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

M07/4/BIOLO/HP3/ENG/TZ2/XX+

22076015

BIOLOGY
HIGHER LEVEL
PAPER 3

Tuesday 15 May 2007 (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.

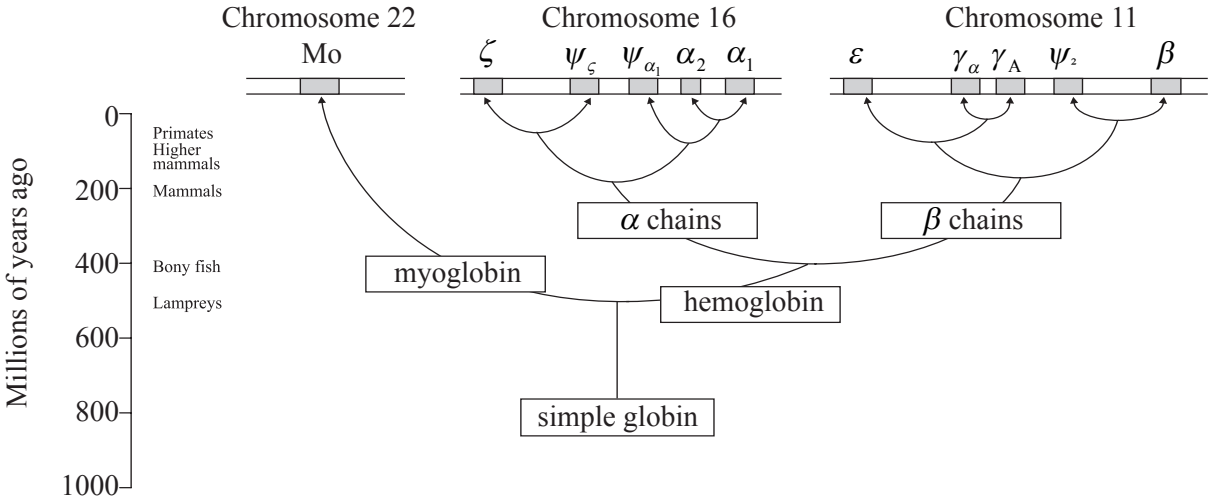
0120

Option D — Evolution

D1. The evolution of hemoglobin molecules has been studied extensively by comparing the amino acid sequences in both myoglobin and hemoglobin. Myoglobin is used for oxygen storage while hemoglobin is used for oxygen transport. Ancient prehistoric animals had a single chain of simple globin for oxygen storage and transport. About 500 million years ago, a gene duplication event occurred and one copy became the present day myoglobin and the other evolved into an oxygen transport protein that gave rise to the present day hemoglobin.

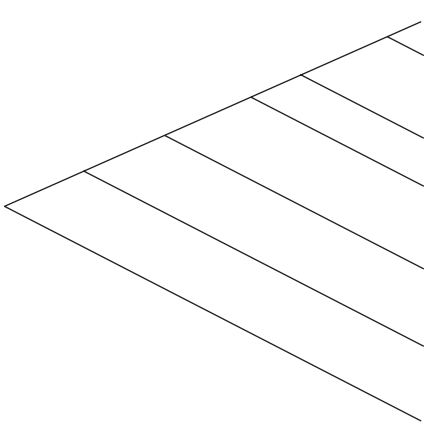
The following figures are phylogenetic trees of hemoglobin in different organisms.

Figure A Note: each shaded area of the chromosomes below represents a gene.



[Source: adapted from C K Mathews, K E van Holde and K G Ahern (2000), *Biochemistry*, 3rd edition, Benjamin Cummings, page 241]

Figure B



taxa	protein	function	induced by
vertebrate	hemoglobin	O_2 transport	low O_2
vertebrate	myoglobin	O_2 storage	
invertebrate	hemoglobin	O_2 transport	low O_2?
plant	hemoglobin	O_2 storage	low O_2?
protist	hemoglobin	electron transfer	light (alga)
bacteria	hemoglobin	electron transfer	low O_2
cyanobacteria	phycocyanin	harvest light	light

[Source: R Hardison (1999), *American Scientist*, **87**, pages 126–137]

(This question continues on the following page)

(Question D1 continued)

