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**BIOLOGY**
**STANDARD LEVEL**
**PAPER 3**

Candidate session number

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Thursday 14 November 2013 (morning)

1 hour

Examination code

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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.
- Write your answers in the boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is *[36 marks]*.

| Option | Questions |
|---|---|
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| Option B — Physiology of exercise | 4 – 6 |
| Option C — Cells and energy | 7 – 9 |
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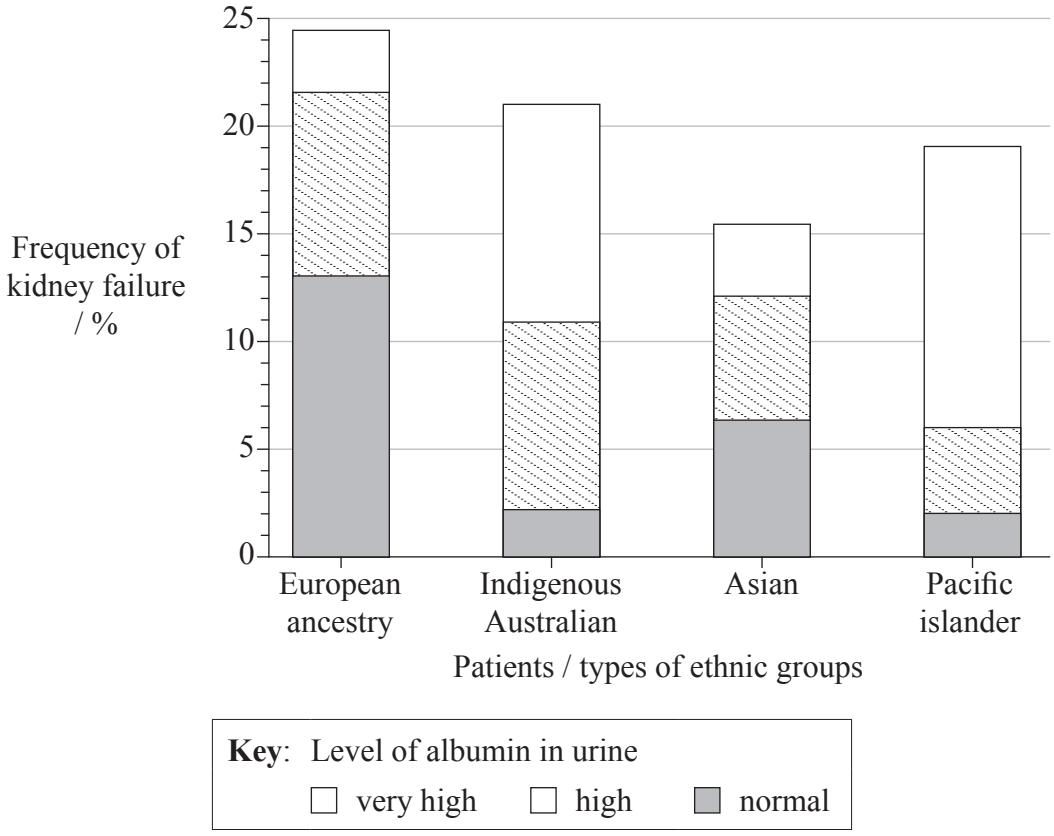
**Option A — Human nutrition and health**

**1.** Inadequate filtering of waste products from the blood is known as kidney failure. If this condition is found in a patient, or albumin is present in their urine, it shows that the patient has chronic kidney disease. Type II diabetes is the leading cause of chronic kidney disease in Australia. The bar graph shows the frequency of kidney failure in patients with type II diabetes in different Australian ethnic groups. It also shows the level of albumin in the urine of patients with both type II diabetes and kidney failure.




[Source: Thomas M. C. *et al*. The burden of chronic kidney disease in Australian patients with type 2 diabetes (the NEFRON study). *Med. J. Aust*. 2006; **185** (3): 140–144. © Copyright 2006. *The Medical Journal of Australia* – adapted and translated with permission. *The Medical Journal of Australia* does not accept responsibility for any errors in translation.]

(a) (i) State the ethnic group with the lowest frequency of kidney failure. *[1]*

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*(Option A continues on the following page)*

*(Option A, question 1 continued)*

(ii) State the frequency of both kidney failure and greater than normal albumin levels in patients of European ancestry with type II diabetes. *[1]*

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(b) Compare the levels of albumin in urine of patients with kidney failure in the different ethnic groups. *[3]*

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(c) The usual method of screening for chronic kidney disease is to test for kidney failure. Using the data in the bar chart, suggest why this method leads to more cases being missed in patients of indigenous Australian ancestry than in patients with European ancestry. *[2]*

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*(Option A continues on the following page)*

*(Option A continued)*

**2.** (a) (i) State how non-essential amino acids can be obtained if they are not present in the diet. *[1]*

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(ii) List **two** consequences of anorexia nervosa. *[1]*

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2. . . . . .

