88106006

International Baccalaureate®
Baccalauréat International
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BIOLOGY
STANDARD LEVEL
PAPER 3

Wednesday 3 November 2010 (morning)

1 hour

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.

0128

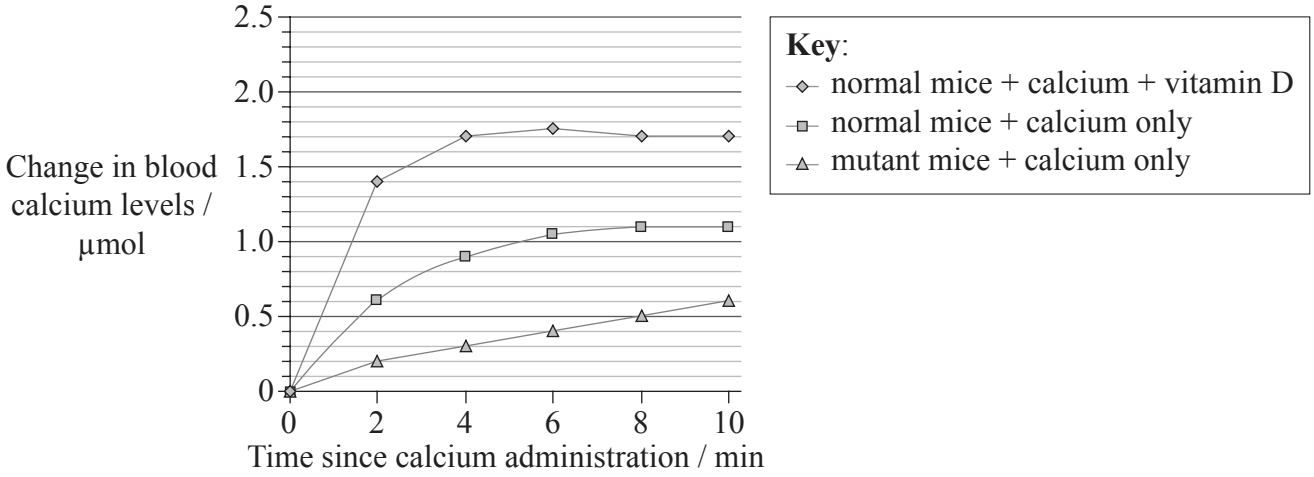
Option A — Human nutrition and health

A1. Rickets, caused by a defective vitamin D receptor (VDR), can be prevented by high calcium intake. A series of experiments were performed to test this. The results are shown in the graphs.

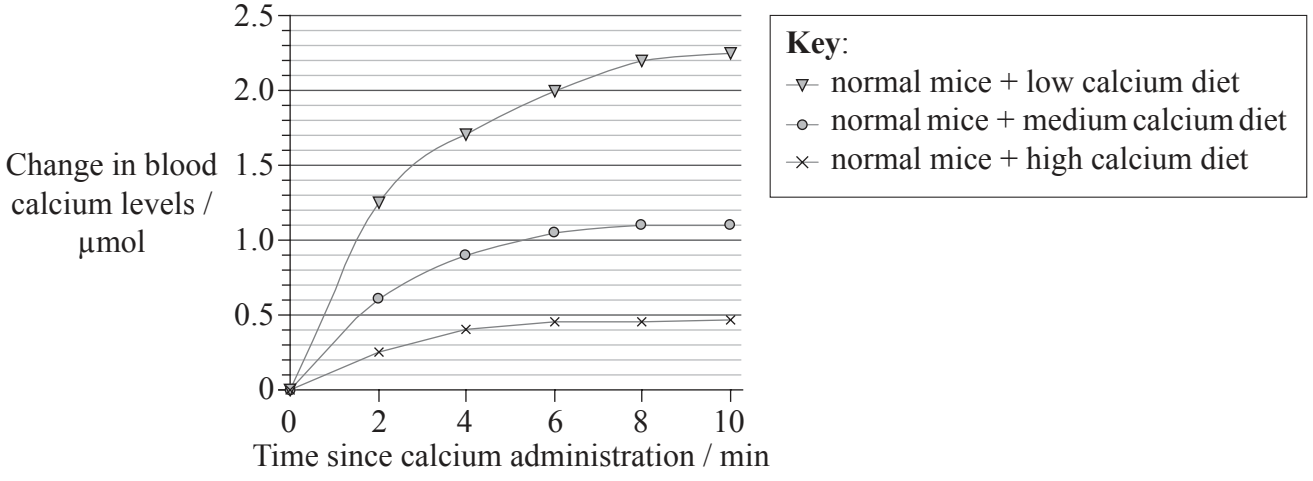
Graph A shows the change in blood calcium levels after calcium administration in normal mice with and without addition of vitamin D. It also shows the change in blood calcium levels in mutant mice, which lack the vitamin D receptor.

Graph B shows the change in blood calcium levels after calcium administration in normal mice after being subjected to one week of low, medium and high calcium diets.

Graph A



Graph B



[S. J. Van Cromphaut, M. Dewerchin, J. G. J. Hoenderop, I. Stockmans, E. Van Herck, S. Kato, R. J. M. Bindels, D. Collen, P. Carmeliet, R. Bouillon et al. (2001) "Duodenal calcium absorption in vitamin D receptor-knockout mice: Functional and molecular aspects" PNAS, 98 (23), pp. 13324–9. Figure 2 (adapted). Copyright 2001 National Academy of Sciences, USA.]

