INTERNATIONAL BACCALAUREATE
BACCALAURÉAT INTERNATIONAL
BACHILLERATO INTERNACIONAL

M00/410/H(3)

BIOLOGY
HIGHER LEVEL
PAPER 3

Friday 12 May 2000 (morning)

1 hour 15 minutes

Name

Number

INSTRUCTIONS TO CANDIDATES

- Write your candidate name and 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 in a continuation answer booklet, and indicate the number of booklets used in the box below. Write your name and candidate number on the front cover of the continuation answer booklets, and attach them to this question paper using the tag provided.
- At the end of the examination, indicate the letters of the Options answered in the boxes below.

OPTIONS ANSWERED		EXAMINER	TEAM LEADER	IBCA
		/20	/20	/20
		/20	/20	/20
NUMBER OF CONTINUATION BOOKLETS USED	. . . . .	TOTAL /40	TOTAL /40	TOTAL /40

Option D — Evolution

D1. There is evidence that humans, chimpanzees and gorillas evolved from a common ancestor. Biologists recently selected a large number of genes at random from the human genome and compared their base sequences with those of the same genes in chimpanzees and gorillas. The number of base substitutions in the evolution of each species from the common ancestor was then deduced.

Some of the base substitutions did not cause a change in the amino acid sequence encoded by the gene. These mutations were assumed to be neutral in terms of natural selection and were used to estimate the total mutation rate in each species.

The other base substitutions did cause a change in the amino acid sequence encoded by the gene, each base substitution causing one amino acid substitution.

The estimated mutation rate was then used to calculate an expected number of amino acid substitutions. The results are shown in the table below.

Species	Mutation rate per nucleotide per year	Observed number of amino acid substitutions per generation	Expected number of amino acid substitutions per generation
Human	0.00000000133	2.6	4.2
Chimpanzee	0.00000000122	1.5	3.2
Gorilla	0.00000000123	1.9	3.1

(Source: Crow, *Nature* (1999), **397** pages 344-347)

(a) Identify which of the three primate species has evolved most rapidly since divergence, with a reason based on the data in the table. *[2]*

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The elimination of deleterious mutations by natural selection causes the number of observed amino acid substitutions to be less than the number expected.

(b) Analyse the data in the table to find in which species most mutations have been eliminated per generation. Show clearly how you have reached your conclusion. *[2]*

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(This question continues on the following page)

(Question D1 continued)

(c) Using the data in the table, evaluate the stability of DNA as a genetic material. *[2]*

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D2. (a) State **one** condition under which the Hardy-Weinberg Principle applies. *[1]*

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(b) Outline the uses of the Hardy-Weinberg Principle. *[3]*

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D3. (a) Outline the experiments of Miller and Urey into the origin of organic compounds on Earth. *[6]*

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(b) Discuss briefly whether scientific experiments can be used to discover the origin of life on Earth. *[4]*

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Option E — Neurobiology and Behaviour

E1. (a) Outline the pain withdrawal reflex in humans. *[6]*

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(b) Discuss briefly the effects of inhibitory psychoactive drugs. *[4]*

