

2011-2015

**NEW ZEALAND**  
BIOLOGY OLYMPIAD



## NATIONAL ENTRANCE EXAMINATION – August 2014

**Examination Date:** Wednesday 20 August 2014

**Total Time allowed:** 2 hours.

This examination consists of 75 questions. Students are advised to allocate equal time to each question (1.5 minutes per question with 7.5 minutes for checking of answers). Marks will not be deducted for incorrect answers.

**Equipment:** **BLACK** Ballpoint pen **ONLY**, eraser, ruler, and calculator.

Please make sure your teacher **photocopies** the completed InspiroScan answer sheet and keeps a copy for his/her records. Your teacher needs to place the **original InspiroScan answer** sheets in the courier bag provided and **courier** to Massey University **immediately**.



THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*  
School of Science & Engineering



THE UNIVERSITY  
OF AUCKLAND

FACULTY OF SCIENCE



**MASSEY**  
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TE KUNENGA KI PŪREHUROA

UNIVERSITY OF NEW ZEALAND



**PEARSON**

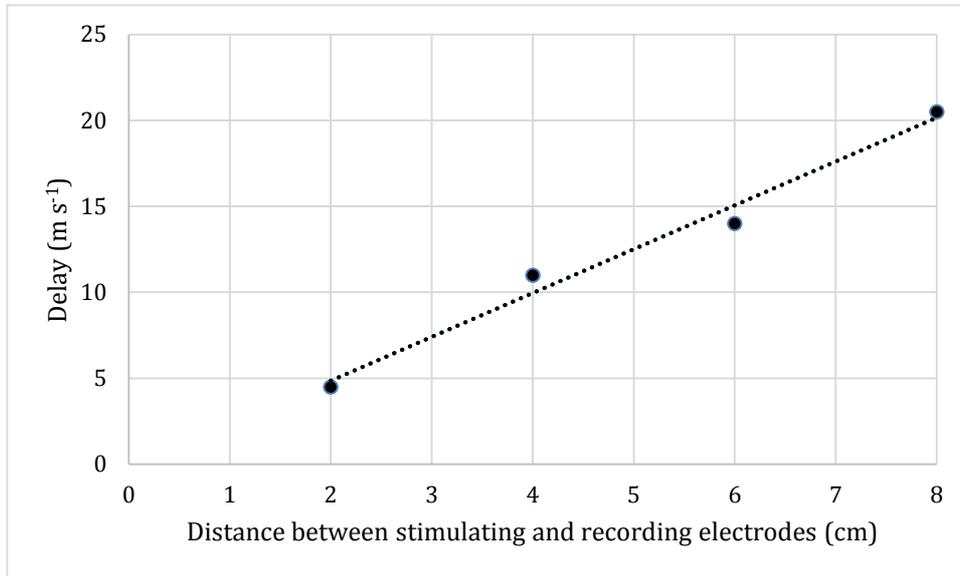
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SOCIETY of  
NEW ZEALAND  
TE APĀRANGI

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## Section A

### Question 1

In an experiment to measure the speed of conduction of a nerve impulse along a giant axon, the distance between the stimulating and recording electrodes was varied and the delay between stimulus and response was recorded for each distance. The results are shown in the graph below.



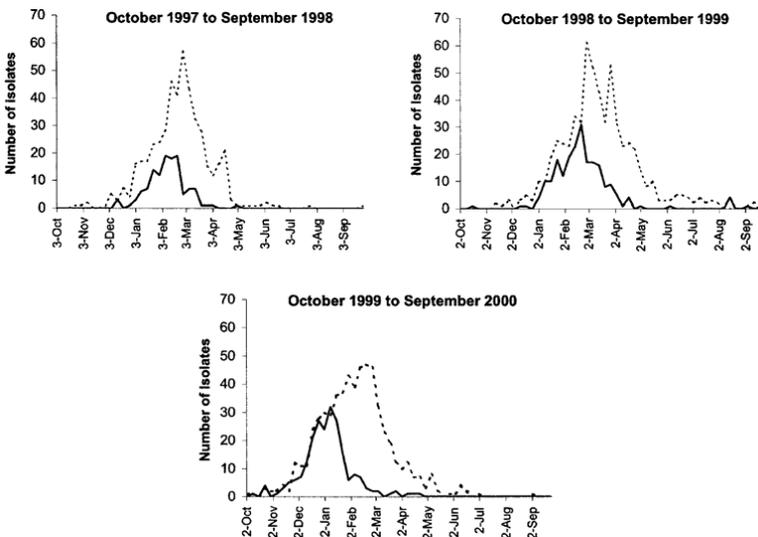
From these results the mean speed of conduction was found to be:

- A. 2.0 cm s<sup>-1</sup>
- B. 2.5 cm s<sup>-1</sup>
- C. 0.5 m s<sup>-1</sup>
- D. 4.0 m s<sup>-1</sup>
- E. 6.0 m s<sup>-1</sup>

### Question 2

The graphs show the number of isolates of influenza (solid black line) and respiratory syncytial virus (dotted line), that were found in samples taken from people (mainly children) in Seattle, Washington.

<http://cid.oxfordjournals.org/content/37/2/201.full>



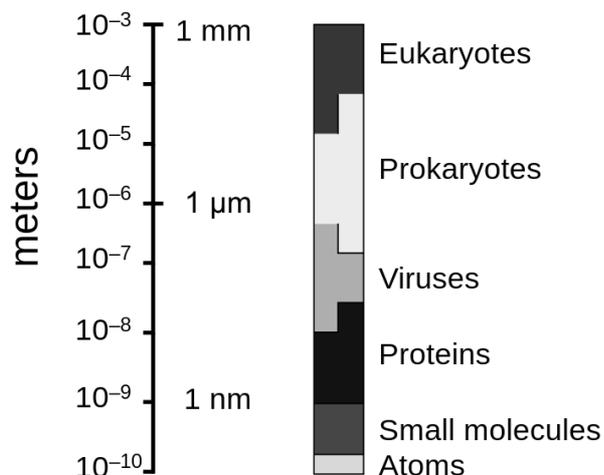
What can be concluded from these data?

- A. You cannot catch the flu in summer.
- B. Medical treatment works in individual patients after about two months.
- C. Influenza infection always peaks in February.
- D. Virus epidemics follow predictable patterns.
- E. Respiratory syncytial virus kills more people than the flu each year.

### Question 3

The following diagram shows the relative scale of different things. According to this diagram what is the approximate size range of typical viruses.

- A.  $0.1\mu\text{m} - 0.8\text{mm}$
- B.  $0.1\mu\text{m} - 0.8\mu\text{m}$
- C.  $0.00001\text{m} - 0.0008\text{m}$
- D.  $10\text{nm} - 80\text{nm}$
- E.  $10\text{nm} - 800\text{nm}$



### Question 4

A suspension of microscopic green algae was divided into two equal samples. Each was given the **SAME** total amount of light energy. Sample I was exposed to continuous light. Sample II was exposed to bursts of light for 5 - 10 seconds duration, followed by dark periods. Photosynthesis took place in both samples, but more occurred in sample I. From *this evidence* we may conclude that

- A. More photosynthesis occurs in the dark than in the light.
- B. Some part of the photosynthetic process can occur in darkness.
- C. Photosynthesis requires darkness as well as light.
- D. Photosynthesis is a very rapid process.
- E. Photosynthesis involves enzymes as well as light.

### Question 5

Find the four-digit number designated by asterisks, given the following:

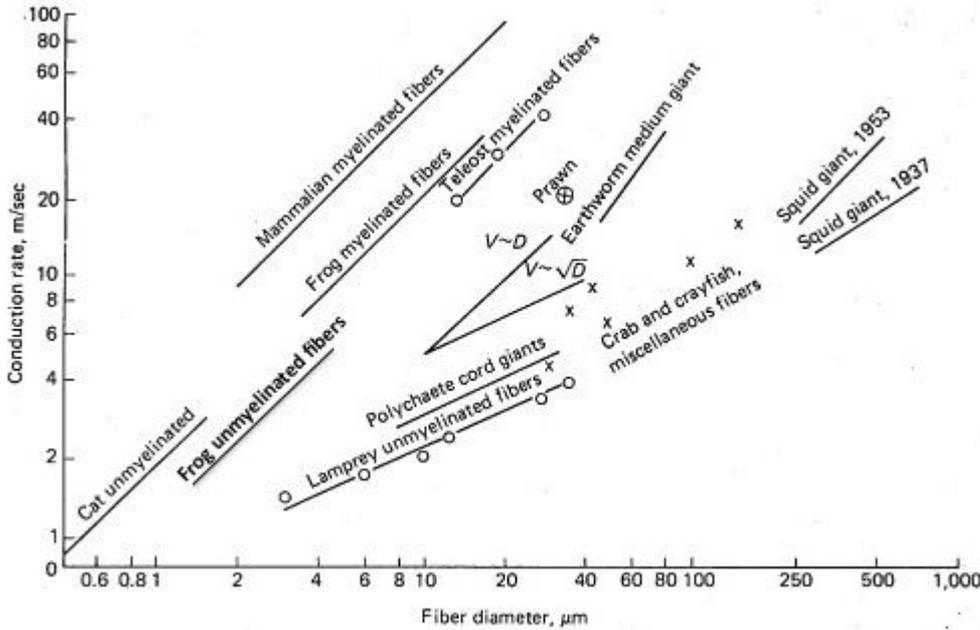
- All four digits of the unknown number are different.
- None of the digits is zero.
- Each "0" on the right of each four-digit number below indicates that the number has a matching digit in a non-matching position with the unknown number.
- Each "+" on the right of each four-digit number below indicates that the number has a matching digit in a matching position with the unknown number.

6152 +0  
 4182 00  
 5314 00  
 5789 +  
 -----  
 \*\*\*\*

- A. 6419
- B. 6741
- C. 5619
- D. 5641
- E. 5629

**Question 6**

The diagram below shows the velocity of nerve impulse conduction as a function of fiber diameter in a variety of animals.



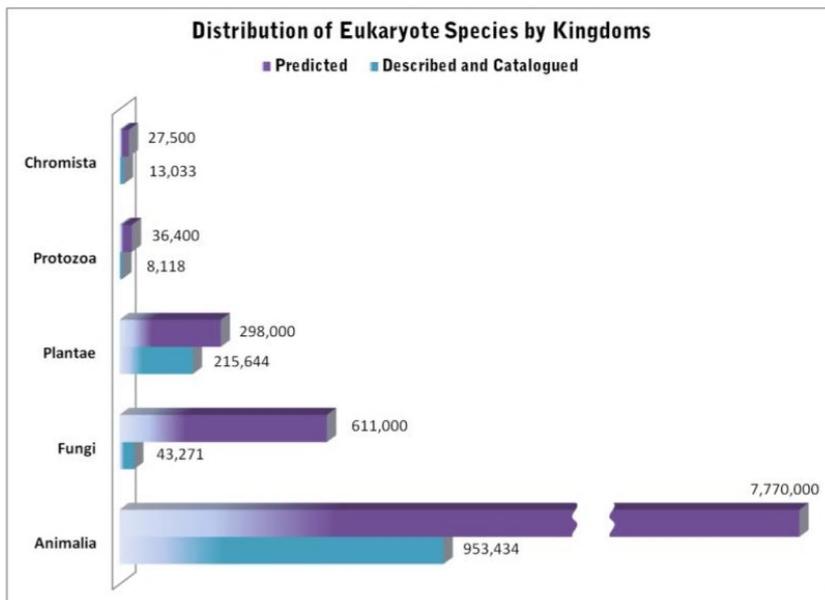
Modified from Bullock and Horridge, 1965, Structure and function of the Nervous System of Invertebrates. W. H. Freeman and Company.

