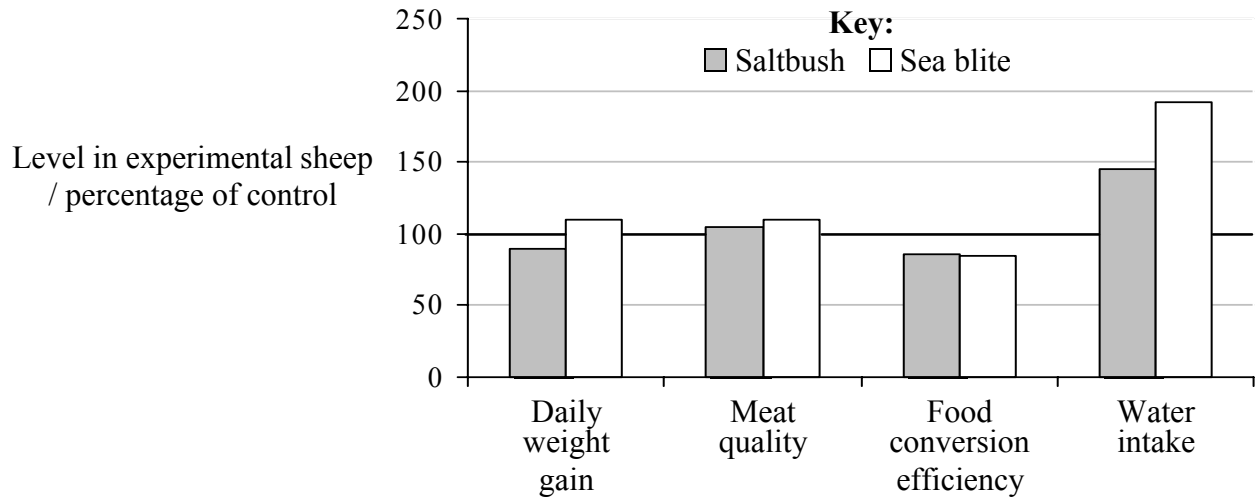
Option F – Applied Plant and Animal Science

F1. As the world's population grows, supplies of freshwater are becoming scarcer. Researchers are investigating the use of sea water to irrigate selected crops which can be fed to livestock. The biomass yield of two freshwater-irrigated plants often used for livestock forage, alfalfa *(Medicago sativa)* and Sudan grass *(Sorghum sudanense),* were compared with those of salt-tolerant crops irrigated by seawater, saltbush *(Atriplex spp.)* and sea blite *(Sueda maritima)*. The results are shown in the bar chart below.



Sheep were raised on a normal diet (control sheep) and compared with sheep fed on a normal diet supplemented with salt-tolerant plants. The results are shown in the bar chart below.



[Source: E Glenn *et al.*, *Scientific America*, (August 1998), pages 56–61]

(a) Compare the biomass yield of crops irrigated with seawater and freshwater. *[2]*

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(This question continues on the following page)

(Question F1 continued)

(b) Compare the daily weight gain and water intake in sheep fed on saltbush with sheep fed on sea blite. *[2]*

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(c) Discuss, using only the data provided, the advantages and disadvantages of using crops irrigated by seawater to feed sheep. *[3]*

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F2. (a) State **two** ways in which animals are useful to humans. *[2]*

1. . . . . .

2. . . . . .

(b) (i) Define the term F_1 *hybrid vigor*. *[1]*

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(ii) Explain how plant-breeding programmes have led to improvement in the yield of rice crops. *[3]*

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F3. (a) List **two** roles of auxins in plants. *[2]*

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2. . . . . .