(a) State how many years ago the hemoglobin split into α chains and β chains. *[1]*

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(b) Estimate the number of gene duplication events that have occurred from the simple globin. *[1]*

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(c) Using figure B, compare the phylogenetic relationship of myoglobin with vertebrate and invertebrate hemoglobin. *[1]*

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(d) Suggest a reason for the difference in function of hemoglobin between plants and animals. *[1]*

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(e) Explain why changes observed in the sequence of amino acids may lead to an underestimate of the actual number of mutations. *[2]*

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D2. (a) Outline Lamarck's theory of evolution. *[2]*

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(b) State **two** major features that place humans in the taxonomic order of primates. *[2]*

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2. . . . . .

D3. (a) Describe why the allele for sickle cell anemia is maintained in populations in regions with a high incidence of malaria. *[4]*

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(b) Explain the biochemical, anatomical and geographical evidence for the evolution of organisms. *[6]*

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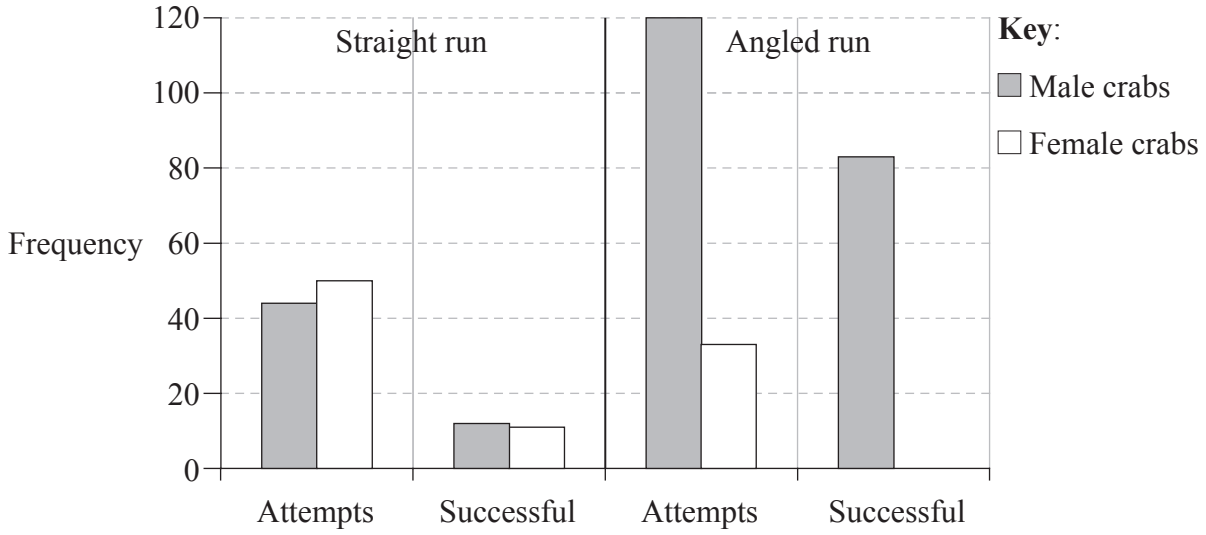
Option E — Neurobiology and Behaviour

E1. Fiddler crabs (*Uca beebei*) live in mixed-sex colonies on the intertidal mudflats on the Pacific coast of Central and South America. Both sexes defend their burrows and forage for food at the surface during low tide. The population of fiddler crabs has an equal number of males and females. The male crabs have one large claw and one small claw. Female crabs are lighter in colour and have two small claws.

Great-tail grackles (*Quiscalus mexicanus*), a large bird, are a common predator of fiddler crabs. Grackles hunt by running straight at the crabs or by running past them then turning sharply back (angled run) to dive on the crabs. Research was undertaken to study the behaviour and predation of the fiddler crabs. The results are shown in the graph below.

Predation of Fiddler Crabs by Great-tail Grackles



[Source: adapted from T Koga *et al.* (2001), *Animal Behaviour*, **62**, pages 201–207, © Elsevier 2001]

(a) Calculate the percentage predation success when grackles hunt male crabs using a straight run. *[1]*

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(b) Determine the percentage difference in the number of attempts made on female crabs by grackles using a straight run versus an angled run. *[1]*

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(This question continues on the following page)

(Question E1 continued)

(c) Outline the predation success of grackles when using a straight run versus an angled run. *[2]*

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(d) Suggest a reason for the difference in predation success of the grackles. *[1]*

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E2. (a) State the **two** sub-divisions of the autonomic nervous system. *[1]*

1. . . . . .