Considering the information in the diagram, which of the statements below is **NOT** correct?

- A. Giant squid have thick nerve fibers
- B. Myelinated fibers conduct nerve impulses faster than unmyelinated fibers.
- C. The giant fibers of the earthworm are thicker than those of polychaete worms.
- D. Teleost myelinated fibers are thicker than frog myelinated fibers.
- E. The thicker mammalian myelinated fibers show the fastest conduction rate.

**Question 7**

Eukaryotes are organisms with their DNA organised in chromosomes, found in a distinct nucleus. Eukaryotes include algae, fungi, plants, and animals. Prokaryotes are single-celled organisms that have neither a nucleus nor other organelles. Prokaryotes include bacteria and cyanobacteria. There are approximately 8.7 million species of eukaryotes on earth – the relative size of each eukaryote group is listed below.



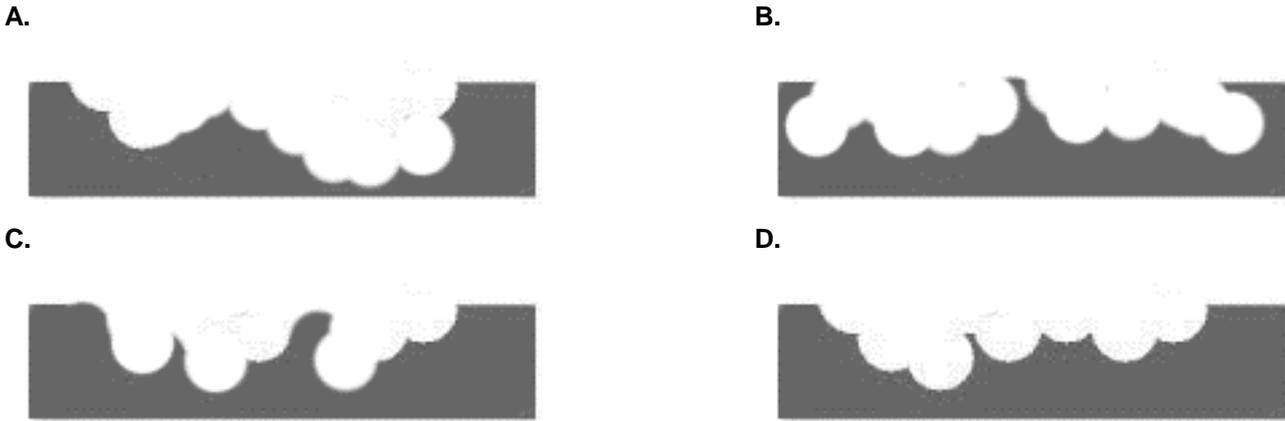
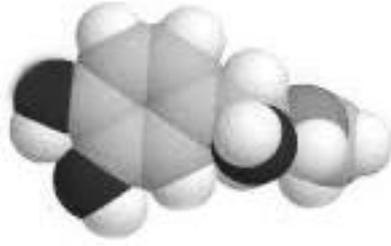
From the information provided, the best conclusion is?

- A. Fungi are not well described as a taxonomic group.
- B. Animals have gone through the most evolution.
- C. Eukaryotes are better described than prokaryotes.
- D. There are not many prokaryotes on Earth.
- E. Simple life is dependent on photosynthesis.

<http://www.sciencedaily.com/releases/2011/08/110823180459.htm>

**Question 8**

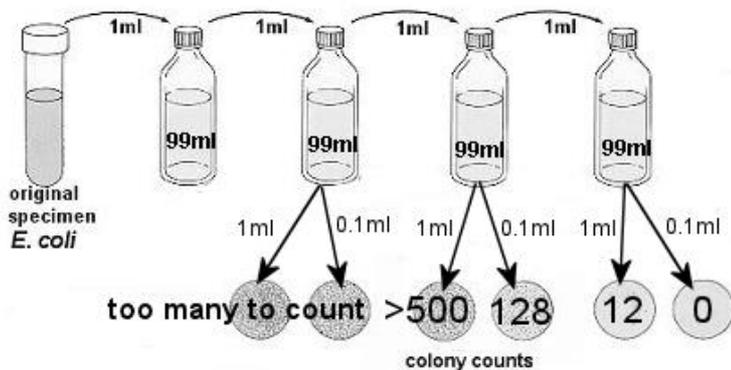
The enzyme 'lock and key' model implies that every enzyme has a substrate that it binds to at a specific site and it then catalyses a reaction. If the model below is an enzyme, which of the substrates does it fit?



**Question 9**

Many laboratory procedures involve the use of dilutions. If a solution has a 1/10 dilution the number represents 1 part of the sample added to 9 parts of diluent. The dilution factor equals the final volume divided by the sample volume. A serial dilution is any dilution in which the concentration decreases by the same quantity in each successive step. Serial dilutions are multiplicative.

Bacterial counts in a stream water sample can be determined by placing a known volume of the stream water into a liquefied agar medium that is then poured into a petri dish. The agar solidifies and bacterial colonies grow within the agar. These colonies can then be accurately counted as the bacteria are equally distributed through the agar. In practice the number of bacteria is usually so great that a serial dilution must be made first so that the number of colonies can be counted. Note that the amount put on the plate is also a dilution as colonies are normally reported as per ml. Plates with 30-300 colonies are used for the calculation as plates with greater than 300 and less than 30 have a high degree of error. Air contaminants can contribute significantly to a really low count and a high count can be confounded by error in counting too many small colonies.

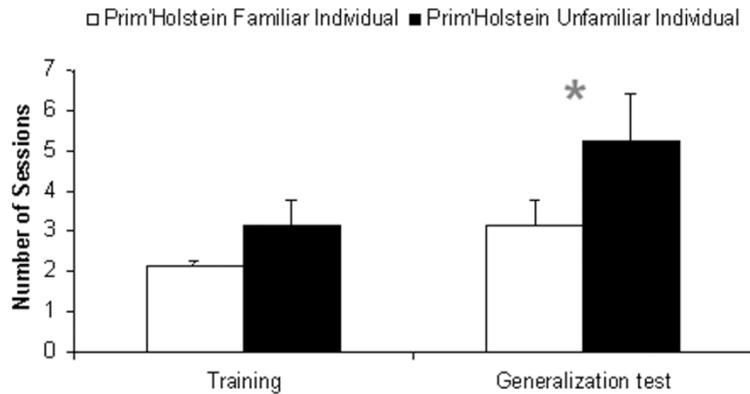


Calculate the number of bacterial cells (*E. coli*) per ml in the original water sample.

- A.  $1.28 \times 10^7$
- B.  $1.28 \times 10^8$
- C.  $1.28 \times 10^9$
- D.  $1.20 \times 10^8$
- E.  $1.20 \times 10^9$

**Question 10**

Facial recognition has been shown in the behaviour of many species. Cows (*Bos taurus*) of the breed Prim Holstein were studied to measure this trait. Cows were shown two pictures, one of a member of their own social group and one of an unfamiliar cow of the same breed. They were rewarded with food when they walked towards the unfamiliar cow's picture. The cows were first trained, using the same pictures of a familiar cow and an unfamiliar cow. Then, in 'generalisation' tests, experimental subjects were shown different angles of familiar cows' faces and unfamiliar cows' faces (examples are shown below). The number of sessions required for cows to reliably choose the correct picture was recorded. The \* sign indicates a statistically significant difference.

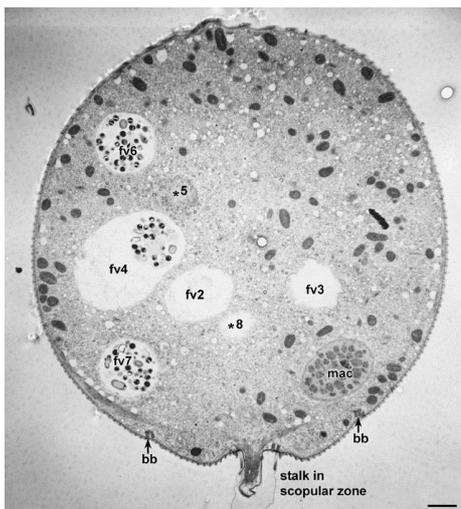


<http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0004441#pone-0004441-t001>

What conclusion can be drawn from the data?

- A. Cows only have a short term memory.
- B. Cows show recognition of familiar individuals.
- C. Cows cannot recognise familiar individuals.
- D. Cows are colour-blind.
- E. Cows will only ever walk towards food.

**Question 11**



*Vorticella* is a genus of protozoa found mainly in freshwater streams. On the left is a transmission electron micrograph showing food vacuoles (fv), a stalk (stalk) and a macronucleus (mac). The bar on the bottom right is 2µm.

What is the maximum diameter of the largest food vacuole shown?

- A. 8µm
- B. 18µm
- C. 180µm
- D. 0.18mm
- E. 0.8mm

<http://www5.pbrc.hawaii.edu/allen/ch19/>

**Question 12**

The two main factors taken into account when measuring biological diversity are richness and evenness. Richness is a measure of the number of different kinds of organisms present in a particular area. Evenness is a measure of the relative abundance of the different species making up the richness of an area. As species richness and evenness increase, so diversity increases. Simpson's Diversity Index (D) is a measure of diversity which takes into account both richness and evenness. Its formula is:

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

Note:  $\sum$  means to sum.

The value of D ranges between 0 and 1 with 0 representing infinite diversity and 1, no diversity. That is, the larger the value of D, the lower the diversity. This is neither intuitive nor logical, so to get over this problem, D is often subtracted from 1 to give Simpson's Index of Diversity  $1 - D$ . The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity.

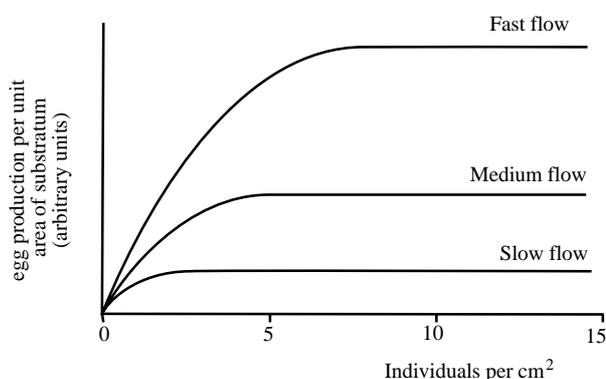
Calculate Simpson's Index of Diversity for a single transect sample of canopy trees in native bush near Rotorua.