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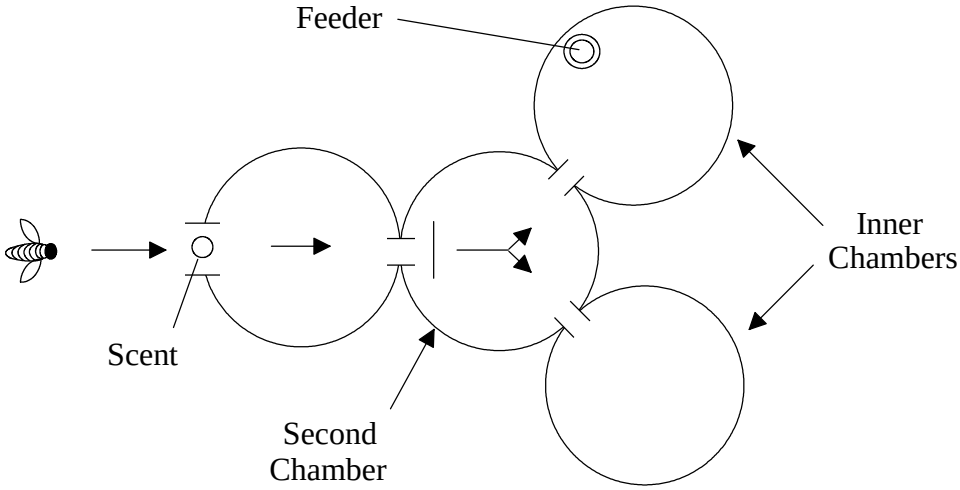
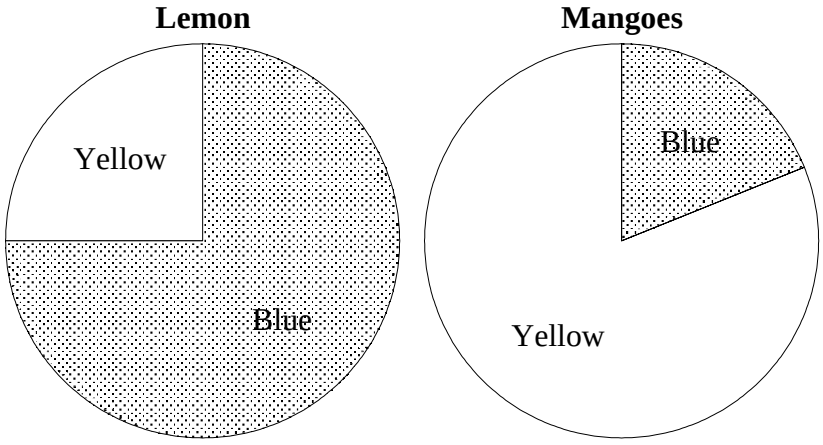
E2. The apparatus shown in the diagram below was used to investigate whether honey bees (*Apis mellifera*) can learn to associate a colour with a smell.



As the bees entered the first chamber they passed a container which gave out either the smell of lemons or of mangoes. When the bees entered the second chamber there was no smell but instead two colours, yellow and blue, marking the entrance to the two inner chambers. One of these inner chambers contained food for the bees. When the smell was of lemons the chamber with the food was marked with the blue colour. When the smell was of mangoes it was marked with the yellow colour. The food was switched every ten minutes between the inner chambers. The smell in the first chamber was also often switched between lemons and mangoes.

This procedure was followed for two days. On the second day the percentage of bees which entered each of the chambers was recorded when each of the smells was used. The results are shown below. In both pie charts the difference between the number of bees entering the two chambers is statistically significant.



(Source: Srinvasan *et al*, *Nature* (1998), **396** pages 637-638)

(This question continues on the following page)

(Question E2 continued)

(a) Analyse the data in the pie charts to reach conclusions about the sensory receptors of honey bees. *[3]*

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(b) As the bees moved through the chambers they had to use their memory twice in order to reach the correct chamber. Identify these **two** examples of the use of memory and where in the chambers they were needed. *[2]*

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(c) Deduce which type of learning was shown by the bees in this experiment. *[1]*

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(d) Suggest an advantage to honey bees of associating a colour with a smell. *[1]*

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E3. (a) State the names of the **two** parts of the autonomic nervous system. *[1]*

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2. . . . . .

(b) State **one** part of the human body that can be controlled by the autonomic nervous system. *[1]*

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(c) State **one** example of an autonomic reflex which can be controlled by the conscious part of the brain. *[1]*