2. . . . . .

(b) Distinguish between rod cells and cone cells. *[2]*

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(c) Draw a labelled diagram of a reflex arc. *[2]*

E3. (a) Outline the symptoms of Parkinson's disease and the role of dopamine. *[3]*

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(b) Media reports have highlighted the use of ecstasy (MDMA) by some people with Parkinson's. Some reports have suggested that the use of this drug may help relieve the symptoms of the condition. State how psychoactive drugs such as ecstasy affect the brain. *[1]*

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(c) Explain how innate behaviour and learned behaviour contribute to the survival of animals. *[6]*

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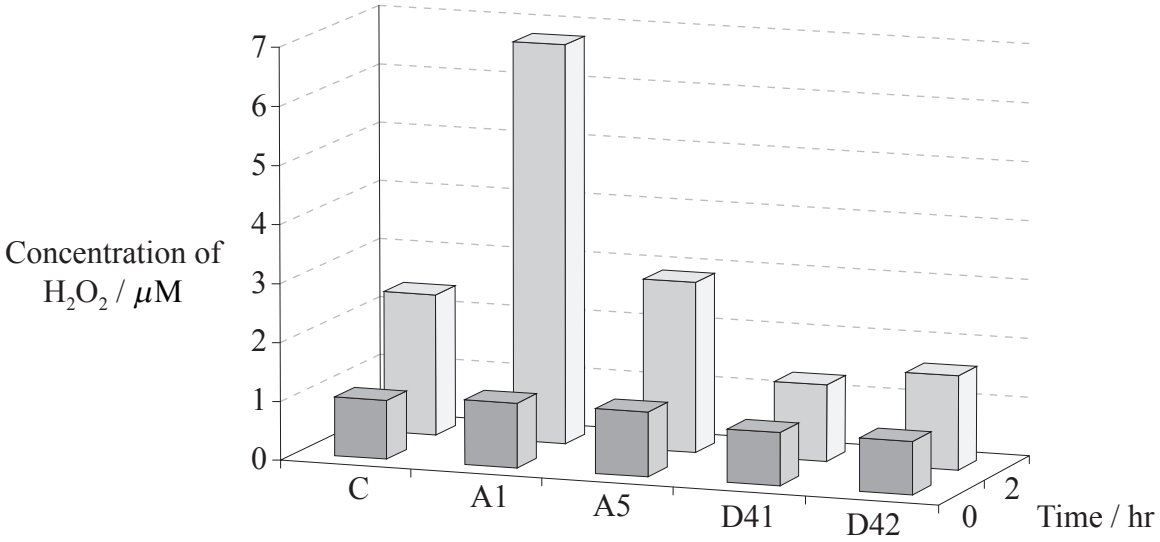
Option F — Applied Plant and Animal Science

F1. Plants have developed defense mechanisms against pathogens such as bacteria, fungi, and viruses. Chemicals released by these pathogens can trigger a defense response in infected plant cells. For example, the production of hydrogen peroxide (H_2O_2) which reacts with pathogen membranes and cellular chemicals, eventually kills both the cell and the pathogen.

The OSRac1 gene was isolated and introduced into a number of rice plant (*Oryza spp*.) lines to study its role in disease resistance of plants to Blast fungus. Experiments were carried out to see if the OSRac1 gene was part of the signalling pathway for hydrogen peroxide production. A control and four other genetically modified rice plant lines were exposed to chemicals known to initiate a defense response and the production of hydrogen peroxide. The results are shown in the graph below.