Species	Number (n)	n(n-1)
Rimu	2	
Rewarewa	8	
Rata	1	
Tawa	1	
Tree fern	3	
<b>Total (N)</b>	<b>15</b>	<b>64</b>

- A. 0.3
- B. 3.0
- C. 0.7
- D. 7.0
- E. D cannot be calculated as we do not know the transect length.

**Question 13**

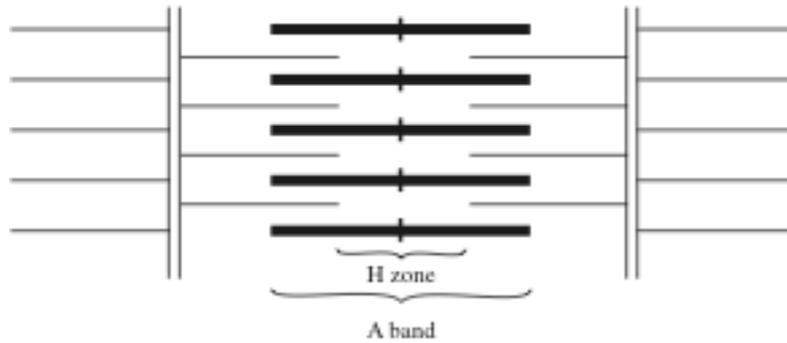
The graph show egg production at different population densities of the barnacle (*Semibalanus balanoides*) at three rates of water flow. Which of the following inferences is supported by these data?



- A. The greater the population density, the more fertile the organisms become.
- B. Beyond a certain population density, overcrowding reduces the rate of egg production by individuals.
- C. An inverse relationship exists between the rate of water flow and egg production.
- D. A linear relationship exists between population density and egg production at all population densities.
- E. The effect of water flow on egg production is greater at a density of 15 individuals per  $\text{cm}^2$  than at a density of 5 per  $\text{cm}^2$ .

**Question 14**

The diagram shows protein filaments in a muscle myofibril.

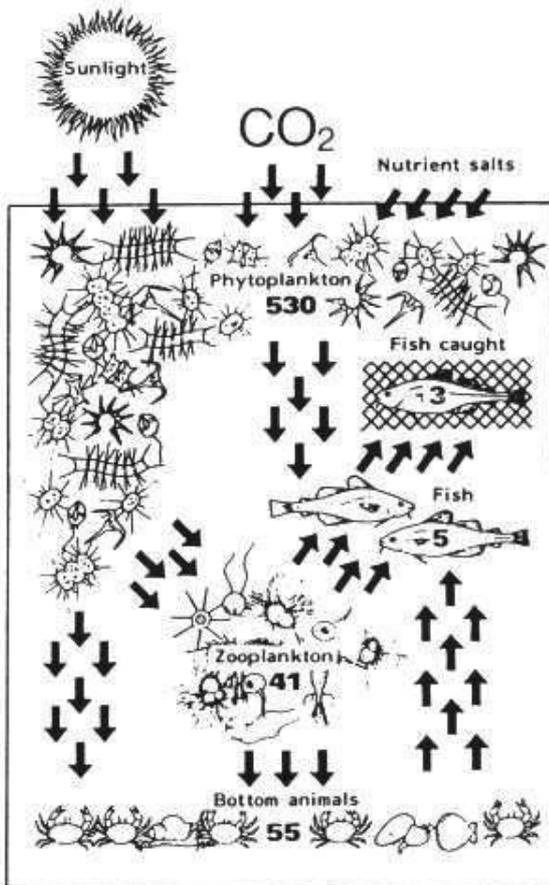


Which one of the following, A to D, correctly describes what would happen to the A band and the H zone when the muscle contracts?

	A band	H zone
A.	shorter	shorter
B.	same	same
C.	shorter	same
D.	same	longer
E.	same	shorter

**Question 15**

The percentage of energy transferred from one trophic level is called the ecological efficiency.



The figure at left summarises the annual production (in million tonnes) in the North Sea (Moeller Christensen and Nystroem, 1977). The arrows show the direction of the energy flow.

Calculate the ecological efficiency of the true primary consumers that are feeding solely on phytoplankton.

- A. 19.1%
- B. 18.1%
- C. 10.4%
- D. 7.5%
- E. 8.7%

<http://www.fao.org/docrep/v7180e/v7180e03.htm>

**Question 16**

The genetic relatedness between various sets of relatives is shown in the table below. For relatedness to your brother, half-brother, first cousin, and so forth, simply read across the “self” row. For relatedness to your father’s brother (your uncle), your father’s half-brother, and so forth, read across the second row.

Generation	Brother	Half-brother	First cousin	Half-first cousin	Second cousin	Half-second cousin
Self	1/2	1/4	1/8	1/16	1/32	1/64
Father’s	1/4	1/8	1/16	1/32	1/64	1/128
Grandfather’s	1/8	1/16	1/32	1/64	1/128	1/256
Great-grandfather’s	1/16	1/32	1/64	1/128	1/256	1/512
Great-great-grandfather’s	1/32	1/64	1/128	1/256	1/512	1/1,024

Table modified from “The Altruism Equation: Seven Scientists Search for the Origins of Goodness” by Lee Alan Dugatkin (2006)

What is your genetic relatedness to your great half-uncle?

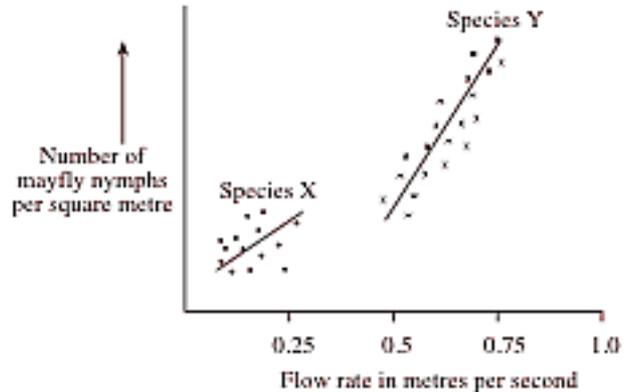
- A. 1/2
- B. 1/4
- C. 1/8
- D. 1/16
- E. 1/32

**Question 17**

The scatter graphs show the relation between the number of mayfly nymphs of two species, X and Y, and the flow rate of the water in which they live. The correlation coefficients for species X is 0.34 and for species Y is 0.87.

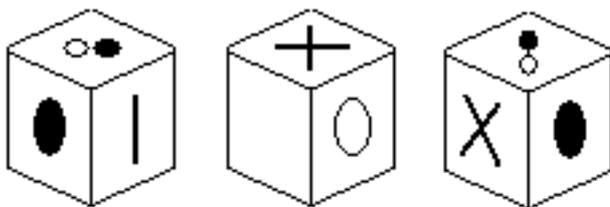
The correlation coefficient for species X is lower than that for species Y because

- A. The scattering of the points is greater.
- B. The mean flow rate is less.
- C. There are fewer points in its scatter graph.
- D. The slope of the line is less.
- E. The number of mayfly nymphs per square metre is less.

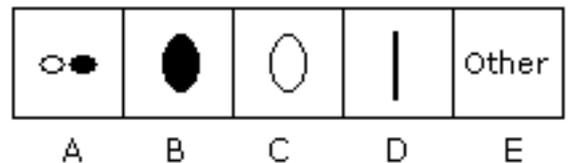


**Question 18**

Three views of the same cube are shown below. Which symbol is opposite the X?



Answers



<http://www.psychometric-success.com/aptitude-tests/spatial-ability-tests-cubes.htm>

**Question 19**

An investigator developed a scoring system that enabled her to predict an individual's body mass index (BMI) based on information about what they ate and how much. Information is collected from a small sample of subjects in order to compute their "diet score," and the weight and height of each subject is measured in order to compute their BMI. The graph on the left shows the relationship between the new "diet score" and BMI, and it suggests that the "diet score" is not a very good predictor of BMI, (i.e. there is little if any association between the two). She then identified the age and gender of the subjects and these data are presented in the graph on the right.



[http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704-EP713\\_MultivariableMethods/BS704-EP713\\_MultivariableMethods\\_print.html](http://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704-EP713_MultivariableMethods/BS704-EP713_MultivariableMethods_print.html)

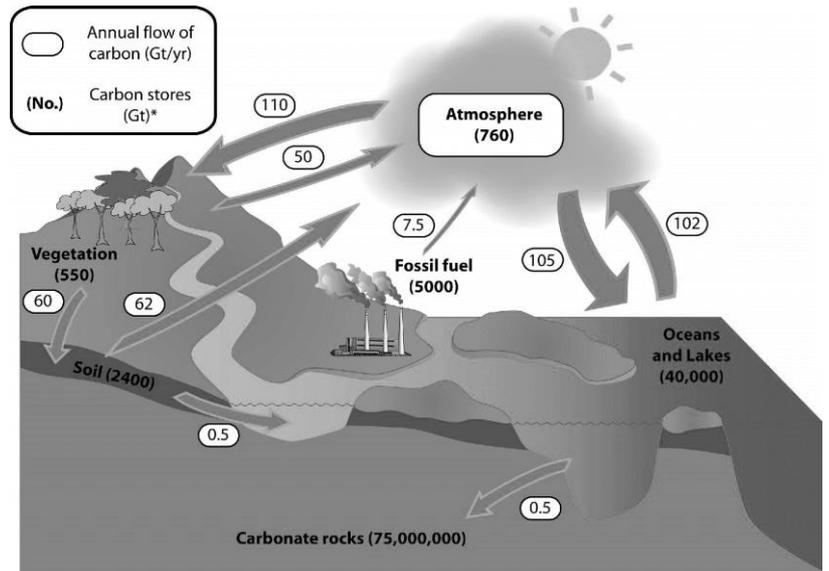
Considering these data what is the best conclusion about the relationship between "diet score" and BMI?

- A. There is no clear association between the two variables.
- B. Age is confounding the association between diet score and BMI.
- C. Gender is confounding the association between diet score and BMI.
- D. Both age and gender have an effect on BMI.
- E. Diet, age, and gender each have an independent effect on BMI.