(This question continues on the following page)

(Question A1 continued)

(a) State the change in blood calcium levels in normal mice 10 minutes after the administration of calcium, with and without the addition of vitamin D. *[1]*

With vitamin D: . . . . . .

Without vitamin D: . . . . . .

(b) Compare the changes in blood calcium levels in normal mice and in mutant mice after the administration of calcium. *[2]*

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(c) Explain, using graph B, the changes in blood calcium levels for the mice with different diets. *[2]*

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(d) Discuss whether the scientists were able to support their hypothesis that rickets caused by the defective vitamin D receptor can be prevented by the intake of large amounts of calcium. *[2]*

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A2. (a) (i) Outline the function of the appetite control centre in the brain. *[3]*

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(ii) Outline the implications for the health of a person who has a BMI of 16 $kg\,m^{-2}$. *[1]*

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(b) List, by completing the table below, the differences between human milk and artificial milk when feeding babies. *[3]*

Component	Human milk	Artificial milk
sugar	lactose	
protein		soya protein
antibodies	present	

A3. Discuss the consequences of products with high food miles. *[4]*

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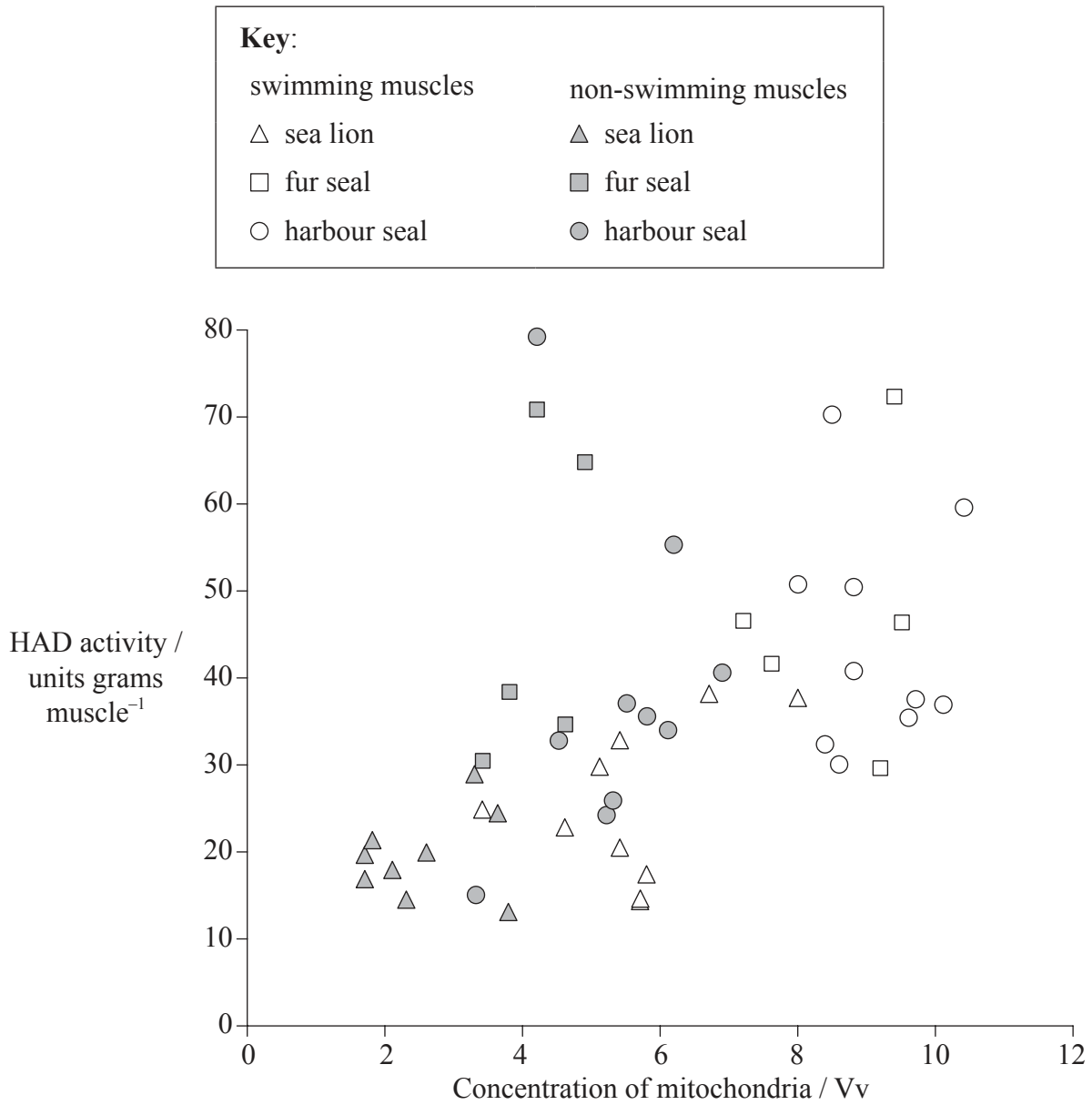
Option B — Physiology of exercise

B1. Marine biologists tested the possible adaptations in skeletal muscles to maintain aerobic metabolism under hypoxic (low oxygen) conditions. Samples were collected from swimming and non-swimming muscles of the following Pinnipeds: sea lions (*Eumetopias jubatus*), fur seals (*Callorhinus ursinus*) and harbour seals (*Phoca vitulina*).