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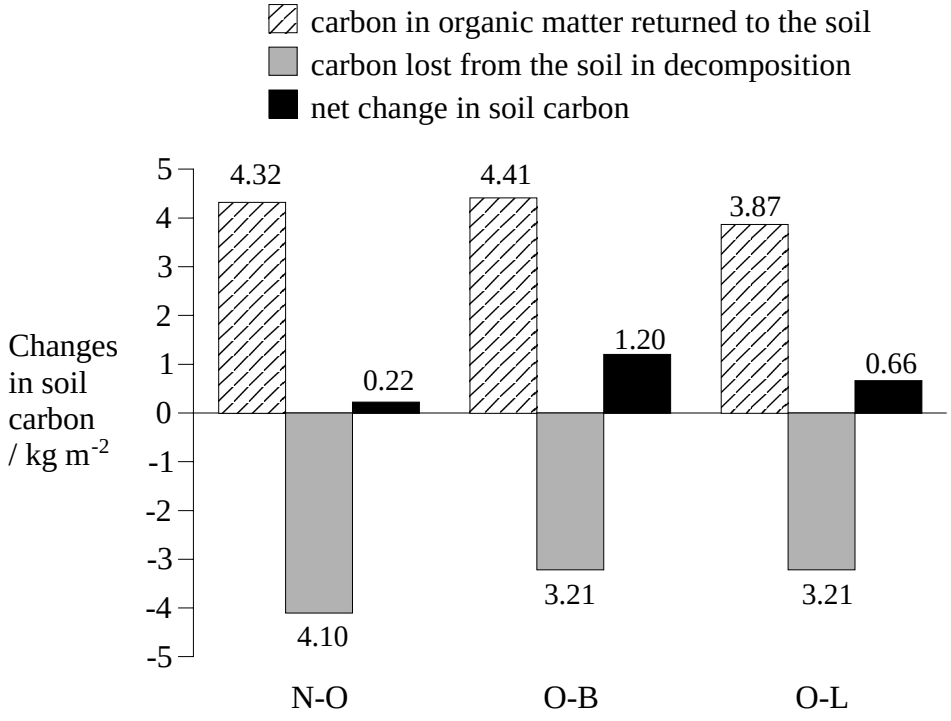
Option F — Applied plant and Animal Science

F1. The fertility of a soil is affected by the amount of organic matter in it. In a fifteen year study, the effect of organic and non-organic farming systems on the amount of organic matter in soils was investigated. The systems used were as follows.

- **Non-organic (N-O)**: maize and soya beans were grown using nitrogen fertiliser and pesticides.
- **Organic using beef cattle (O-B)**: legumes and grasses were grown and fed to cattle and the manure from the cattle was returned to the soil.
- **Organic using legumes (O-L)**: legumes were grown and ploughed into the soil before growing other crops.

In all three systems the parts of the crops that were not harvested were returned to the soil. The total amount of carbon in organic matter returned to the soil during the period was measured. The total amount of carbon in the soils at the start and end of the fifteen year period was also measured. From these measurements the amount of carbon lost from the soil by decomposition of organic matter was estimated. The results are shown in the bar chart below.



(Source: Tilman, *Nature* (1998), **396** pages 262-264)

(a) (i) Compare the net changes in soil carbon of the different systems. *[2]*

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(ii) Using only the data in the bar chart, deduce the reasons for the differences in the net change of soil carbon during the study. *[2]*

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(b) Discuss briefly whether the organic farming systems used in the investigation could help to reduce the greenhouse effect. *[3]*

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F2. Outline **three** different uses of **named** domesticated animals. *[3]*

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F3. (a) Outline the difference between pollination and fertilisation in flowering plants. *[4]*

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(b) Explain how varieties of wheat that give improved yields have been developed. *[6]*

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Option G — Ecology and Conservation

G1. (a) Explain how, in the oxygen cycle, interconversions between water, carbon dioxide, ozone and oxygen take place. *[6]*

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(b) Outline how human activities have caused ozone depletion and how they can be reduced or prevented. *[4]*