**Question 20**

The global carbon cycle is represented in the diagram at right. Human activities that affect the distribution of carbon include the burning of fossil fuels and cultivation practices such as land clearance. The greatest annual flow of carbon is by:

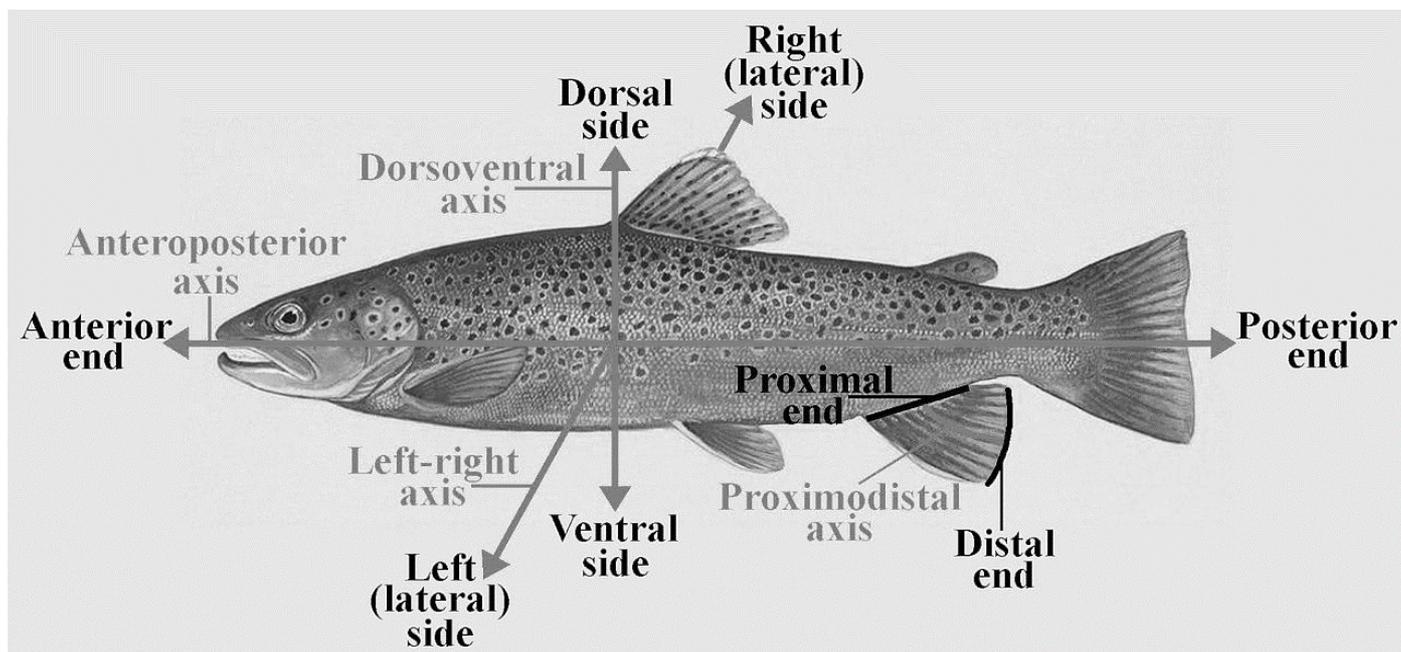
- A. Dissolving of atmospheric carbon dioxide in water bodies.
- B. Erosion of calcium carbonate in soils and rocks by water.
- C. Release of carbon dioxide during respiration.
- D. Fixation of atmospheric carbon dioxide by plants.
- E. Release of carbon dioxide from volcanoes.



\* 1 Gt = 1 Gigatonne = 1 billion metric tonnes  
<http://www.qld.gov.au/environment/land/soil/soil-properties/carbon/#lightbox-uid-0>

### Question 21

The diagram below shows the anatomical planes and directions of a fish.



[http://en.wikipedia.org/wiki/Anatomical\\_terms\\_of\\_location#mediaviewer/File:Anatomical\\_Directions\\_and\\_Axes.JPG](http://en.wikipedia.org/wiki/Anatomical_terms_of_location#mediaviewer/File:Anatomical_Directions_and_Axes.JPG)

Fully describe the anatomical position of the gonad relative to the gut in a fish.

- A. The gonad is a paired organ and each gonad lies dorsal to the gut.
- B. The gonad is a paired organ and each gonad lies dorsal to the gut just lateral to the midline.
- C. The gonad lies dorsal to the gut and extends laterally.
- D. The gonad is a paired organ and each gonad lies lateral to the gut.
- E. The paired gonad is lateral to the gut.

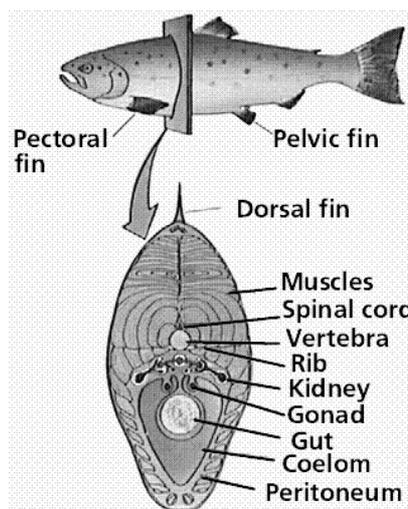
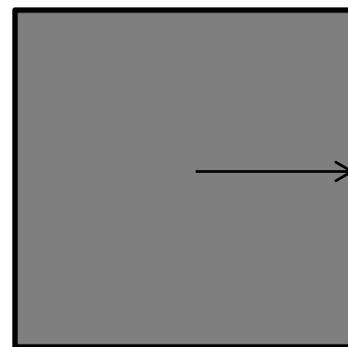
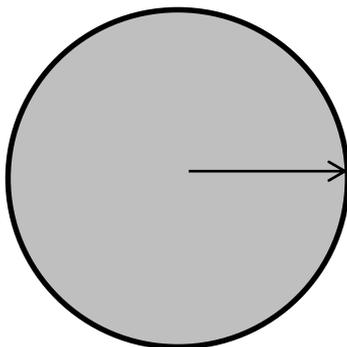


Image from Purves et al., *Life: The Science of Biology*, 4th Edition

### Question 22

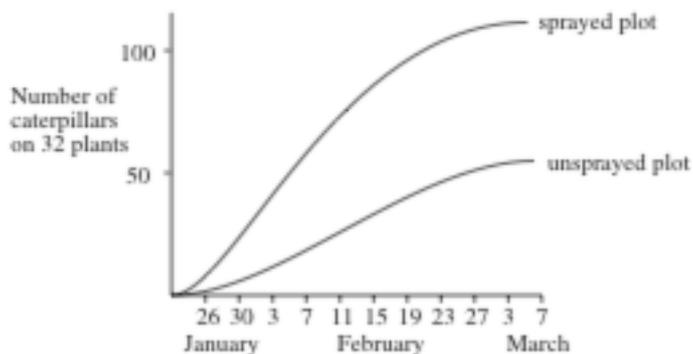
“Square trees” are being investigated to make forestry more sustainable. The underlying concept involves modifying the genome of trees so that the trunks grow in a 3D ‘cuboid’ shape instead of a cylinder. If the arrows on the cross sections of the trees shown are the same size, and the trunks are the same height, what is the percentage wood gained in tree on the right when compared with tree on the left? (Cuboid volume = base x height x width), (Cylinder volume =  $\pi r^2 \times$  height).

- A. 21%
- B. 10%
- C. 34%
- D. 5%
- E. 31.4%



**Question 23**

Two similar plots of cabbage plants were used in an investigation to determine the effectiveness of an insecticide. One plot was sprayed with the insecticide on 26th December. The second plot was left unsprayed as a control. The graph shows the number of caterpillars that were found on the plots during the following January, February and March.

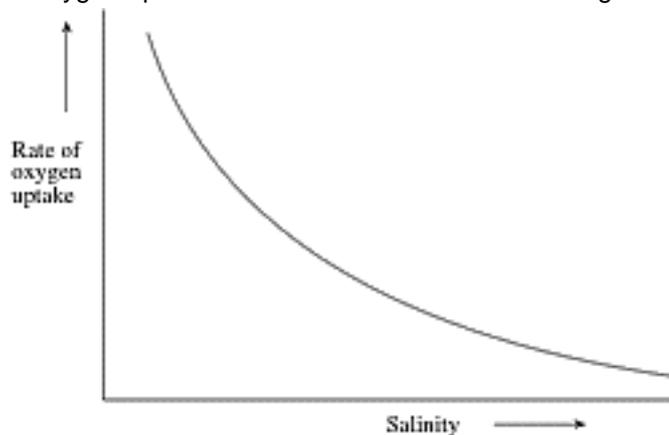


Which one of the following statements is the best explanation of these data?

- A. The caterpillars on the cabbage sprayed with insecticide were resistant to the insecticide.
- B. In the sprayed plot the insecticide killed many of the natural predators of the caterpillars.
- C. The effect of the insecticide had worn off by the time the caterpillars had hatched from their eggs.
- D. The insecticide was applied too late in the life cycle and had the effect of delaying pupation.
- E. The insecticide had no effect on the caterpillars.

**Question 24**

The graph below shows how the oxygen uptake of an estuarine crustacean changes with the salinity of the water.

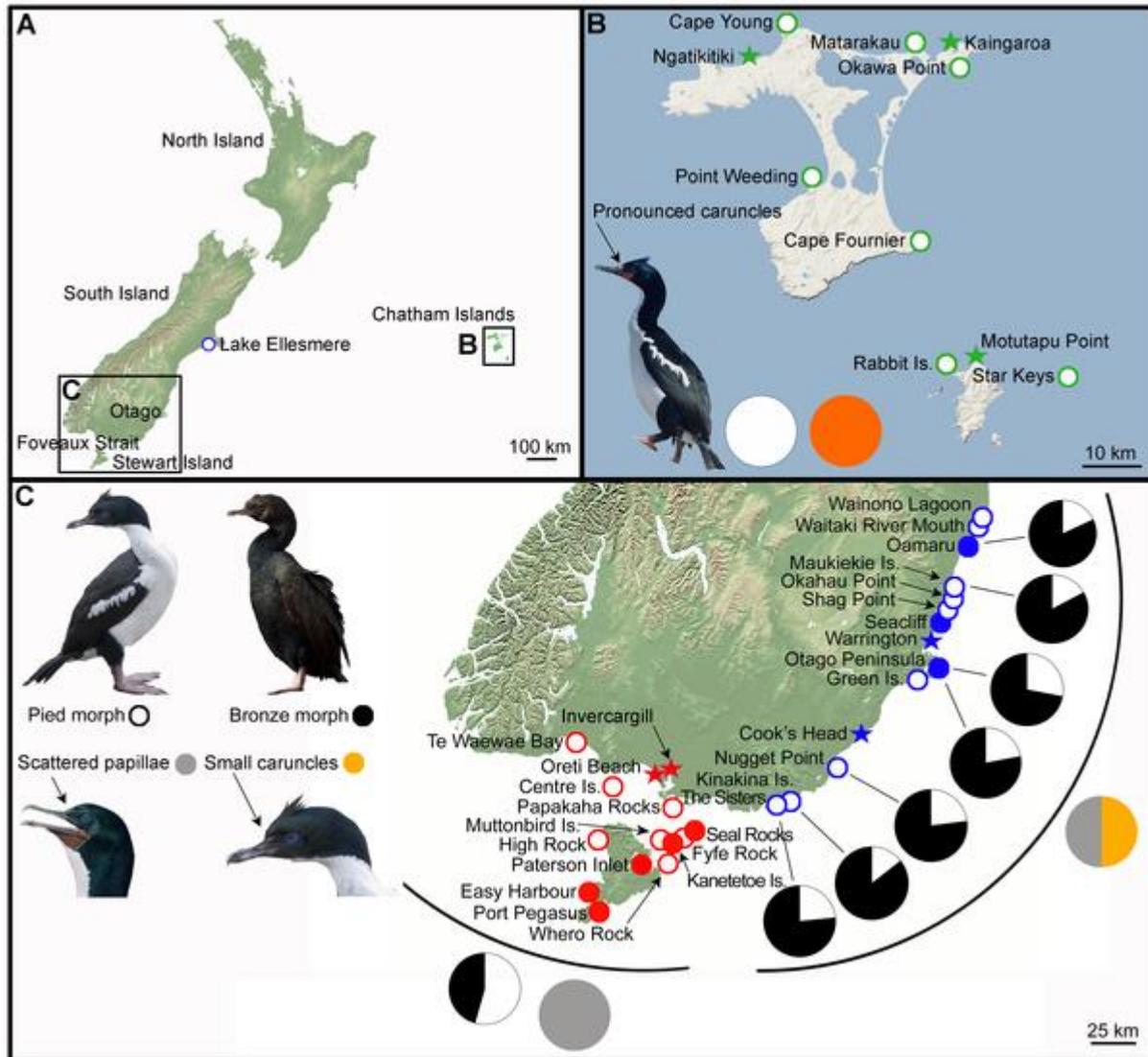


From this information the most acceptable conclusion is that:

- A. Oxygen diffuses faster in more concentrated salt solutions.
- B. Oxygen diffuses faster in more dilute salt solutions.
- C. Respiration rate is greater in more concentrated salt solutions.
- D. Removal of excess water from the body is an energy-requiring process.
- E. Uptake of water by the body is an energy-requiring process.