The sampled muscles were measured for concentration of mitochondria. The activity of β-hydroxyacyl-CoA dehydrogenase (HAD), an enzyme used for the oxidation of fatty acids used in respiration, was assessed at different concentrations of mitochondria.



[S. B. Kanatous et al. (April, 1999) "High aerobic capacities in the skeletal muscles of pinnipeds: adaptations to diving hypoxia" J Appl Physiol 1999 86: 1247-1256, figure 3B. Am Physiol Soc, used with permission.]

(This question continues on the following page)

(Question B1 continued)

(a) State the general relationship between concentration of mitochondria and the activity of HAD. *[1]*

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(b) Distinguish between the non-swimming muscles of sea lions and the non-swimming muscles of fur seals. *[2]*

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(c) Compare swimming muscles and non-swimming muscles in Pinnipeds. *[2]*

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(d) Studies of harbour seals led to the hypothesis that stores of fats (triglycerides) may play an important role in ATP production, especially during diving. Discuss this hypothesis using the data provided. *[3]*

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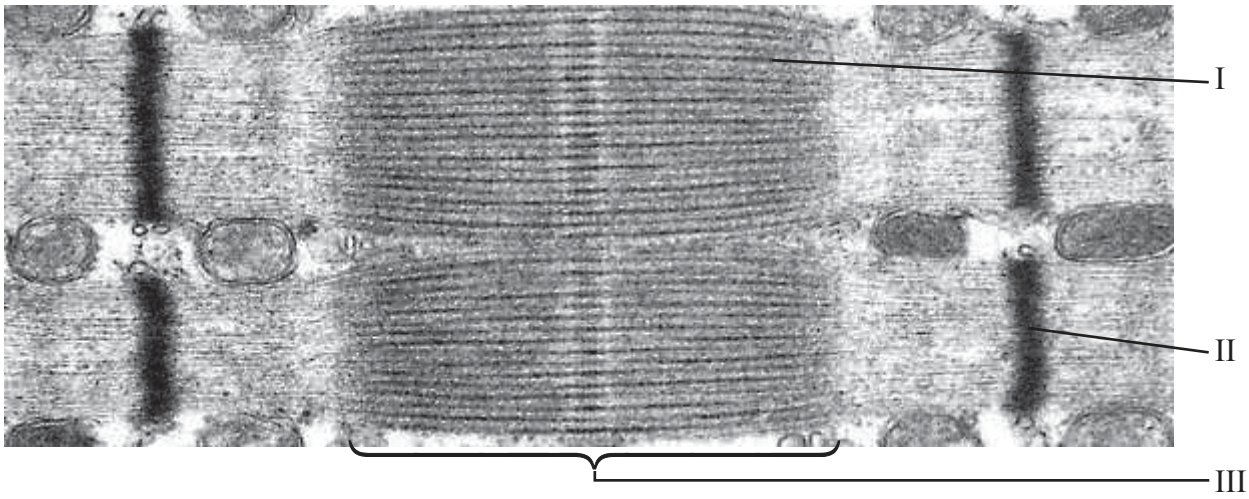
B2. (a) Label the parts of the following micrograph of the striated muscle. *[3]*



[Coen A.C. Ottenheijm, Leo M.A. Heunks and Richard P.N. Dekhuijzen(2008) Diaphragm adaptations in patients with COPD. _Respiratory Research_, 9(12), doi:10.1186/1465-9921-9-12. © 2008 Ottenheijm _et al._; licensee BioMed Central Ltd.]

I. . . . . .

II. . . . . .

III. . . . . .

(b) Outline the effect of training on vital capacity. *[1]*

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B3. (a) Outline the effects of moderate-intensity exercise and high-intensity exercise on muscle fibres and heart rate. *[2]*

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(b) Evaluate the risks and benefits of using blood transfusions to improve performance in sports. *[4]*

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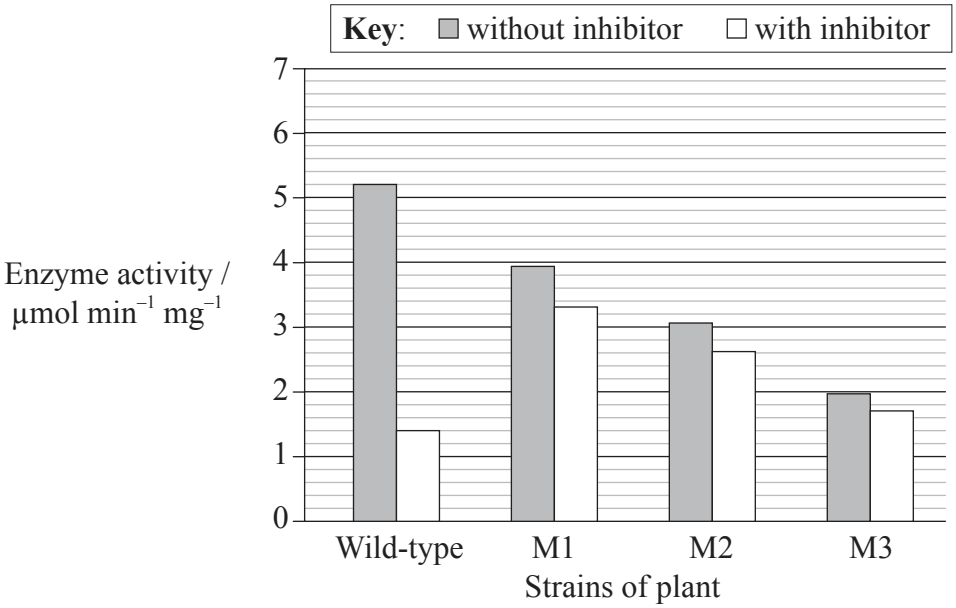
Option C — Cells and energy

C1. Metabolic pathways can be controlled by end-product inhibition of the enzyme-catalysed reactions.