Key: C: control
A1 and A5: rice plants with the OSRac1 gene always turned on
D41 and D42: rice plants with the OSRac1 gene suppressed

[Source: adapted from E Ono *et al.* (2001), *Proceedings of the National Academy of Sciences USA*, **98** (2), pages 759–764, copyright 2001, National Academy of Sciences, USA]

(a) Identify the concentration of H_2O_2 at time 0 for the control plants. *[1]*

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(This question continues on the following page)

(Question F1 continued)

(b) Compare the change in H_2O_2 production in the control and genetically modified plants two hours after the chemical was applied. *[3]*

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(c) Evaluate whether the data supports the hypothesis that OSRac1 gene is involved in disease resistance. *[1]*

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(d) Suggest **one** possible concern about the use of transgenic plants with the disease resistant gene. *[1]*

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F2. (a) Outline the effect of **two** biotic factors on plant productivity. *[2]*

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(b) Outline a breeding programme to improve the milk yield in cattle. *[2]*

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F3. (a) Discuss the use and misuse of antibiotics and growth hormones in livestock production. *[6]*

(b) Explain how monoculture can lead to nutrient depletion and suggest how this problem may be overcome. *[4]*

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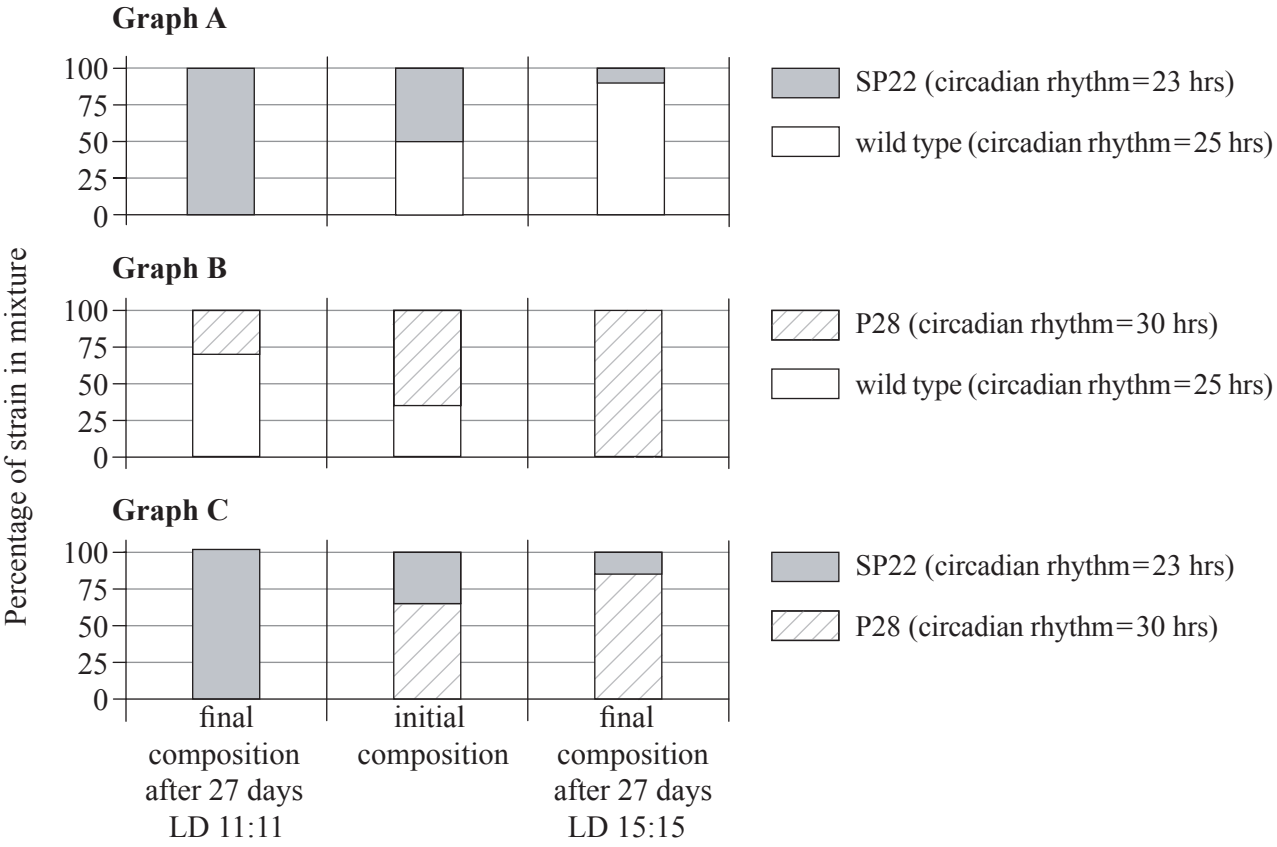
Option G — Ecology and Conservation

G1. Cyanobacteria (photosynthetic organisms) show a circadian rhythm or "biological clock" in which their biological activities are linked with the day-night cycle. When cyanobacteria are grown on or close to their optimum circadian rhythm, their fitness (development, growth and longevity) is improved.