(b) Explain **three** ways in which a greenhouse can improve the productivity of plants. *[3]*

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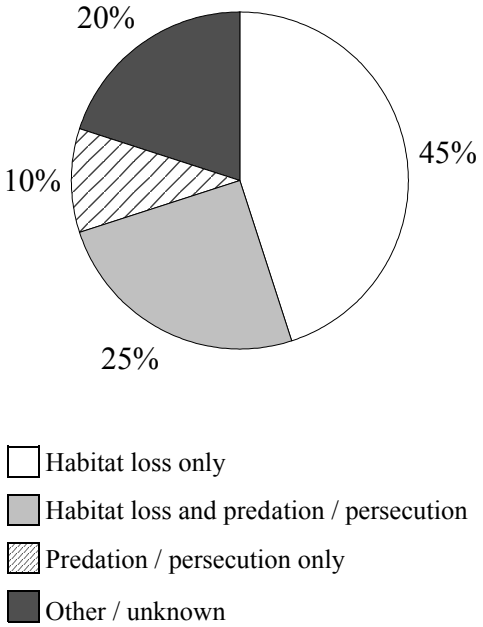
Option G – Ecology and Conservation

G1. Understanding the ecological mechanism that causes extinction is fundamental to conservation as not all organisms are threatened by the same factors. A total of 1012 threatened bird species in 95 families were studied to see how they were threatened by different factors:

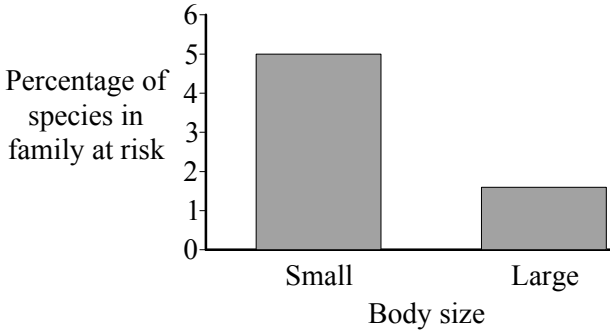
- habitat loss
- persecution by humans and introduced predators
- other factors (introduced competitors, hybridization and disease) and unknown risk factors.

Scientists investigated the relationship between body size and the risk of extinction, both due to habitat loss and to persecution/predation. Birds were classified as small (mean body mass 1 to 1000 g) and large (mass greater than 1000 g). The results are shown in the pie chart and bar charts below.

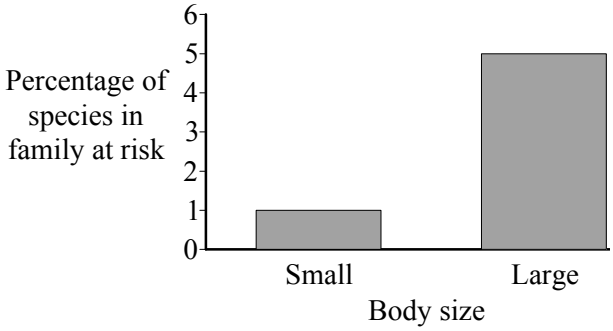
Percentage of all 1012 species threatened by each type of factor



Extinction risk from habitat loss



Extinction risk from persecution/predation



[Source: modified from B Owens *et al*., *Proceedings of the National Academy of Sciences*, (2000), **97**, pages 12144-12148]

(a) (i) State the percentage of species affected in some way by habitat loss. *[1]*

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(ii) Calculate the approximate number of bird species threatened by predation / persecution only. *[1]*

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(This question continues on the following page)

(Question G1 continued)

(b) State **two** factors that could have caused habitat loss. *[2]*

1. . . . . .

2. . . . . .

(c) Outline, using the bar charts, the effect of body size on the risk of extinction. *[2]*

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(d) Discuss the methods of conservation that would avoid the extinction of large species. *[3]*

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G2. (a) Temperature is an abiotic factor affecting distribution of plant species. State **one** other abiotic factor that affects the distribution of plant species. *[1]*

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(b) To test how temperature affects growth, some plants were grown at 20 °C and another group at 30 °C. After a number of weeks, the height of the plants was measured. Explain how the t-test could be used to test the significance of the effect of temperature on plant growth. *[3]*

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G3. The total solar energy received by a grassland is 5×10^5 kJ m^{-2} y^{-1}. The net production of the grassland is 5×10^2 kJ m^{-2} y^{-1} and its gross production is 6×10^2 kJ m^{-2} y^{-1}. The total energy passed on to primary consumers is 60 kJ m^{-2} y^{-1}. Only 10 % of this energy is passed on to the secondary consumers.

(a) Calculate the energy lost by plant respiration. *[2]*

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(b) Construct a pyramid of energy for this grassland. *[3]*