KAS III is the initial enzyme of fatty acid production in plants and bacteria. The substrates for this reaction are acetyl CoA and malonyl-ACP.

Three different strains of plant were generated, each with a different mutated KAS III gene: M1, M2 and M3. The enzyme activity of the normal (wild-type) and the three mutant strains was tested without and with the addition of the inhibitor, dodecanoyl-ACP. Dodecanoyl-ACP has a similar structure to malonyl-ACP. The graph shows the mean activity of the enzymes.



[Abbadi et al., 2010, "Knockout of the regulatory site of 3-ketoacyl-ACP synthase III enhances short- and medium-chain acyl-ACP synthesis", The Plant Journal, 24 (1) pp. 1-9, Figure 4 (adapted). Reprinted with permission of John Wiley & Sons Inc.]

(a) State the activity of the wild-type enzyme without the inhibitor and with the inhibitor. *[1]*

Without inhibitor: . . . . . .

With inhibitor: . . . . . .

(b) Distinguish between the enzyme activity without the inhibitor in the wild-type and the mutant strains. *[1]*

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(This question continues on the following page)

(Question C1 continued)

(c) Explain why the activity of the enzyme from wild-type plants changes when the inhibitor is added. *[3]*

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(d) The scientists concluded that the enzymes of the mutant plants had a reduced activity, but were insensitive to the inhibition by dodecanoyl-ACP. Evaluate these conclusions. *[3]*

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C2. (a) (i) State **two** products of glycolysis. *[2]*

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(ii) Explain H^+ movement in mitochondria and its significance for chemiosmosis. *[3]*

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(b) State **two** limiting factors of photosynthesis. *[2]*

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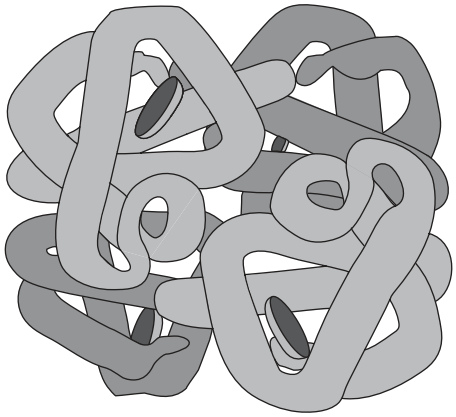
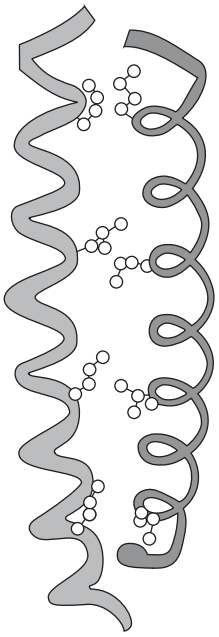
C3. The diagrams below show the structure of hemoglobin and keratin.

Hemoglobin



[Source: Open University, OpenLearn LearningSpace http://openlearn.open.ac.uk/mod/oucontent/view.php?id=398484&section=2.9#back_longdesc_id398850388353]

Keratin



[Source: provided by IB]

Outline the differences between these two proteins. *[3]*

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Option D — Evolution

D1. Superoxide dismutase is an enzyme used by cells to protect themselves against oxidative damage. These enzymes can have different metals as part of their structure.

A study to compare two dismutases from *Escherichia coli* bacteria and two dismutases from eukaryotic cells was undertaken. The following enzymes were used:

- *E. coli* dismutase with iron (Fe)
- *E. coli* dismutase with manganese (Mn)
- eukaryotic mitochondrial dismutase with manganese (Mn)
- eukaryotic cytoplasmic dismutase with copper-zinc (Cu-Zn).

The following shows part of the amino acid sequences of these enzymes. Boxes enclose identical amino acids in the sequence of the two *E. coli* and mitochondrial dismutases.