### Question 25

Data for the distribution and morphology of the Chatham Island (*Leucocarbo onslowi*) and Stewart Island (*L. chalconotus*) shags are shown in the figure below.



Rawlence NJ, Till CE, Scofield RP, Tennyson AJD, Collins CJ, et al. (2014) Strong Phylogeographic Structure in a Sedentary Seabird, the Stewart Island Shag (*Leucocarbo chalconotus*). PLoS ONE 9(3): e90769. doi:10.1371/journal.pone.0090769

The pie charts in Section C indicate the proportion of the different morphological forms at each locality. White sectors indicate the proportion of pied morph expected and black the bronze morph. Grey sectors indicate the proportion of shags with scattered papillae and orange, small caruncles in breeding plumage.

What features would you expect to see in a shag population in Foveaux Strait?

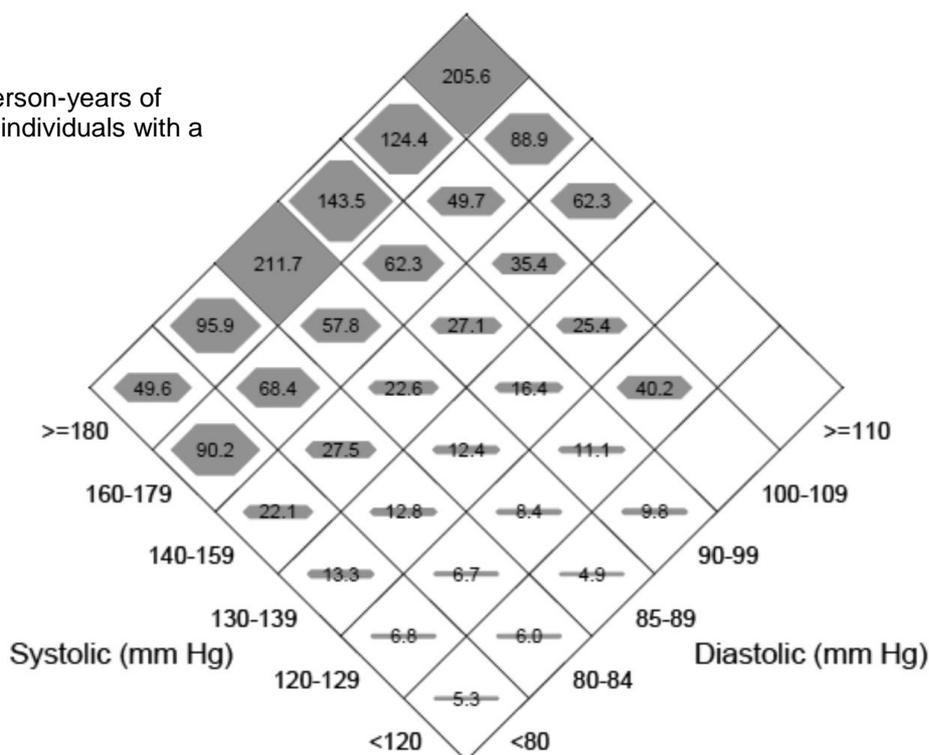
- 20% pied morphs and 80% dark-bronze morphs.
- 30% pied morphs and 80% dark-bronze morphs AND 50%:50% small bright orange caruncles: dark to dull orange scattered papillae in breeding plumage.
- 50% pied and dark-bronze morphs AND 50%:50% small bright orange caruncles: dark to dull orange scattered papillae in breeding plumage.
- 60% pied morphs and 40% dark-bronze morphs AND all with small bright orange caruncles.
- 60% pied morphs and 40% dark-bronze morphs all with dark to dull orange scattered papillae in breeding plumage.

**Question 26**

A new diamond graph method has been developed that can represent 3 variables equally on a 2-D graph. The diamond graph is essentially a 3-D bar graph viewed from above rather than from the side. Instead of using rising parallel bars, the diamond graph uses expanding polygons within a diamond-shaped grid to represent values. This diamond graph depicts the age-adjusted incidence rates of end-stage renal disease due to any cause per 100,000 person-years according to six categories of both systolic and diastolic blood pressure (Klag, Whelton, Randall, et al. 1996).

What is the incidence per 100,000 person-years of end-stage renal disease expected in individuals with a blood pressure of 170/100 (mm Hg)

- A. 143.5
- B. 124.4
- C. 62.3
- D. 49.7
- E. None of the above.



(Li, Buechner, Tarwater, and Muñoz, 2003)

**Question 27**

In 1976, minced beef was tested in Cork City, Ireland, for the level of bacterial contamination using processes called the total aerobic plate count (APC) and the coliform count. In some areas, meat is classed as unsafe to eat if it contains more than 10 million per gram total viable count (APC method) or 50 per gram of coliform count (total coliform method). Results from 5 different markets were sampled on two different days and the results (count/g) are shown below.

Market	Sample 1		Sample 2	
	APC	Total Coliform	APC	Total Coliform
A	$2.4 \times 10^7$	$3 \times 10^5$	$4.1 \times 10^7$	$2.9 \times 10^5$
B	$3.5 \times 10^5$	$8 \times 10^4$	$3.0 \times 10^6$	$3.0 \times 10^6$
C	$3.7 \times 10^8$	$4.8 \times 10^5$	$1.0 \times 10^8$	$4.0 \times 10^5$
D	$3.2 \times 10^6$	$4.2 \times 10^5$	$1.9 \times 10^7$	$1.3 \times 10^5$
E	$2.0 \times 10^7$	$5.3 \times 10^5$	$2.1 \times 10^7$	$2.2 \times 10^5$

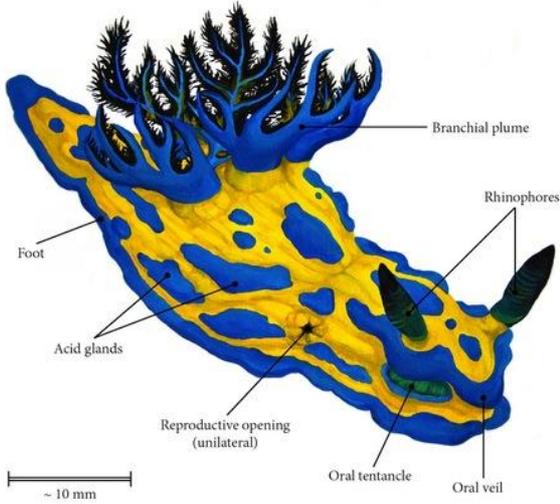
<http://www.jstor.org/stable/i25555828>

Which market(s) sells minced beef that always meets the safety guidelines given?

- A. Market A.
- B. Markets B.
- C. Markets B and D.
- D. None of the markets, due to coliform count.
- E. None of the markets, due to coliform count and/or APC count.

**Question 28**

External Anatomy of *Tambja verconis*



At left is a diagram of the beautiful nudibranch (sea slug), *Tambja verconis*. This sea slug is found in north-eastern waters of New Zealand. What is the approximate maximum length of this sea slug in cm?

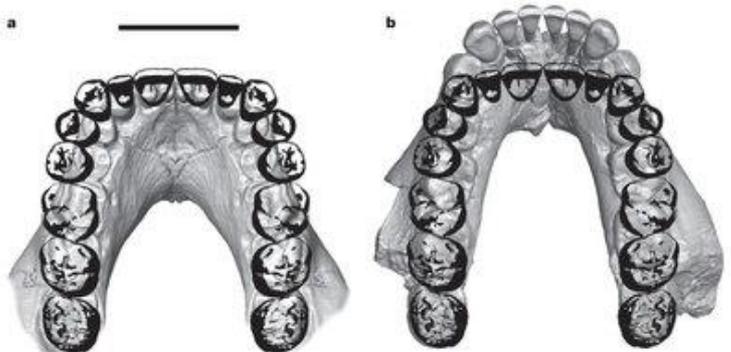
- A. 20 mm
- B. 2 cm
- C. 4.8 mm
- D. 48 mm
- E. 4.8 cm

<http://scientificillustration.tumblr.com/post/42376170639/wadeangeli-art-this-dorid-nudibranch-sea-slug>

**Question 29**

Dental arcades are a feature that is used to differentiate between *Homo sapiens* and their recent ancestors. Dental arcades of recently discovered *Homo* species have been compared with data on previously discovered species. The reconstructed upper arcade of KNM-ER 62000 (outlined in black; discovered 2012) is occluded with (a) the reconstructed lower arcades of KNM-ER 60000 (shown in grey; also discovered 2012) and (b) KNM-ER 1802 (shown in grey; discovered 1973). What is a logical conclusion that can be made from these data?

- A. Early *Homo* species were scavengers.
- B. There was morphological variation in early *Homo* species.
- C. Modern *Homo sapiens* have taken large evolutionary leaps from early *Homo* species.
- D. Early *Homo* species had an 'overbite' in their jaws.
- E. Fossils that are discovered at the same time, are the same shape.