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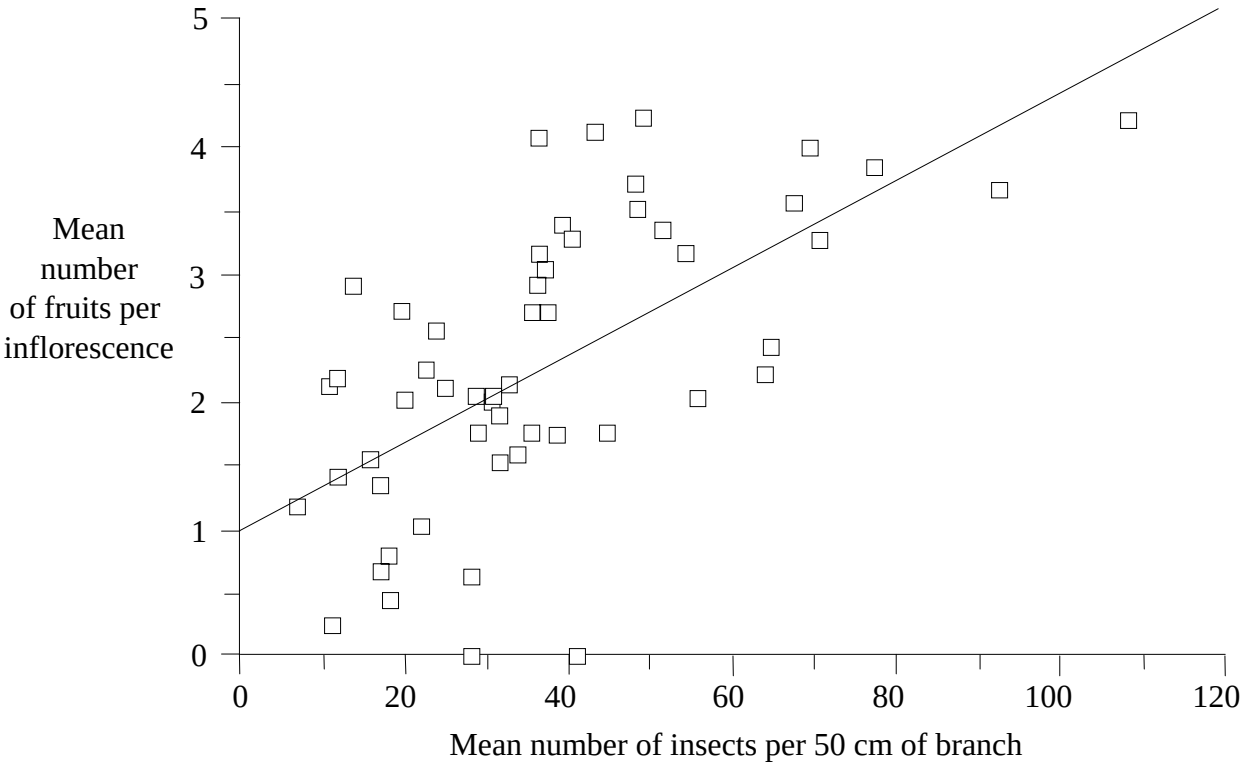
G2. Many species of insect are found on trees. Large numbers of one species of insect are found on *Acacia zanzibarica* trees in Northern Tanzania. Ecologists measured the population density by counting the number of insects on 50 cm lengths of branch.

Acacia zanzibarica is an angiospermophyte. It produces inflorescences (groups of flowers) which attract pollinating insects. If a flower is successfully pollinated and fertilised it can develop into a fruit. The ecologists counted the number of fruits developing in each inflorescence on the 50 cm lengths of branch and calculated mean numbers. The results are shown in the scattergram below.



(Source: Willmer and Stone, *Nature* (1997), **388** pages 65-166)

(a) State the relationship between the numbers of the insect and the mean number of fruits per inflorescence. *[1]*

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(b) Suggest causes for the relationship shown in the scattergram based on:

(i) herbivory. *[1]*

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(ii) predation. *[1]*

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(This question continues on the following page)

(Question G2 continued)

The insects that the ecologists found were ants, which live inside enlarged thorns that the *Acacia zanzibarica* trees grow. The ants feed on secretions produced specially by glands on the trees. The ants attack other insects and mammals feeding on the leaves and flowers.