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E. coli (Fe)	Ser	–	Phe	–	Glu	–	Leu	–	Pro	–	Ala	–	Leu	–	Pro	–	Tyr	–	Ala	–	Lys	–	Asp	–	Ala	–	Leu	–	Ala
E. coli (Mn)	Ser	–	Tyr	–	Thr	–	Leu	–	Pro	–	Ser	–	Leu	–	Pro	–	Tyr	–	Ala	–	Tyr	–	Asp	–	Ala	–	Leu	–	Glu
Mitochondrial (Mn)	Lys	–	His	–	Thr	–	Leu	–	Pro	–	Asp	–	Leu	–	Pro	–	Tyr	–	Asp	–	Tyr	–	Gly	–	Ala	–	Leu	–	Glu
Cytoplasmic (Cu-Zn)	AcAla	–	Thr	–	Lys	–	Ala	–	Val	–	Cys	–	Val	–	Leu	–	Lys	–	Gly	–	Asp	–	Gly	–	Pro	–	Val	–	Gln

	⑯						⑳												㉕								
E. coli (Fe)	Pro	–	His	–	Ile	–	Ser	–	Ala	–	Glu	–	Thr	–	Ile	–	Glu	–	Tyr	–	His	–	Tyr	–	Gly	–	Lys
E. coli (Mn)	Pro	–	His	–	Phe	–	Asp	–	Lys	–	Gln	–	Thr	–	Met	–	Glu	–	Leu	–	His	–	His	–	Thr	–	Lys
Mitochondrial (Mn)	Pro	–	His	–	Ile	–	Ser	–	Ala	–	Glu	–	Ile	–	Met	–	Gln	–	Leu	–	His	–	His	–	Ser	–	Lys
Cytoplasmic (Cu-Zn)	Gly	–	Thr	–	Ile	–	His	–	Phe	–	Glu	–	Ala	–	Lys	–	Gly	–	Asp	–	Thr	–	Val	–	Val	–	Val

[H. M. Steinman and R. L. Hill (1973) "Sequence homologies among bacterial and mitochondrial superoxide dismutases". PNAS journal (USA), 70 (12), pp. 3725-–3729. Used with the permission of the authors.]

(a) State how many amino acids are in the same position in the *E. coli* (Fe), *E. coli* (Mn) and the mitochondrial dismutase sequences shown. *[1]*

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(b) State the amino acids which are present in the same position in at **least one** bacterial dismutase and in **both** eukaryotic dismutases. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(c) Compare the *E. coli* (Mn) and the mitochondrial dismutases. *[2]*

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(d) Using the diagram, suggest whether the evolution of bacterial dismutase and cytoplasmic dismutase is convergent **or** divergent. *[1]*

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(e) The sequences of the two bacterial dismutases and the mitochondrial dismutase show a high degree of homology. Discuss how this supports the endosymbiotic theory for the origin of mitochondria. *[2]*

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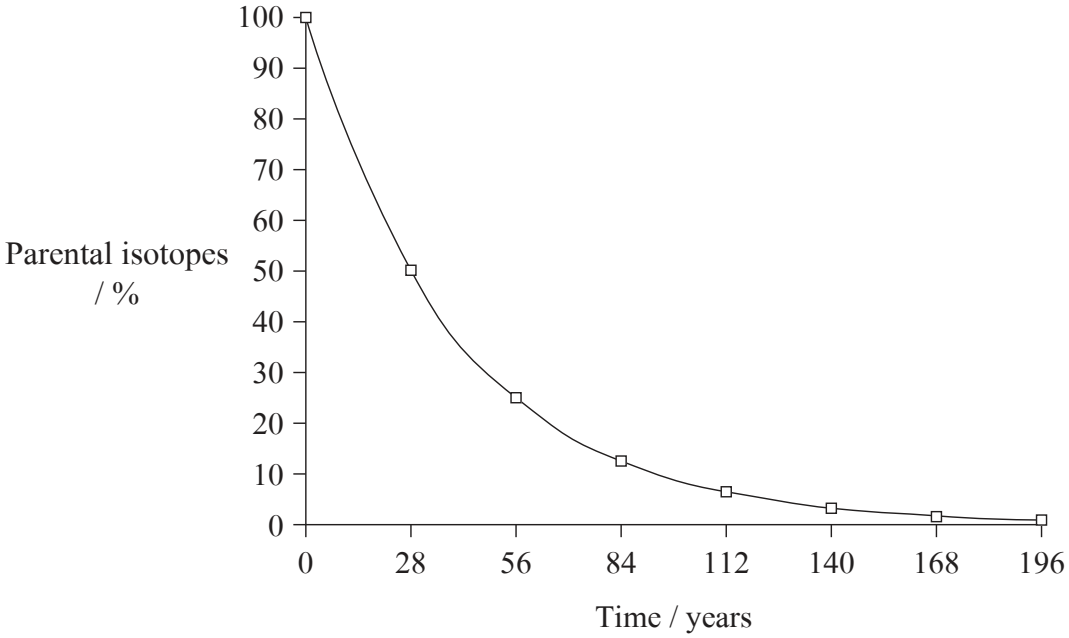
D2. (a) The graph below shows the half-life of Strontium-90.



Define the term *half-life* using the graph above. *[2]*

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(b) Outline the date and distribution of *Australopithecus afarensis* illustrated by the fossils found. *[2]*

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D3. (a) Describe transient polymorphism. *[3]*

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(b) Explain how punctuated equilibrium affects the pace of evolution. *[4]*