(b) Explain the causes, consequences and treatment of phenylketonuria (PKU). *[3]*

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*(Option A continued)*

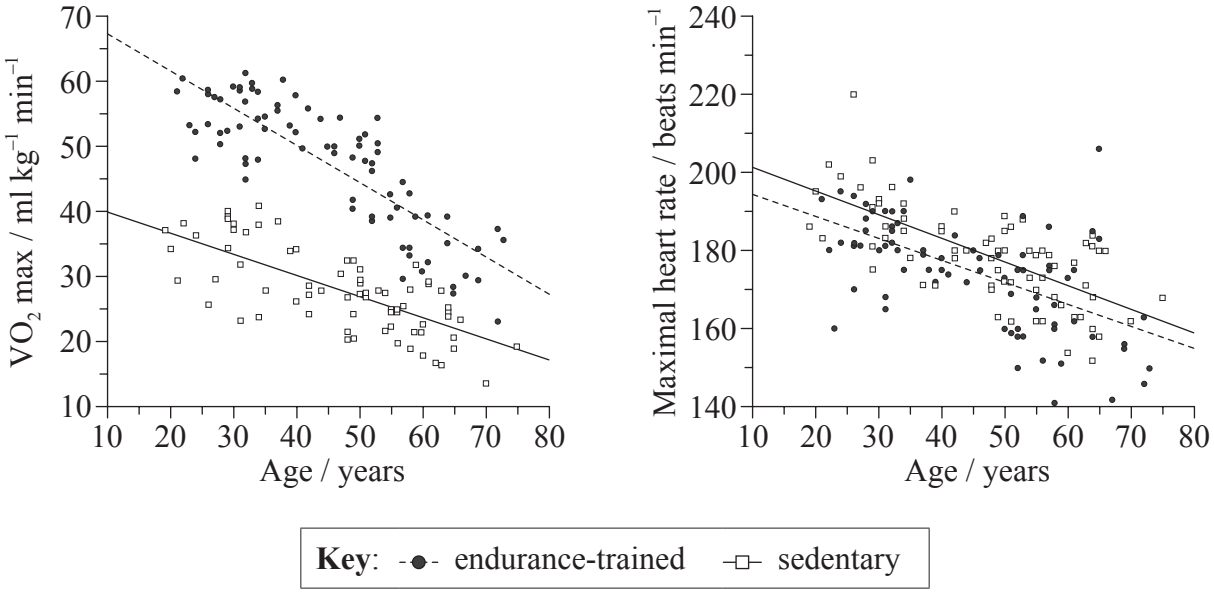
**3.** (a) Outline the molecular structure of different types of fatty acids. *[3]*

(b) Evaluate the benefit of reducing cholesterol in the diet. *[3]*

## End of Option A

**Option B — Physiology of exercise**

**4.** Aerobic capacity is a function of both $VO_2$ max and heart beat rate. A study was conducted to see the effect of regular endurance exercise on maximal aerobic capacity in women. The scatter graphs show the effect of age on $VO_2$ max and maximal heart rate for two groups of women. The endurance-trained group had been competing in long distance races for at least the past two years. The sedentary group performed no regular physical exercise but were healthy and non-obese.




[Source: H. Tanaka *et al.* (1997) 'Greater rate of decline in maximal aerobic capacity with age in physically active vs. sedentary healthy women'. *Journal of Applied Physiology*, **83** (6), pp. 1947–1953. © The American Physiological Society (APS).]

(a) State the effect of age on the maximal heart rate shown in this study. *[1]*

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*(Option B continues on the following page)*

*(Option B, question 4 continued)*

(b) Compare the effect of age on $VO_2$ max in endurance-trained and sedentary women. *[2]*

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(c) Predict, with a reason, the effect of a programme of regular endurance exercise on maximal heart rate. *[2]*

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(d) Deduce, with a reason from the data, the age range over which exercise is likely to have beneficial effects. *[2]*

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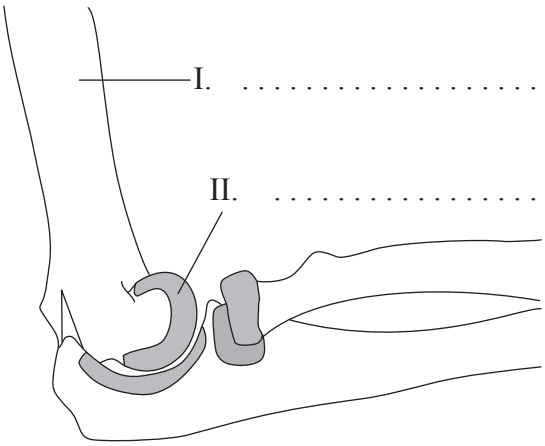
*(Option B continues on the following page)*

*(Option B continued)*

**5.** (a) Label the following diagram of the side view of the human elbow joint. *[1]*




(b) State the function of structures I and II. *[2]*

I: . . . . . .

II: . . . . . .