<http://www.nature.com/nature/journal/v488/n7410/full/nature11322.html>

**Question 30**

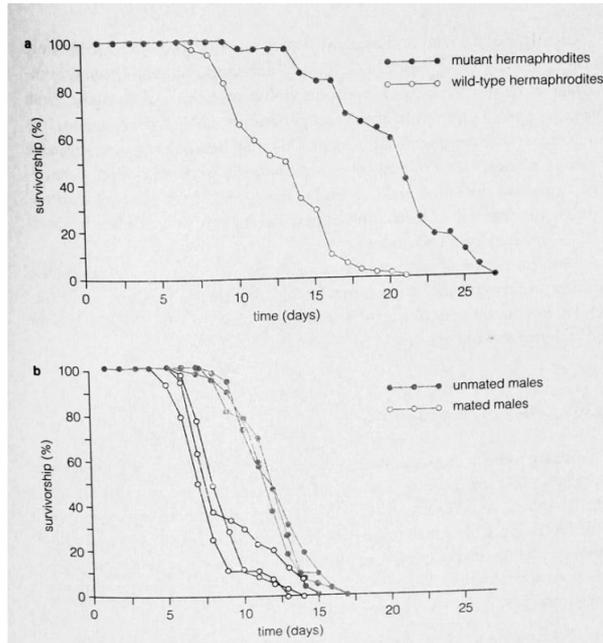
The gastrocnemius (calf) muscle of a frog and the sciatic nerve supplying it can be kept alive in a special salt solution (Ringer's solution) and stimulated to contract by a single electric shock delivered to the nerve supplying the muscle. The response is called a twitch, and can be recorded by attaching the tendon of the muscle to a lever attached to a pen that makes a mark on a revolving drum (called a kymograph). The recording below is of a single twitch after stimulation of the nerve supplying the muscle.



- The distance (d) is **NOT** affected by the
- A. Velocity of the nerve impulse.
  - B. Temperature of the Ringer's solution.
  - C. Strength of the stimulus.
  - D. Speed of rotation of the kymograph drum.

**Question 31**

Biology is often focused on survival and/or reproduction of individuals. Normal 'wild-type' male nematode worms were compared with two different mutant male strains – one group which did not produce sperm (top graph) and one group which did not mate (bottom graph). Their survivorship curves are below.



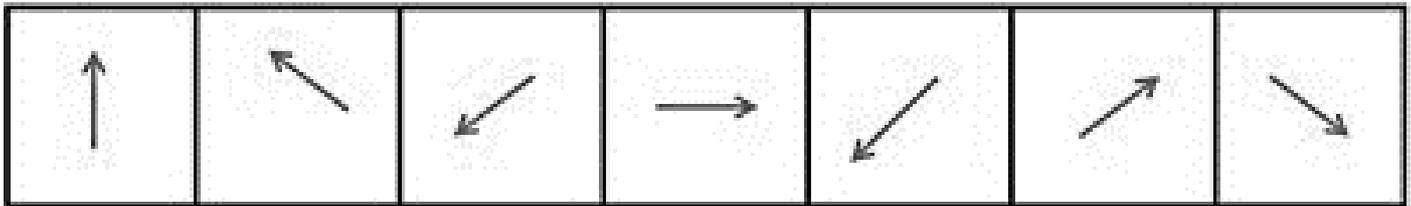
What is the best conclusion that can be made from these data?

- A. There is a cost to mating **and** sperm production that shortens a nematode's life.
- B. There is a cost to mating **or** sperm production that shortens a nematode's life.
- C. The cost of mating is offset by having many offspring
- D. Nematode females probably eat the males after mating.

Adapted from Krohne , 1998 General Ecology

**Question 32**

Which diagram below does not fit the series?



- A.**
- B.**
- C.**
- D.**
- E.**

**Question 33**

The table below summarises the complications by age for measles cases in the United States from 1987-2000.

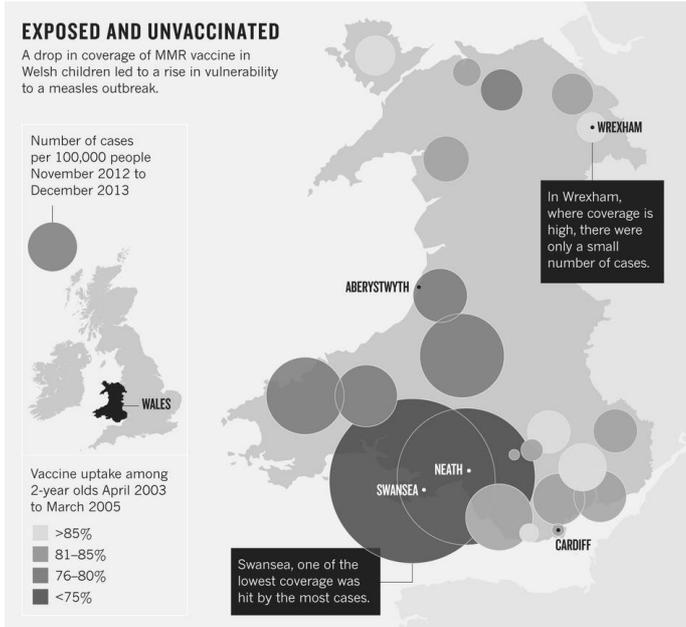
Complication	Overall (67,032 cases with age information)	No. (%) of persons with complication, by age group				
		<5 years (n = 28,730)	5–9 years (n = 6492)	10–19 years (n = 18,580)	20–29 years (n = 9161)	>30 years (n = 4069)
Any	19,480 (29.1)	11,883 (41.4)	1173 (18.1)	2369 (12.8)	2656 (29.0)	1399 (34.4)
Death	177 (0.3)	97 (0.3)	9 (0.1)	18 (0.1)	26 (0.3)	27 (0.7)
Diarrhea	5482 (8.2)	3294 (11.5)	408 (6.3)	627 (3.4)	767 (8.4)	386 (9.5)
Encephalitis	97 (0.1)	43 (0.2)	9 (0.1)	13 (0.1)	21 (0.2)	11 (0.3)
Hospitalization	12,876 (19.2)	7470 (26.0)	612 (9.4)	1612 (8.7)	2075 (22.7)	1107 (27.2)
Otitis media	4879 (7.3)	4009 (14.0)	305 (4.7)	338 (1.8)	157 (1.7)	70 (1.7)
Pneumonia	3959 (5.9)	2480 (8.6)	183 (2.8)	363 (2.0)	554 (6.1)	379 (9.3)

Source: Centers for Disease Control and Prevention. [http://jid.oxfordjournals.org/content/189/Supplement\\_1/S4/F3.expansion.html](http://jid.oxfordjournals.org/content/189/Supplement_1/S4/F3.expansion.html)

Based on the data, which statement is correct?

- A. Measles is relatively more deadly in young people compared with older people
- B. Catching measles will give you pneumonia
- C. Most of the measles cases with complications reported were young people, below 19 years of age
- D. Hospitalization is rare with measles
- E. Encephalitis is a deadly complication of measles

**Question 34**



[http://www.nature.com/nature/journal/v507/n7490\\_supp/fig\\_tab/507S17a\\_G1.html](http://www.nature.com/nature/journal/v507/n7490_supp/fig_tab/507S17a_G1.html)

What is the best conclusion(s) that can be made from the diagram at left of measles cases and immunisation rates in Wales?

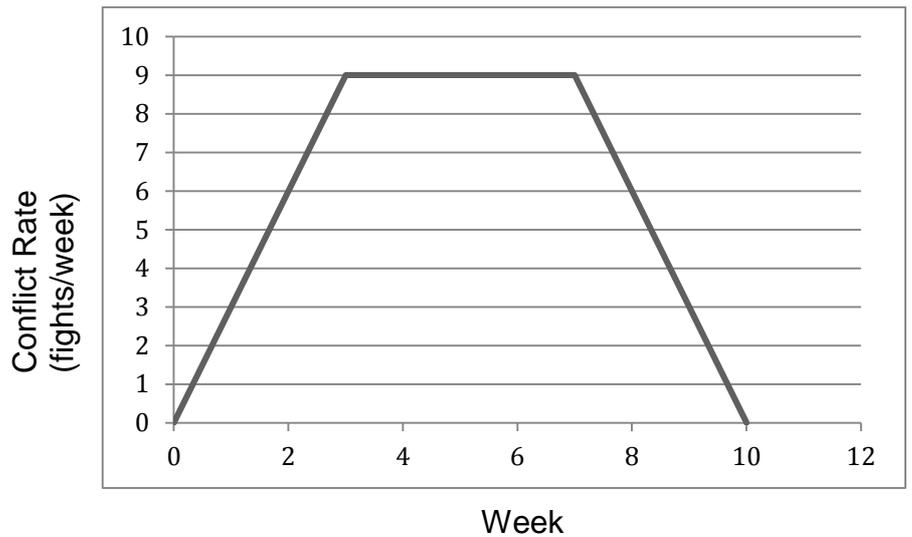
- A. A vaccination programme does not always stop outbreaks of disease.
- B. Higher infection rates are linked with lower vaccination rates.
- C. Outbreaks can occur in geographical clusters.
- D. Only B and C are valid conclusions.
- E. A, B and C are valid conclusions.

**Question 35**

The graph at right shows the conflict rate of primates, measured throughout the day and night over 10 weeks of a study period.

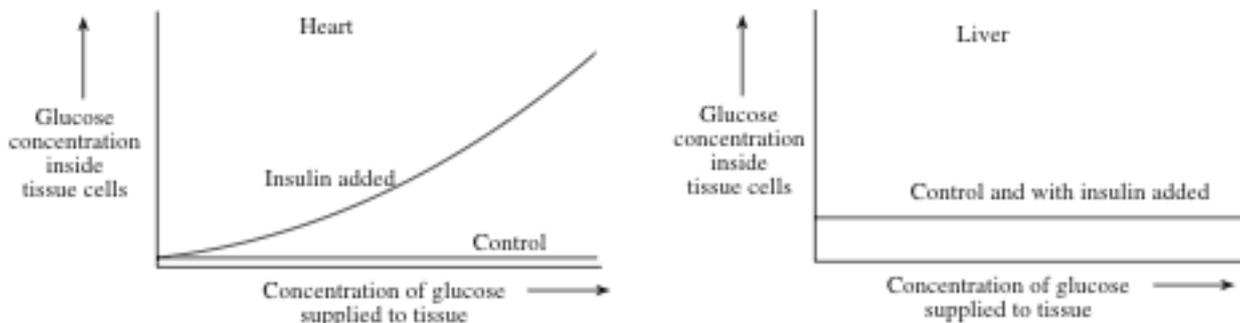
How many fights occurred in total?

- A. 9
- B. 59
- C. 12
- D. 63
- E. 14



### Question 36

The graphs show the effect of insulin on the glucose concentrations inside the cells of liver and of heart muscle when these two tissues were supplied with increasing concentrations of glucose.

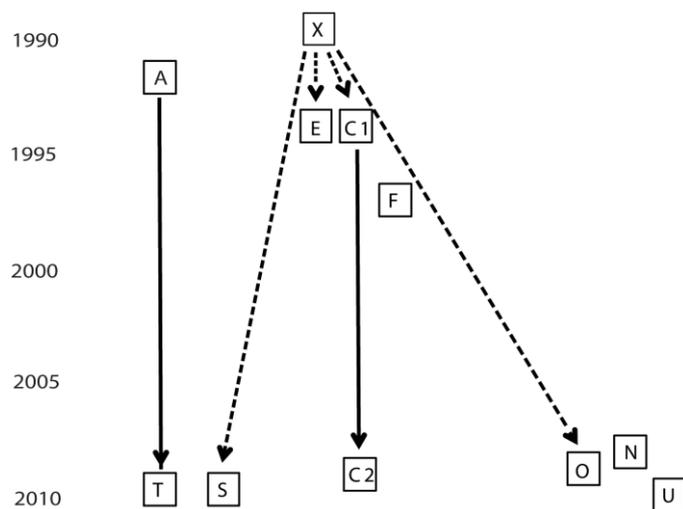


The best interpretation of these data is that:

- A. Liver cells are impermeable to glucose.
- B. Insulin increases the entry of glucose into heart and liver cells.
- C. Insulin increases the entry of glucose into the heart tissue but not into liver cells.
- D. Insulin is metabolised rapidly by liver cells.
- E. Insulin is metabolised rapidly by heart cells.