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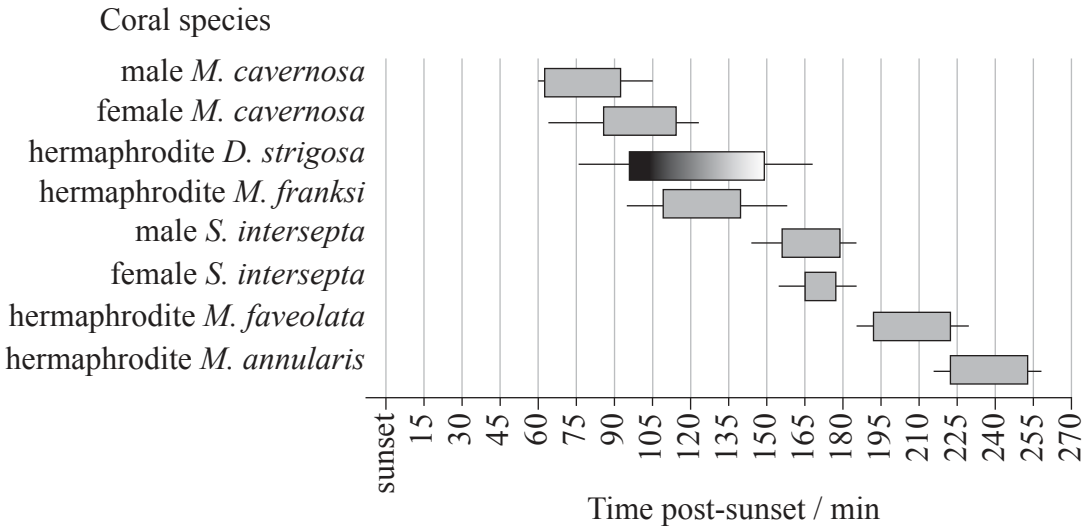
Option E — Neurobiology and behaviour

E1. Corals can be male, female or hermaphrodite (both male and female) and the release of their gametes is called spawning. Data was collected to study the spawning behaviour in the Gulf of Mexico of three genera of coral: *Montastraea*, *Stephanocoenia* and *Diploria*.

The spawning behaviour is expressed in minutes post-sunset. Peak spawning windows are shown as grey bars (▭) and the range as black bars (———). *D. strigosa* is shown as a shaded gradient indicating a strong bias towards spawning in the early portion of this window.



[Adapted from P. D. Vize, J. A. Embesi, M. Nickell, D. P. Brown and D. K. Hagman (2005) "Tight temporal consistency of coral mass spawning at the Flower Garden Banks, Gulf of Mexico, from 1997–2003." _Gulf of Mexico Science_, 1, pp. 107–114.
]

(a) State the range of the time of spawning for the male *M. cavernosa*. *[1]*

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(b) Suggest why it may be advantageous for each species of coral to spawn within a tight time frame. *[1]*

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(c) Discuss the significance of different spawning windows for different species. *[2]*

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(This question continues on the following page)

(Question E1 continued)

(d) Suggest **one** factor that may influence the spawning behaviour of corals in the Gulf of Mexico. *[1]*

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(e) Scientists hypothesized that the release of the male gamete triggers a chemical signal for females to release their eggs. Discuss this hypothesis. *[2]*

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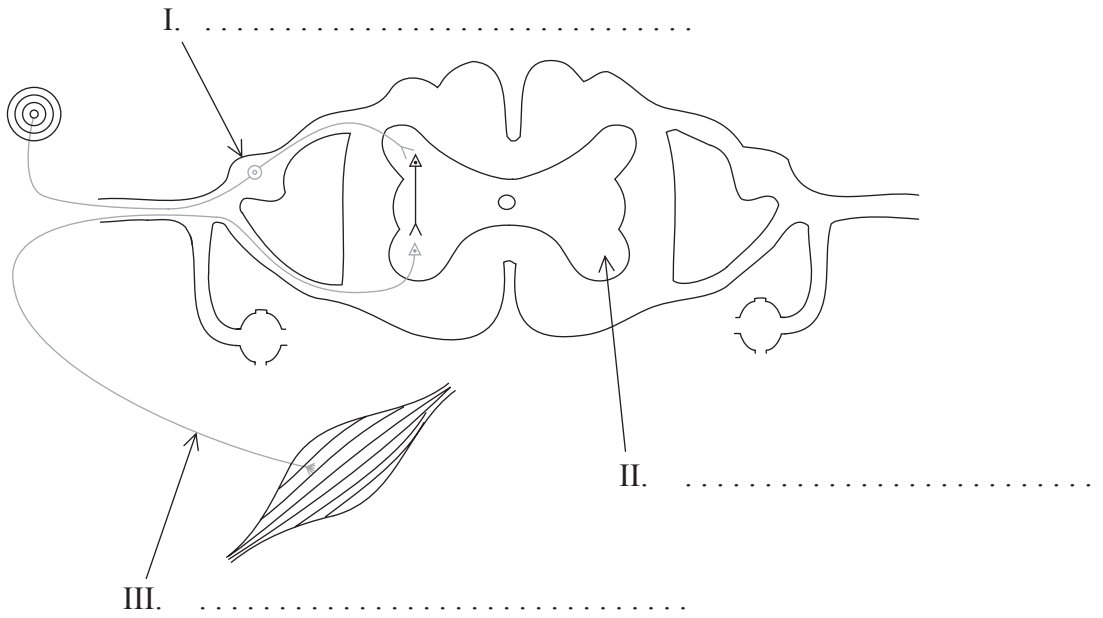
E2. (a) Label the parts of the reflex arc shown below. *[3]*



(b) Explain how decision-making is influenced by the central nervous system (CNS). *[3]*

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E3. (a) Outline Pavlov's experiments into the conditioning of dogs. *[3]*

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(b) Outline how sound stimuli are detected in the ear. *[2]*

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Option F — Microbes and biotechnology

F1. Antibiotics are sometimes given orally to poultry to prevent disease that may lead to reduced growth. Antibiotic resistance of bacteria from turkeys and chickens bred for meat and from egg laying hens was measured.