(c) State an injury that might occur in this joint. *[1]*

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*(Option B continues on the following page)*

*(Option B continued)*

**6.** (a) (i) Distinguish between *fast muscle fibre* and *slow muscle fibre*. *[2]*

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(ii) Outline which methods of ATP production are used in muscle fibres during different intensities of exercise. *[2]*

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(b) Discuss the ethics of using anabolic steroids for muscle build-up. *[3]*

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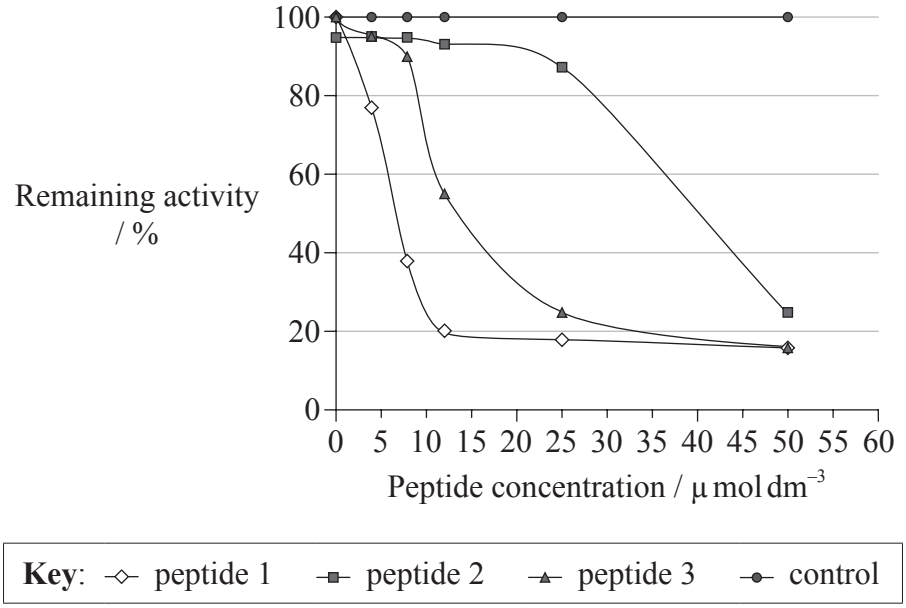
## End of Option B

**Option C — Cells and energy**

**7.** *Trypanosoma brucei* is a parasite which causes sleeping sickness. The parasites rely exclusively on glycolysis for energy production. Peptides acting as inhibitors of an enzyme from the glycolytic pathway are being studied as possible drugs to kill the parasite. The glycolytic enzyme triose phosphate isomerase was incubated in the presence of various concentrations of three different peptides and the remaining activity was measured. As a control, the enzyme was incubated without inhibitor peptides.




[Source: adapted from D A Kuntz, *et al.*, (1992), Eur. J. Biochem, **207**, pages 441–447. Copyright © 2005, John Wiley and Sons]

(a) State the remaining activity of triose phosphate isomerase when $8\,\mu mol\,dm^{-3}$ of peptide 1 is used. *[1]*

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*(Option C continues on the following page)*

*(Option C, question 7 continued)*

(b) Compare the effect of increasing the concentration of peptide 2 and peptide 3 on the remaining activity. *[2]*

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(c) Identify, with a reason, which of the peptides is the most effective inhibitor of triose phosphate isomerase. *[1]*

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(d) Deduce, with reasons, whether the peptides act as competitive **or** non-competitive inhibitors of triose phosphate isomerase. *[2]*

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*(Option C continues on the following page)*

*(Option C continued)*

**8.** (a) (i) Other than acting as catalysts state **three** functions of proteins, giving an example of each. *[3]*

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(ii) Distinguish between *fibrous proteins* and *globular proteins*. *[2]*