Researchers investigated competition between cyanobacteria with different optimal circadian rhythms. Wild type (most frequent genotype) cyanobacteria and two mutant strains – SP22 and P28, were placed in dishes containing a nutrient gel. The cyanobacteria were exposed to two different light-dark cycles (for a period of 27 days): 11 hours light then 11 hours dark (LD 11:11), or 15 hours light followed by 15 hours dark (LD 15:15). The graphs below show the initial and final composition of cyanobacteria in the dishes.



[Source: adapted from Y Ouyang *et al.* (1998), *Proceedings of the National Academy of Sciences, USA*, **95** (15), pages 8660–8664, copyright 1998, National Academy of Sciences, USA]

(a) State the initial composition of the P28 strain in graph B. *[1]*

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(This question continues on the following page)

(Question G1 continued)

(b) Compare the wild type strain in competition against the mutant strains

(i) when exposed to the LD 15:15 cycle. *[1]*

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(ii) when exposed to the LD 11:11 cycle. *[1]*

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(c) A new strain of cyanobacteria with a circadian rhythm of 27 hours was isolated. Predict, giving a reason, what would happen if this new strain was grown with the wild type when exposed to the LD 15:15 cycle. *[2]*

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(d) Explain whether or not this data supports the competitive exclusion principle. *[2]*

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G2. (a) State the role of the following organisms in the nitrogen cycle. *[2]*

Nitrosomonas: . . . . . .

Rhizobium: . . . . . .

(b) Explain how living organisms can affect the abiotic environment during succession. *[2]*

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G3. (a) Explain the factors that affect the distribution of an animal species. *[5]*

(b) Outline the consequences of releasing raw sewage into a stream. *[4]*

Option H — Further Human Physiology

H1. Atherosclerosis is a chronic disease caused by elevated serum cholesterol levels resulting in deposition of lipids in arteries. Diet modification, weight reduction and exercise are initially prescribed to alleviate high cholesterol levels. Due to health and possibly genetic reasons, these attempts may be unsuccessful. Drugs may then be prescribed to lower cholesterol production. One of the enzymes that can be competitively inhibited by these drugs is involved in the pathway for the synthesis of bile and steroid hormones.

The safety and effectiveness of a new member of a family of drugs called statins was investigated. The effect of the drug on the blood serum levels of cholesterol, low density lipoproteins (high levels are unhealthy), high density lipoproteins (high levels are healthy) and triglycerides (high levels are unhealthy) are shown below.

	Serum blood level / % change from baseline			
Dose of drug / mg	**Cholesterol**	**Low density lipoproteins**	**High density lipoproteins**	**Triglycerides**
0 (placebo)	4	4	–3	10
10	–29	–39	6	–19
20	–33	–43	9	–26
40	–37	–50	6	–29

[Source: adapted from Parke-Davis, (2000), Lipitor® (Atorvastatin Calcium) tablets, Spec #0155G247, page 4, Parke-Davis, New York, www.216.86.213.73/2pdfs/0494lipitor.pdf]

(a) State the dose that was most effective in raising the level of high density lipoproteins in the treated groups. *[1]*

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(b) State the relationship between dose and cholesterol levels. *[2]*

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(This question continues on the following page)

(Question H1 continued)

(c) Distinguish the effect of dose size on low density lipoproteins and high density lipoproteins. *[1]*

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(d) Explain the use of a placebo in these investigations. *[1]*

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(e) Suggest **one** possible physiological side effect when taking statins for atherosclerosis. *[1]*

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H2. (a) Outline the transport functions of the lymphatic system. *[2]*

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(b) State **two** materials **not** absorbed by the digestive system. *[1]*

1. . . . . .

2. . . . . .

(c) Distinguish between endopeptidases and exopeptidases. *[1]*

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H3. (a) Explain the control of thyroxin secretion in humans. *[6]*

(b) Discuss the problems of gas exchange at high altitudes. *[4]*