Excrement was collected and *Escherichia coli* bacteria were isolated. These bacteria were tested for resistance to a range of antibiotics and the results are shown below.

Number of antibiotics to which *E. coli* are resistant	**Turkeys *n* = 43**	**Chickens *n* = 45**	**Egg laying hens *n* = 20**
0	7	9	13
1	8	5	3
2	7	7	0
3	2	7	3
4	5	7	1
≥5	14	10	0

[Source:Antibiotic resistance of faecal _Escherichia coli_ in poultry, poultry farmers and poultry slaughterers. A. E. van den Bogaard, N. London, C. Driessen, E. E. Stobberingh. _Journal of Antimicrobial Chemotherapy_, 47, June 1, 763--771. 2001, Oxford University Press.]

(a) Calculate the percentage risk of bacteria becoming resistant to more than five kinds of antibiotics in turkeys and egg laying hens. *[1]*

Turkeys: . . . . . .

Egg laying hens: . . . . . .

(b) Compare the incidence of drug resistance in bacteria from chickens and egg laying hens. *[2]*

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(c) Discuss the hypothesis that giving antibiotics increases antibiotic resistance in poultry bacteria. *[2]*

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(This question continues on the following page)

(Question F1 continued)

(d) Suggest how antibiotic-resistant bacteria are passed from animals to humans. *[1]*

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F2. (a) Distinguish between Archaea and Eukarya. *[2]*

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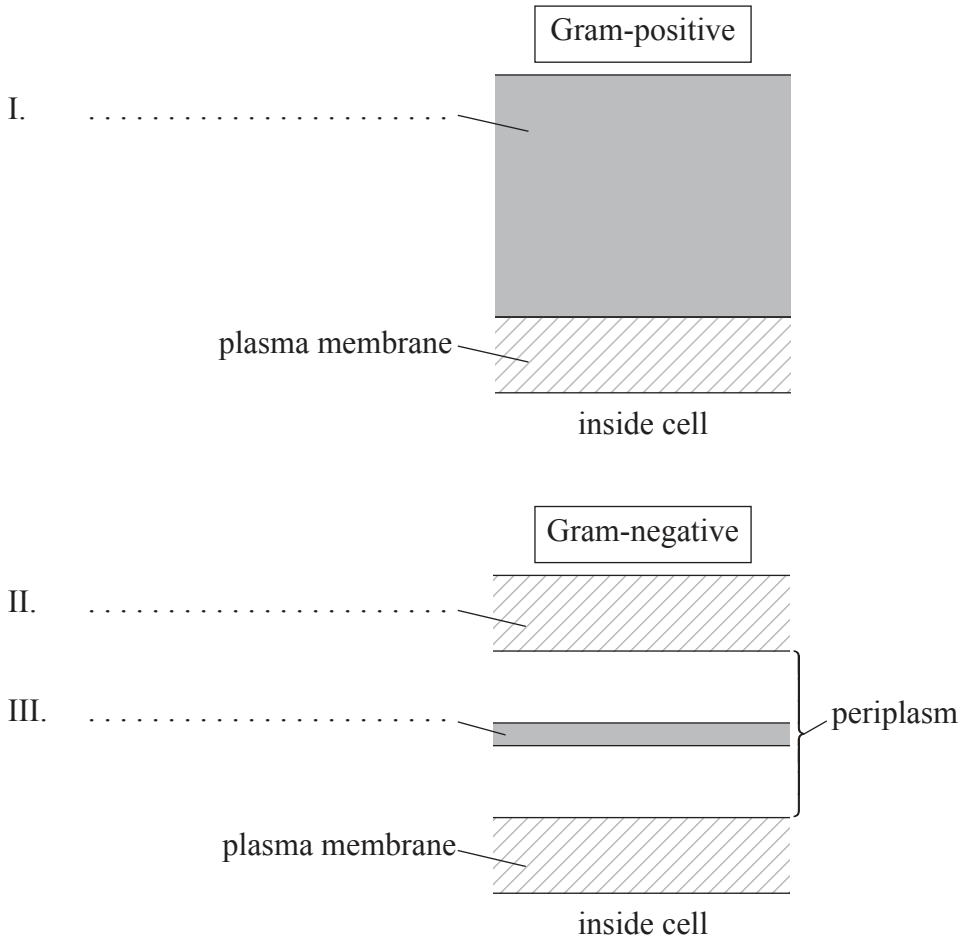
(b) Label the parts of the cell walls in Gram-positive Eubacteria and Gram-negative Eubacteria shown below. *[3]*



F3. (a) Microorganisms can be used in many different ways. Outline the production of soy sauce using microorganisms. *[3]*

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(b) Explain the consequences of releasing raw sewage into rivers and the involvement of microorganisms in this process. *[4]*