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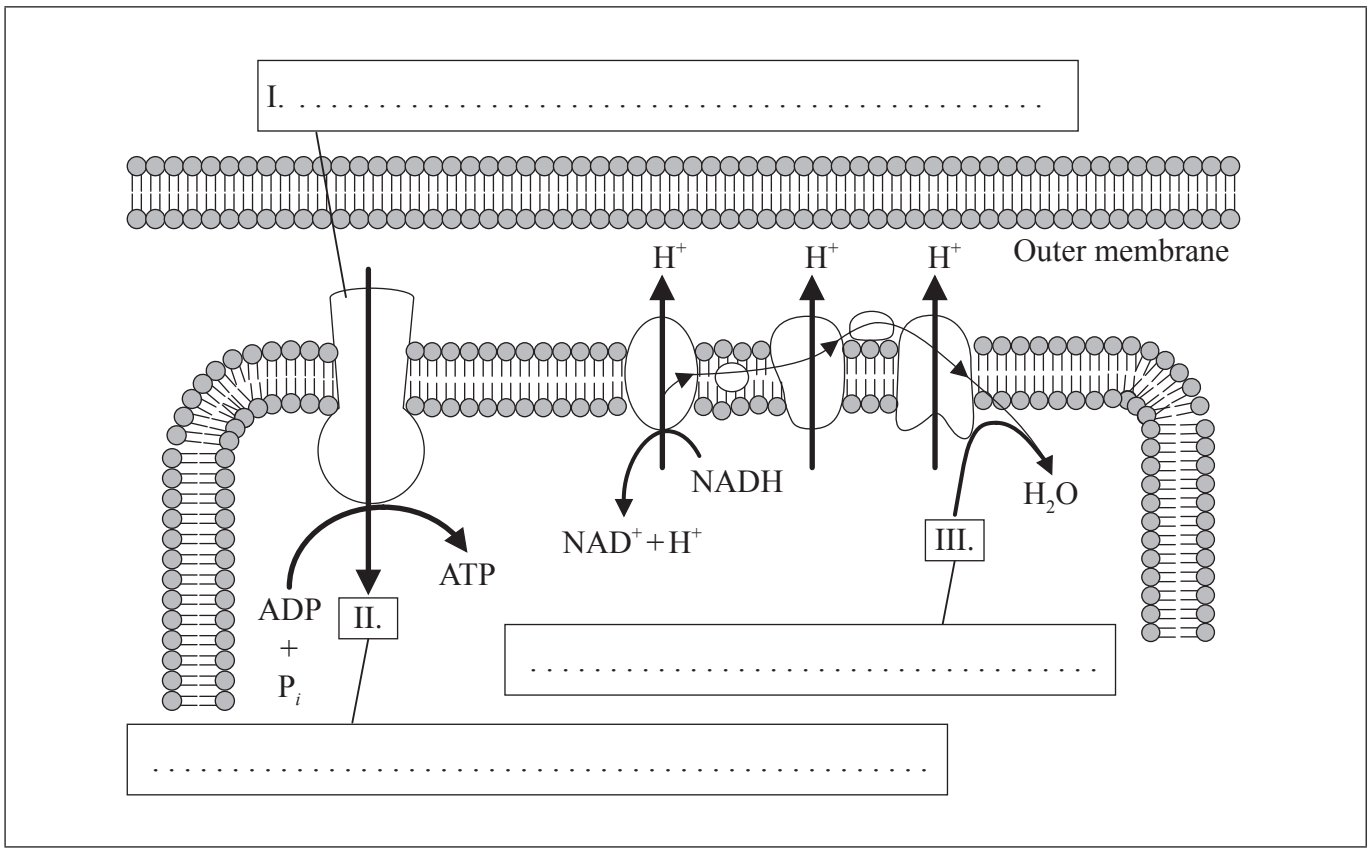
*(Option C continues on the following page)*

*(Option C, question 8 continued)*

(b) The diagram shows chemiosmosis in the mitochondrion. Label I, II and III. *[3]*




[Source: © International Baccalaureate Organization 2014]

*(Option C continues on the following page)*

*(Option C continued)*

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

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(b) Explain the relationship between the structure of the chloroplast and its function. *[3]*

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## End of Option C

Please **do not** write on this page.

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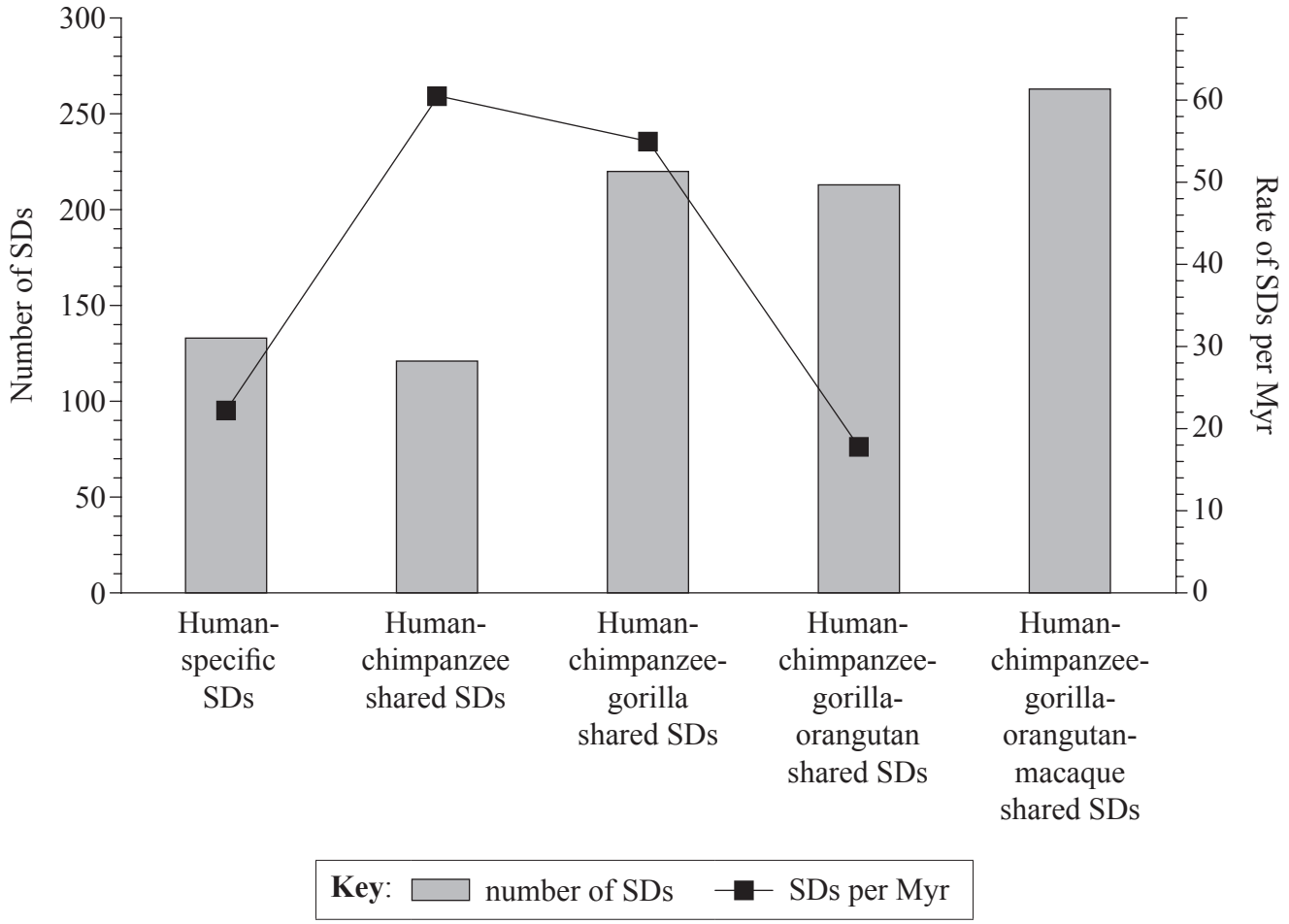
**Option D — Evolution**