### Question 37

Tuberculosis (TB) kills more than two million people annually and is a disease studied by scientists around the world.



<http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0091024>

The diagram on the left shows the chronology of a TB outbreak in New Zealand. "Each square represent a subject at the time of the TB diagnosis. Broken lines represent known close direct contact with the initial index case "X" during X's period of infectiousness. Solid lines show assumed connections between a case of presumed reactivation (C1 to C2) and a case of potential child-parent transmission (A to T)". What is the best conclusion to be made from these data?

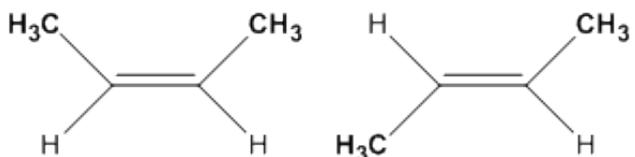
- A. Tuberculosis is widespread in New Zealand.
- B. Tuberculosis can stay dormant in a human before symptoms are shown.
- C. Tuberculosis outbreaks occur in geographical patterns.
- D. Patient X and Patient A are responsible for all of the tuberculosis infections in this study.
- E. None of these conclusions are valid.

**Question 38**

Geometric isomers are molecules which have the same molecular formula with the same connectivity between atoms but which have a different orientation across a double bond. The diagram below shows the different types of geometric isomers.

**Geometric isomers**

mcat-review.org

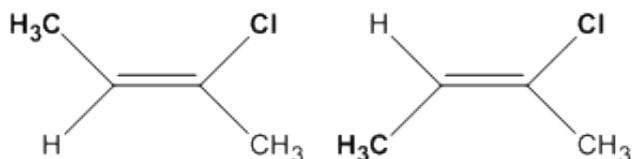


Cis

Trans

When both sides of the double bond contains the same 2 groups, then cis and trans is used. Cis = same side, Trans = opposite sides.

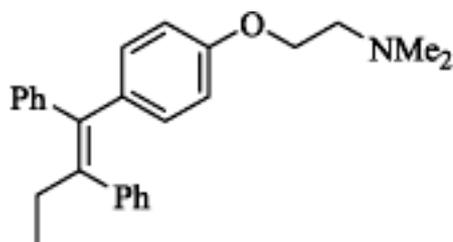
When different groups are attached to either side, Z and E is used. Z is when the higher priority groups (ranked according to the Cahn-Ingold-Prelog rules) are orientated on the same side across the double bond. Zusammen is the German word for together. E is when the higher priority groups are orientated on different sides across the double bond. Entgegen is the German word for opposed.



(Z)

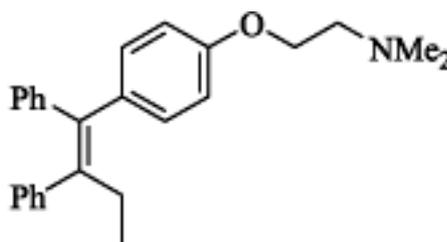
(E)

The isomerization of a molecule may have significant effects on its biological function. Tamoxifen is an antiestrogenic drug used to treat and prevent a form of breast cancer without the negative side effects of traditional chemotherapy. It exists as (Z)-Tamoxifen and its structure is shown below (1). It also exists less commonly as another isomer (2) that has estrogenic activity and therefore promotes the growth of breast cancer.



(Z)-Tamoxifen (1)

Antiestrogenic activity



(2)

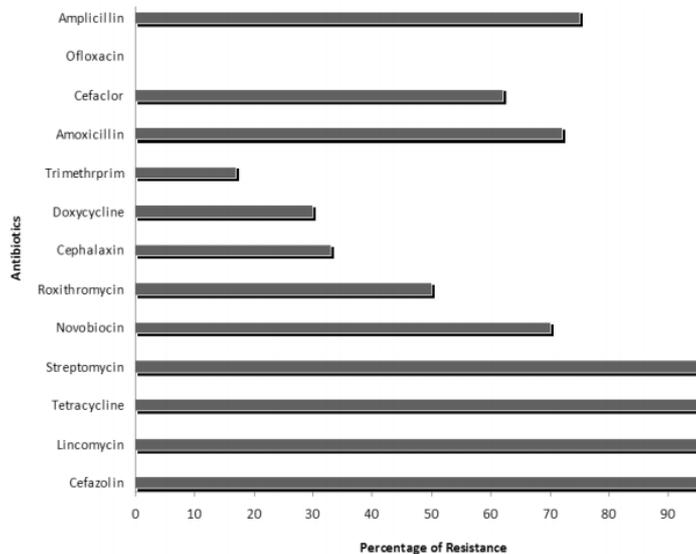
Estrogenic activity

Isomer 2 is best described as:

- Cis-Tamoxifen
- Trans-Tamoxifen
- E-Tamoxifen
- Cis(Z)-Tamoxifen
- None of the above

**Question 39**

Bacterial contamination of meat was studied in Karachi, Pakistan in 2010. Of the 342 bacterial pathogens isolated from meat samples, 120 (35%) were identified as *Escherichia coli* and 51 (15%) of these *E. coli* isolates were characterized as serotype 0157:H7, which is known to cause hemorrhagic colitis. Other potentially pathogenic isolates were *Listeria* species 14 (4%), *Klebsiella* 27 (8%), *Enterobacter* species 51 (15%), and *Staphylococcus aureus* 24 (7%). Antibiotic susceptibility was tested on the total microbial population and the results are shown below.



What is the probability that a pathogenic bacterium chosen at random would be **E coli 0157:H7** that is resistant to **Novobiocin**?

- A. 0%
- B. 10.50%
- C. 12.60%
- D. 70.15%
- E. 24.5%

Ali, et al. 2010. Microbial contamination of raw meat and its environment in retail shops in Karachi, Pakistan. *J Infect Dev Ctries*; 4(6):382-388.

**Question 40**

The diagram shows the sequence of bases in a strand of DNA that codes for a polypeptide composed of ten amino acids. An additional base sequence coding for the start signal is on the left also codes for methionine.

**T A C G G T C A A T C T G G T T C T G G T T C T T C T G A G C A A**

When the polypeptide for which this gene codes was hydrolysed, it yielded the amino acids shown in the table.

Amino acid	Number of amino acid residues per polypeptide
w	1
x	2
y	3
z	4

The correct sequence of amino acids in the polypeptide is:

- A. x y z x z y z z w y
- B. y z x y z z y z w x
- C. z x y z y z y y w z
- D. y x z y z y z z x w
- E. y x z y z y z z w x

## **Section B**

### **KĀKĀRIKI – CONSERVATION OF NEW ZEALANDS PARAKEETS**

There are five main species of kākāriki: yellow-crowned parakeet, orange-fronted parakeet, red-crowned parakeet, Forbes' parakeet and Antipodes Island parakeet. All are bright green in colour but with distinguishing coloured areas on the head. The yellow-crowned parakeet is rare but is found throughout forested areas of the North, South and Stewart Islands as well as the sub-Antarctic Auckland Islands. The orange-fronted parakeet is critically endangered with around 300 birds found in just three alpine beech forest valleys in Canterbury. The red-crowned parakeet was widespread throughout the mainland last century but today is very rare on the mainland and only common on islands free of mammalian predators. Forbes' parakeet is restricted to the Chatham Island and also critically endangered. The Antipodes Island parakeet is restricted to the Antipodes Islands.

Deforestation, disease, introduced predators, and shooting by farmers have all contributed to the present restricted distribution of these species. An important conservation tool for the restoration of endangered birds is the translocation of species to habitats that have been restored and introduced predators eradicated.

#### **Question 41**

Luis Ortiz-Catedral at the Ecology and Conservation Lab, Institute of Natural & Mathematical Sciences, Massey University, has been studying kākāriki on Raoul Island, a remote volcanic island approximately 995 km north of New Zealand. There had not been a confirmed record of resident parakeets on Raoul Island since 1836 following the introduction of goats, cats and rats. Goats were removed from the island in 1986. Then, in the world's largest multi-species eradication project to date, the New Zealand Department of Conservation (DOC) successfully removed domestic cats, and Norway and Pacific rats (kiore) from Raoul Island using aerial drops of poisoned bait for rats between 2002 and 2004, and follow-up ground-based control for cats.

Prior to the removal of these invasive species on Raoul, the last strongholds for Kermadec red-crowned parakeets were the Herald Islets (ca. 50 breeding pairs) and Macauley (ca. 10,000 breeding pairs) 2-4 km east and 108 km south respectively off the coast of Raoul Island. Since 2000 (i.e. two years prior to initiation of the predator removal programme), staff from DOC have carried out bird surveys roughly once a year on Raoul to assess the effect of the removal of predators. No parakeets were detected prior to eradication of cats and rats. After the cat and rat eradication there were infrequent sightings of one to three parakeets. In 2008 during the parakeet survey, 100 parakeets were caught during a 13-day mist-netting period. Of these, 59 were female and 41 were male, of which 56 were adults and 44 sub-adults hatched in 2008. One full pre-mating display followed by copulation was also observed and two nests were located in fallen logs of Kermadec pohutukawa.

Considering the data given above what conclusion can be drawn about the presence of red-crowned parakeets on Raoul Island?

- A. Red-crowned parakeets are now frequent visitors to Raoul Island from their breeding sites on the Herald Islets.
- B. Red-crowned parakeets have successfully recolonised Raoul Island after eradication of invasive predators.
- C. Red-crowned parakeets have been successfully translocated to Raoul Island.
- D. Eradication of invasive predators on Raoul Island has allowed remnant populations of red-crowned parakeets to increase.
- E. Red-crowned parakeets are now common on Raoul Island after eradication of invasive species.

#### **Questions 42 - 47**

Understanding the foraging ecology of a species is crucial when conservation management involves translocation of the species. Work by Kearvell et al. (2002) had described the foods consumed by orange-fronted parakeets in the South Island and noted that for most of the year the species fed almost exclusively on *Nothofagus* spp (beech trees) and that invertebrates made up nearly 70% of the food items consumed in spring.

Luis' research group recorded data on the diet of translocated orange-fronted parakeets on Maud Island, in the Marlborough Sounds, South Island. They recorded the foraging of the parakeets on each research visit to Maud Island from March 2007 to January 2009, visiting approximately every two months (17 visits in total).