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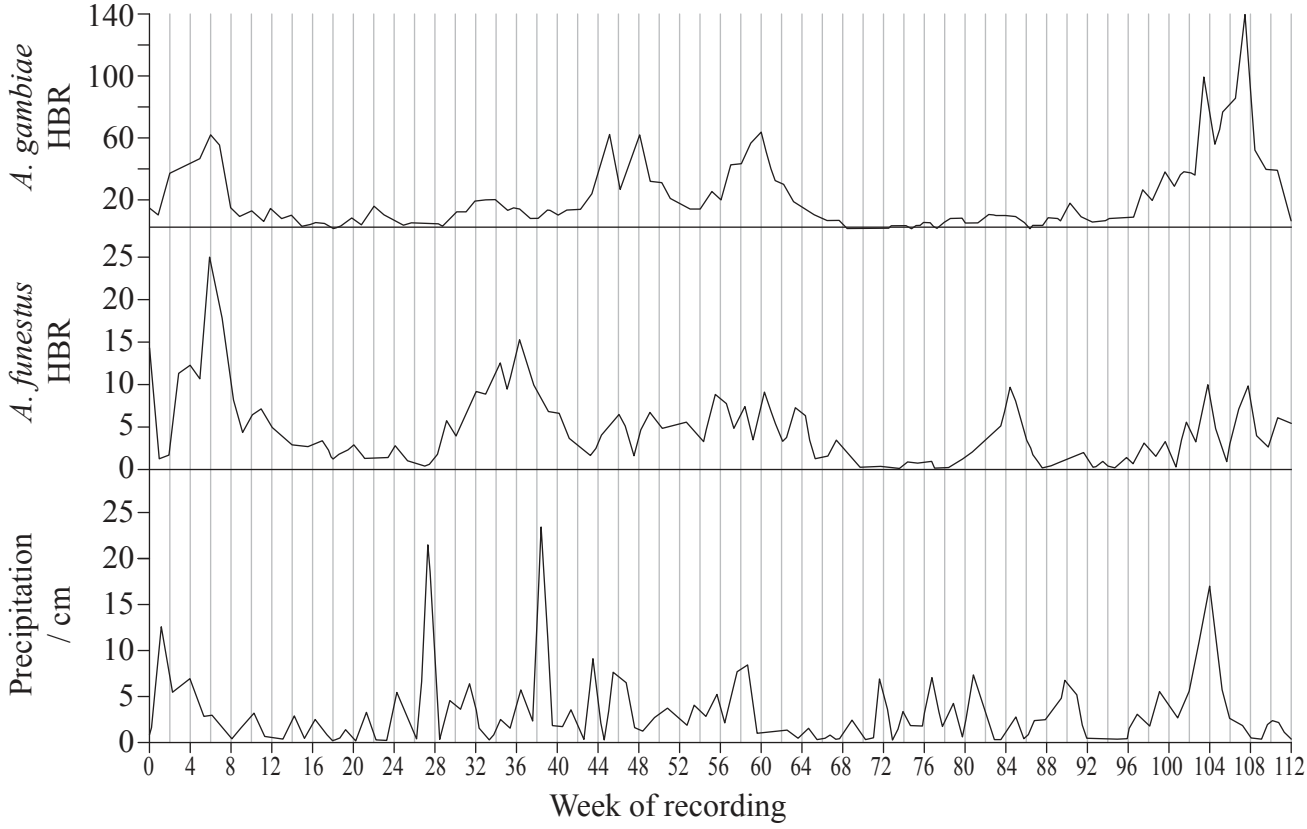
Option G — Ecology and conservation

G1. Many factors affect the distribution of animal species including weather patterns. The mosquito *Anopheles* is a carrier of malaria, a disease that kills one to two million people annually. The eggs of the mosquito are laid in water and they hatch out as larvae before turning into adult mosquitoes. A study was undertaken to look at the influence of weather patterns on the incidence of bites on children. Being bitten increases the risk of catching malaria.

The graphs show human biting rates (HBR) by *Anopheles gambiae* and *Anopheles funestus* and precipitation over the study period.



[J.A. Patz _et al._, 1998, "Predicting key malaria transmission factors, biting and entymological inoculation rates, using modelled soil moisture in Kenya", _Tropical Medicine & International Health_, 3, pp. 818-827, Figure 1 (adapted). Used with permission of John Wiley & Sons Inc.]

(a) State the week number when the highest human biting rate (HBR) is found for *A. gambiae*. *[1]*

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(This question continues on the following page)

(Question G1 continued)

(b) Calculate the difference in peak HBR for *A. gambiae* and *A. funestus* for week 6. *[1]*

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(c) Evaluate the effect of increased precipitation on HBR for both species. *[3]*

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(d) Suggest how predictions of global climate changes, such as predictions of precipitation patterns, could be used to help control malaria. *[1]*

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(e) Suggest another factor which might affect the ecological distribution of mosquitoes. *[1]*

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

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(b) Describe a primary succession in a **named** type of habitat. *[3]*

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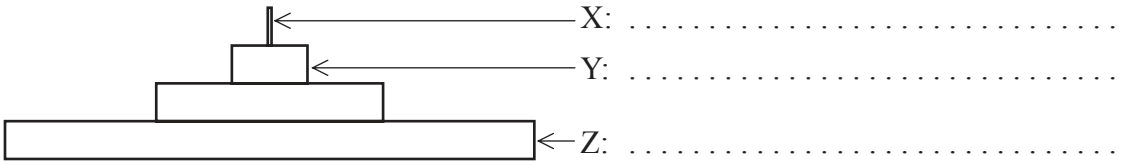
G3. (a) Label the levels of the trophic pyramid of energy shown below. *[3]*



(b) Discuss the impact of alien species on the environment. *[3]*

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