**10.** Analysis of the genome of primates reveals many DNA segments that have been duplicated. It is possible to deduce the stage in evolution at which segmental duplications (SDs) occurred by comparing human and other primate genomes. Human-specific SDs occurred after humans and chimpanzees diverged. Human-chimpanzee shared SDs occurred after the common human-chimpanzee ancestor diverged from gorillas and so on. It is possible to estimate the rates at which SDs occurred during evolution using knowledge of when the primates changed. In the chart the bars indicate numbers of shared SDs and the line shows estimates of the rate of SDs per millions of years (Myr).




[Source: Reprinted by permission from Macmillan Publishers Ltd:
Tomas Marques-Bonet, Jeffrey M. Kidd, Mario Ventura, Tina A. Graves, Ze Cheng *et al.* (2009) 'A burst of segmental duplications in the genome of the African great ape ancestor.' *Nature*, **457**, pp. 877–881.]

(a) (i) State the number of SDs that can be found in humans but not in other primates. *[1]*

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*(Option D continues on the following page)*

*(Option D, question 10 continued)*

(ii) State the rate of SDs after the divergence of macaques from the other primates, giving the units. *[1]*

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(b) Outline the trends in the rate of SDs occurring since the separation of orangutans from other primates. *[2]*

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(c) Explain how the number of human-chimpanzee shared SDs can be the lowest despite the rate of SDs per millions of years being the highest. *[2]*

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(d) A few SDs were found in humans and gorillas but not chimpanzees. Suggest how this might have occurred. *[1]*

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*(Option D continues on the following page)*

*(Option D continued)*

**11.** (a) Outline **two** processes needed for the spontaneous origin of life on Earth. *[2]*

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(b) State **two** properties of RNA that would have allowed it to play a role in the origin of life. *[2]*

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2. . . . . .

(c) Discuss the endosymbiotic theory for the origin of eukaryotes. *[3]*

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*(Option D continues on the following page)*

*(Option D continued)*

**12.** (a) Define *allele frequency*. *[1]*

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(b) Compare allopatric speciation and sympatric speciation using the table below. *[3]*