(c) State the name of the type of interaction shown by the ants and *Acacia zanzibarica* trees. *[1]*

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(d) Explain how the activities of the ants could have affected the number of fruits formed per inflorescence by the *Acacia zanzibarica* trees. *[3]*

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G3. (a) Estimate the number of species of living organism in the world. *[1]*

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(b) Compare the relative biodiversity of temperate forests, tropical forests and tundra. *[2]*

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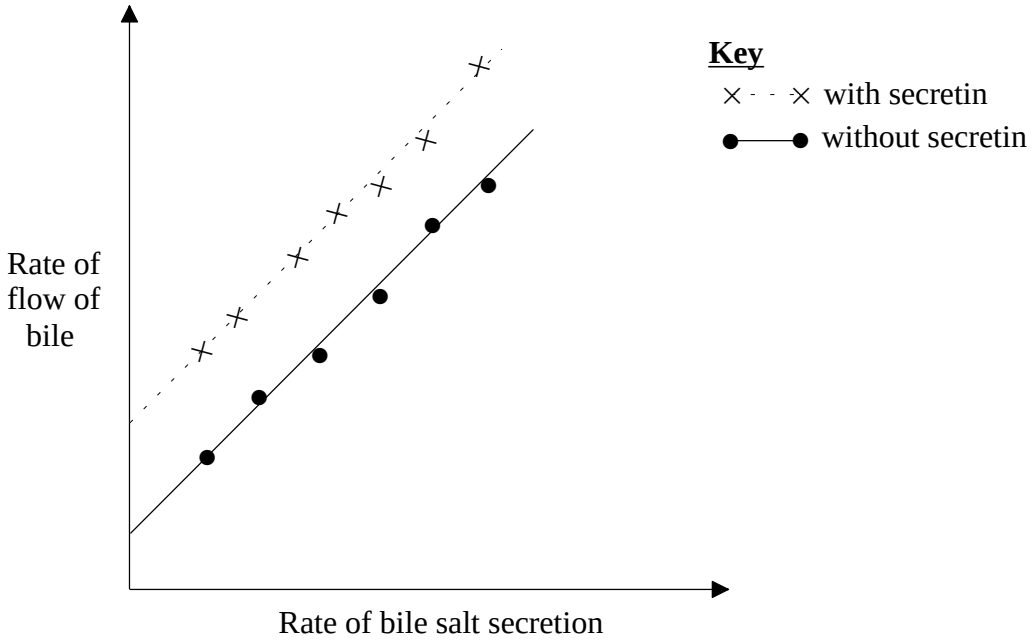
Option H — Further Human Physiology

H1. Bile is formed by the liver and drains through canaliculi (narrow tubes) into the gall bladder, where it is stored. During bile formation, liver cells secrete bile salts which cause water to be drawn into the canaliculi by osmosis. The graph below shows the rate of bile flow into the gall bladder at different levels of bile salt secretion. The effect of a hormone, **secretin**, is also shown.



(Source: Horner Andrews, in *Liver*, Edward Arnold (1979), page 31)

(a) (i) State the relationship between the rate of bile salt secretion and the rate of bile flow, without secretin. *[1]*

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(ii) Suggest the cause of this relationship. *[1]*

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(b) Suggest when the rate of secretion of bile salt by liver cells needs to be highest. *[1]*

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(This question is continued on the following page)

(Question H1 continued)

(c) Using only the data in the graph, outline the effect of secretin on bile flow. *[2]*

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(d) Secretin causes HCO_3^- (hydrogen carbonate) ions to be secreted into the bile. The results in the graph show that in addition to HCO_3^- and bile salt, another solute is secreted into the bile. Explain how this conclusion can be drawn from the results in the graph. *[2]*

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H2. State how the supply of oxygen to respiring tissues is helped by: *[1]*

(a) the diaphragm.

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(b) myoglobin. *[1]*

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(c) the Bohr shift. *[1]*

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H3. (a) Explain how the structure of a cell in the epithelium of a villus in the ileum allows it to absorb food efficiently. *[6]*

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(b) Outline the functions of the lymphatic system. *[4]*

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