| Allopatric | Sympatric |
|---|---|
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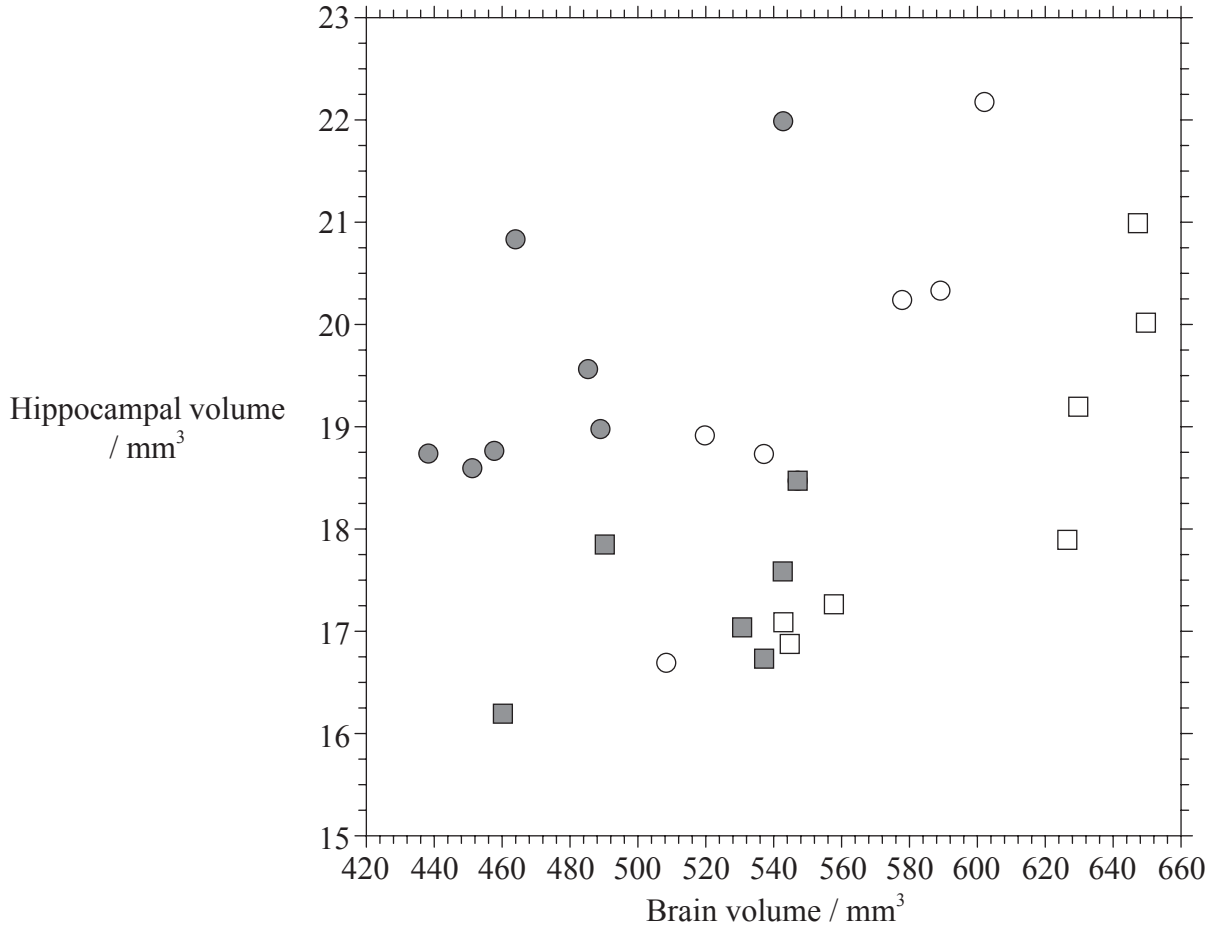
## End of Option D

**Option E — Neurobiology and behaviour**

**13.** The hippocampus plays an important role in memory and spatial navigation. A larger hippocampus relative to brain volume has been associated with better spatial memory in birds. Two subspecies of the white-crowned sparrow, *Zonotrichia leucophrys gambelii* (migratory) and *Zonotrichia leucophrys nuttalli* (non-migratory) were compared. The graph shows the relationship between the volumes of the hippocampus and the brain in adult and young sparrows.




**Key**: *Z. leucophrys gambelii* (migratory) ● adult sparrow ■ young sparrow; *Z. leucophrys nuttalli* (non-migratory) ○ adult sparrow □ young sparrow

[Source: Adapted from V. V. Pravosudov et al. (2006) 'The relationship between migratory behaviour, memory and the hippocampus: an intraspecific comparison.' *Proceedings of the Royal Society B*, **273** (1601), pp. 2641–2649. Fig. 3. By permission of the Royal Society.]

*(Option E continues on the following page)*

*(Option E, question 13 continued)*

(a) State the relationship between brain volume and hippocampal volume in the non-migratory sparrows. *[1]*

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(b) Compare the hippocampal volume in migratory and non-migratory young and adult sparrows. *[2]*

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(c) Relative hippocampal volume is the ratio between the volume of the hippocampus and the volume of the whole brain (hippocampus/brain).

(i) Analyse the data in the scattergraph to find which of the four groups of birds has the highest relative hippocampal volume. *[1]*

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(ii) Suggest a reason why this group needs the largest relative hippocampal volume. *[1]*

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*(Option E continues on the following page)*

*(Option E, question 13 continued)*

(d) It is possible that non-migratory species possess more advanced cognitive skills other than spatial memory. Use the data to evaluate this hypothesis. *[2]*

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**14.** (a) Using the table below, distinguish between *rod cells* and *cone cells*. *[3]*

| Characteristic | Rod cells | Cone cells |
|---|---|---|
| Location | | |
| Light intensity detected | | |
| Connection to optic nerve | | |

(b) Outline how sound is perceived in the ear. *[3]*

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*(Option E continues on the following page)*

*(Option E continued)*

**15.** (a) List **two** examples of inhibitory psychoactive drugs. *[2]*

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2. . . . . .

(b) Explain how decision making takes place in the central nervous system (CNS). *[3]*

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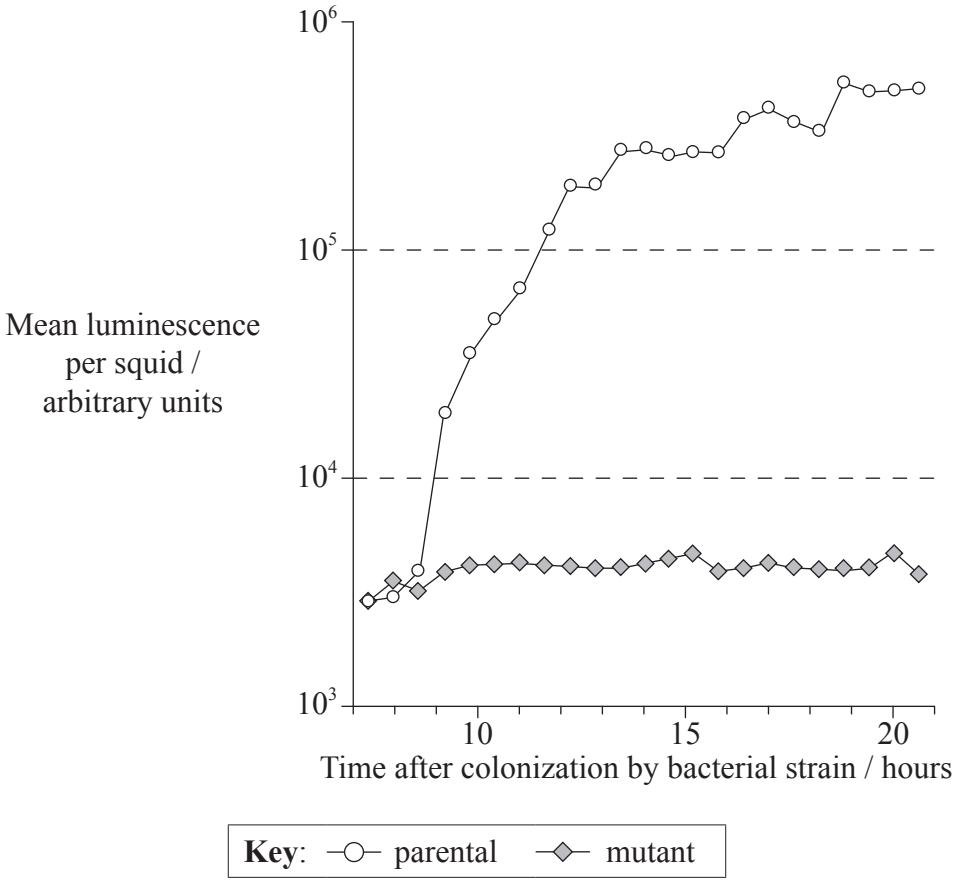
## End of Option E

**Option F — Microbes and biotechnology**

**16.** The bacterium *Vibrio fischeri* produces an enzyme called luciferase. This bacterium often colonizes the squid (*Euprymna scolopes*). A mutant strain of *V. fischeri* was obtained that was unable to produce luciferase. The graph shows the mean luminescence per squid after being colonized by the parental and mutant bacterial strains.




[Source: K. L. Visick and M. J. McFall-Ngai (2000) '*Vibrio fischeri lux* Genes Play an Important Role in Colonization and Development of the Host Light Organ.' *Journal of Bacteriology*, **182**, pp. 4578–4586. Fig. 2. Reproduced with permission from American Society for Microbiology.]

(a) State the mean luminescence per squid 11.5 hours after colonization by parental *V. fischeri*. *[1]*

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*(Option F continues on the following page)*

*(Option F, question 16 continued)*

(b) Between 8.5 and 10.5 hours after colonization with the parental bacterial strain, luminescence increases by a factor of approximately 10. Estimate the factor by which luminescence increases between 8.5 and 17 hours after colonization with the parental bacterial strain. *[1]*

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(c) Using the data in the graph, distinguish between luminescence in squid colonized by the parental and mutant bacterial strains. *[2]*

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(d) Bioluminescence only happens when *V. fischeri* becomes part of a population with high density, for example when bacteria colonize the light organs of squid. Evaluate whether the data supports this hypothesis. *[2]*

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*(Option F continues on the following page)*

*(Option F, question 16 continued)*

(e) *V. fischeri* and *V. cholerae* are both classified in the Eubacteria domain. Suggest **one** characteristic that is shared by these organisms to allow them to be classified as Eubacteria and not as Archaea or as eukaryotes. *[1]*

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**17.** (a) State the habitat of the following Archaea. *[2]*

Methanogens: . . . . . .

Halophiles: . . . . . .

(b) Outline the role of saprotrophic bacteria in the treatment of sewage. *[2]*

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*(Option F continues on the following page)*

*(Option F, question 17 continued)*

(c) Explain the formation of methane from biomass. *[3]*

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**18.** (a) Explain the use of acids for food conservation. *[2]*

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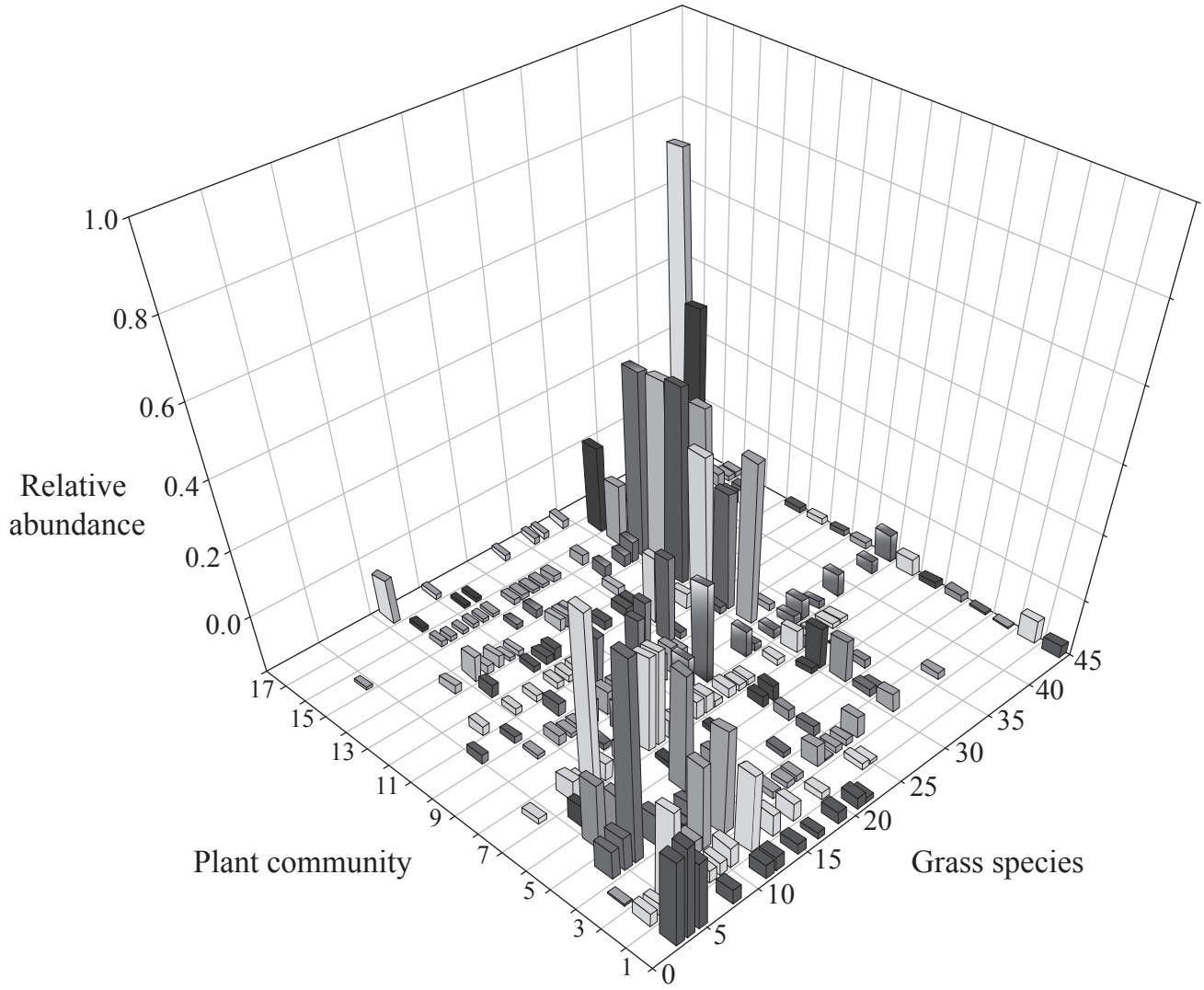
(b) Using the table below, state the organisms involved in the following processes. *[2]*

| Process | Organism |
|---|---|
| Wine production | |
| Nitrogen fixation | |

## End of Option F

**Option G — Ecology and conservation**

**19.** The relative abundance of different grass species in the 17 plant communities of the Serengeti ecosystem in Tanzania is presented in the graph below. The communities are listed along a transect that runs from the dry south-eastern boundary of the park (community 1), north and west across the plains and woodlands to Lake Victoria (community 17).




[Source: Adapted from A. Dobson (2009) 'Food-web structure and ecosystem services: insights from the Serengeti.' *Philosophical Transactions of the Royal Society B*, **364**, pp. 1665–1682, Fig. 3. By permission of the Royal Society.]

(a) State the grass species that is most abundant in plant community 1. *[1]*

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*(Option G continues on the following page)*

*(Option G, question 19 continued)*

(b) Analyse the graph to find whether species 45 has a broad **or** narrow realized niche. *[1]*

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(c) Both communities 1 and 17 have a low overall abundance of grasses. Suggest a reason for this in

(i) community 1. *[1]*

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(ii) community 17. *[1]*

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(d) Evaluate the conclusion that there are trends in the distribution of plants along the transect of Serengeti grass communities. *[3]*

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*(Option G continues on the following page)*

*(Option G continued)*

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

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(b) (i) State the type of ecological change that will occur following the formation of an island from cooled lava in the Pacific Ocean. *[1]*

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(ii) Outline the ecological changes that will occur on the island of cooled lava. *[4]*

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*(Option G continues on the following page)*

*(Option G continued)*

**21.** (a) State **one** benefit to organisms living on the surface of the Earth, of ozone in the stratosphere. *[1]*

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(b) The Simpson diversity index formula is given below.

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

(i) State what *N* and *n* stand for in this formula. *[1]*

*N*: . . . . . .

*n*: . . . . . .

(ii) Discuss **three** reasons for the conservation of biodiversity in rainforests. *[3]*

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## End of Option G

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