132 feeding bouts were recorded with a total of 124 observations (81%) consisting of dietary items and 29 (19%) of non-dietary items such as bark, sticks and grit. Orange-fronted parakeets were observed to consume fruits 94 times, leaves 19 times, flowers six times and invertebrates five times.

The table below gives the plant species and food types ingested by translocated orange-fronted parakeets on Maud Island.

Species	Type	Proportion of diet (feeding bouts in brackets)
Sycamore ( <i>Acer pseudoplatanus</i> *)	Fruits	3.36 (4)
Titoki ( <i>Alectryon excelsus</i> )	Fruits	1.68 (2)
Makomako ( <i>Aristotelia serrata</i> )	Fruits, leaves	13.44 (16)
Putaputaweta ( <i>Carpodacus serratus</i> )	Fruits, leaves	5.88 (7)
Karamu ( <i>Coprosma robusta</i> )	Fruits	8.40 (10)
Tree lucerne ( <i>Cytisus palmensis</i> *)	Flowers, leaves	5.04 (6)
Akeake ( <i>Dodonea viscosa</i> )	Leaves	0.84 (1)
Kohekohe ( <i>Dysoxylum spectabile</i> )	Flowers	0.84 (1)
Koromiko ( <i>Hebe stricta</i> )	Flowers	1.68 (2)
Manuka ( <i>Leptospermum scoparium</i> )	Fruits	7.56 (9)
Mahoe ( <i>Melicope ramiflora</i> )	Fruits, leaves, flowers	43.70 (52)
Whauwhaupaku ( <i>Pseudopanax arboreus</i> )	Fruits	5.04 (6)
Pine ( <i>Pinus radiata</i> *)	Leaves	1.68 (2)
Karo ( <i>Pittosporum</i> sp.)	Fruits	0.84 (1)

\*Introduced species.

#### Question 42

The most important food type for orange-fronted parakeets in the South Island in spring was?

- A. Leaves.
- B. Flowers.
- C. Fruit.
- D. Beech trees.
- E. Invertebrates

#### Question 44

The most important food type for orange-fronted parakeets on Maud Island was?

- A. Leaves.
- B. Flowers.
- C. Fruit.
- D. Invertebrates.
- E. None of the above.

#### Question 46

The introduced plant species consumed most frequently by the orange-fronted parakeet on Maud Island was?

- A. Sycamore
- B. Makomako
- C. Tree lucerne
- D. Manuka
- E. Mahoe

#### Question 43

The percentage of plant material consumed by orange-fronted parakeets on Maud Island was?

- A. 96%
- B. 90%
- C. 76%
- D. 71%
- E. 15%

#### Question 45

The native plant species consumed most frequently by the orange-fronted parakeet on Maud Island was?

- A. Sycamore
- B. Makomako
- C. Tree lucerne
- D. Manuka
- E. Mahoe

#### Question 47

Considering all the data above, the best conclusion about the diet of the orange-fronted parakeet is?

- A. They have very specific dietary preferences.
- B. They rely primarily on fruit for energy.
- C. Invertebrates are an important food source in spring.
- D. They exhibit dietary flexibility.
- E. They feed on the most abundant plant species in an area.

## THE RENA OIL SPILL – BIOLOGY WHEN DISASTER STRIKES



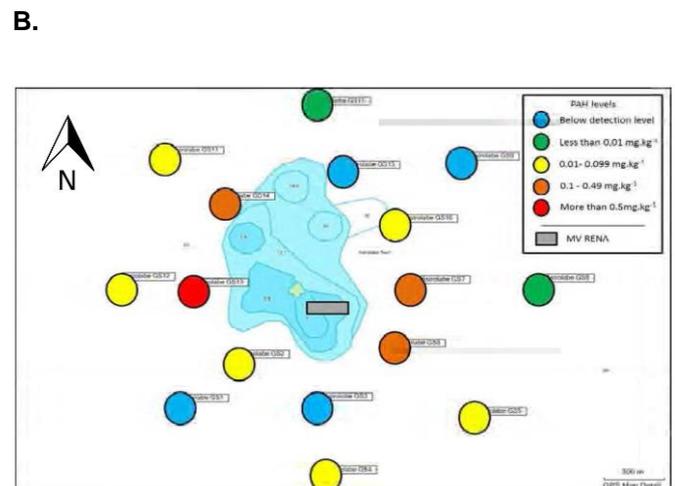
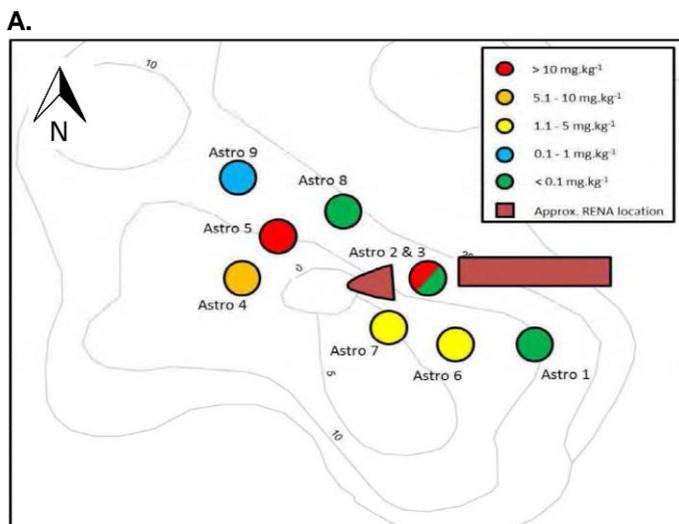
The grounding of the CV *Rena* on October 5, 2011 was New Zealand's worst maritime environmental disaster when the container ship spilled approximately 350 tonnes of heavy fuel oil into the ocean. The container ship ran aground on Otaiti (Astrolabe Reef) just off Mōtītī Island in the Bay of Plenty, releasing oil into a relatively pristine marine environment. Te Mauri Moana, a group of scientists led by the University of Waikato as part of the Government's \$4.2 million *Rena* Long-term Environmental Recovery Plan, undertook one of the most comprehensive, multi-disciplinary studies ever done following a marine pollution event. Their findings are summarised in the report; "*Rena* Environmental Recovery Monitoring Programme 2011-2013."

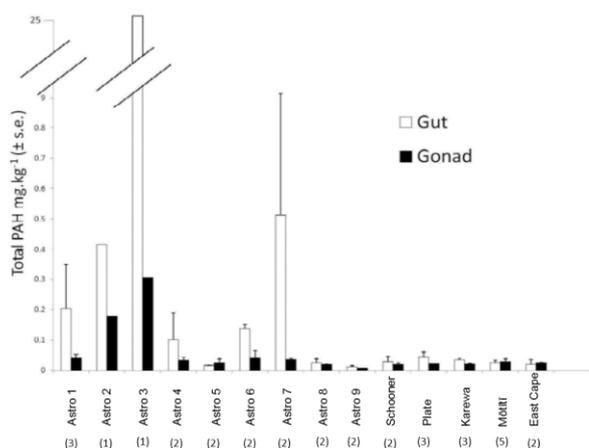
By international standards the oil spill was relatively minor but it occurred in an otherwise uncontaminated coastline in an area renowned for its beauty and highly valued for tourism, recreation and fisheries. Iwi, government, commercial stakeholders and the public were rightly concerned there would be long-lasting negative impacts on beaches, reefs and fisheries. Te Mauri Moana reports on fifteen monitoring and research programmes focused on the range of ecosystems and habitats within the Bay of Plenty.

### Questions 48 - 52

Chemical contamination of the sediments and fauna of Otaiti Reef and Mōtītī Island and the surrounding soft sediments was examined to determine if the discharge of fuel oil (and later release of container debris) from the *Rena* resulted in significant chemical contamination of the marine environment and marine organisms. Amongst other contaminants the presence of polycyclic aromatic hydrocarbons (PAHs) from fuel oil was examined in sediments and from selected organisms.

The maps below shows the PAH levels in sediments collected from **A.** on Otaiti Reef and **B.** off-reef.





The graph at left shows the PAH levels in sea urchins collected from Otaiti Reef and nearby islands. The numbers in brackets indicate the number of samples collected at each site. All sea urchins on Otaiti reef showed elevated PAH levels in the gonad with an average level of 0.057 mg kg<sup>-1</sup>. Gut levels averaged 1.58 mg kg<sup>-1</sup> but at Astro 2 and 3 were orders of magnitude higher than at other sites on Otaiti Reef. PAH levels in the gonad and gut from urchins from Mōtītī Island averaged 0.026 mg kg<sup>-1</sup> and 0.03 mg kg<sup>-1</sup> respectively and were similar to levels found elsewhere, including East Cape.

### Question 48

Off-reef sediment levels of PAH are greatest?

- North of the *Rena*.
- East of the *Rena*.
- South of the *Rena*.
- West of the *Rena*.
- East and West of the *Rena*.

### Question 50

On-reef sediment levels of PAH are greatest at?

- Astro 2/3
- Astro 4
- Astro 5
- Astro 6
- Astro 7

### Question 49

The shallowest on-reef sampling site was?

- Astro 2/3
- Astro 4
- Astro 5
- Astro 6
- Astro 7

### Question 51

The levels of PAH in sea urchin guts from the most contaminated Otaiti reef site are how much higher than those from Mōtītī Island?

- 61 times higher.
- 53 times higher.
- 2 times higher.
- 3 times higher.
- 4 times higher.

### Question 52

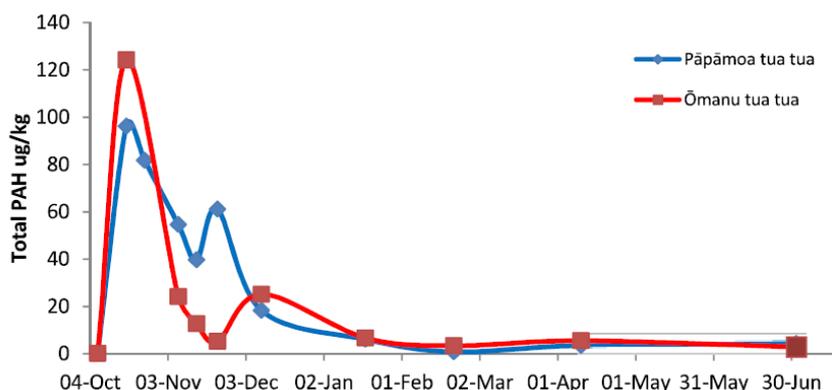
Considering these data what is the main, substantiated, conclusion that can be drawn about the effect of fuel oil contamination on the sediments and fauna of Otaiti Reef and Mōtītī Island from the grounding of the *Rena*?

- On reef sediment PAH levels generally match PAH levels in sea urchins because sea urchins ingest sand as they graze.
- Significant contamination of sediments and accumulation within the food chain has occurred.
- Contamination of sediments and sea urchins on and around Otaiti, particularly in the close vicinity of the ship's hull, has occurred.
- Otaiti Reef and Mōtītī Island show contamination of sediments and sea urchins.
- Widespread contamination of sediments and some marine organisms has occurred.

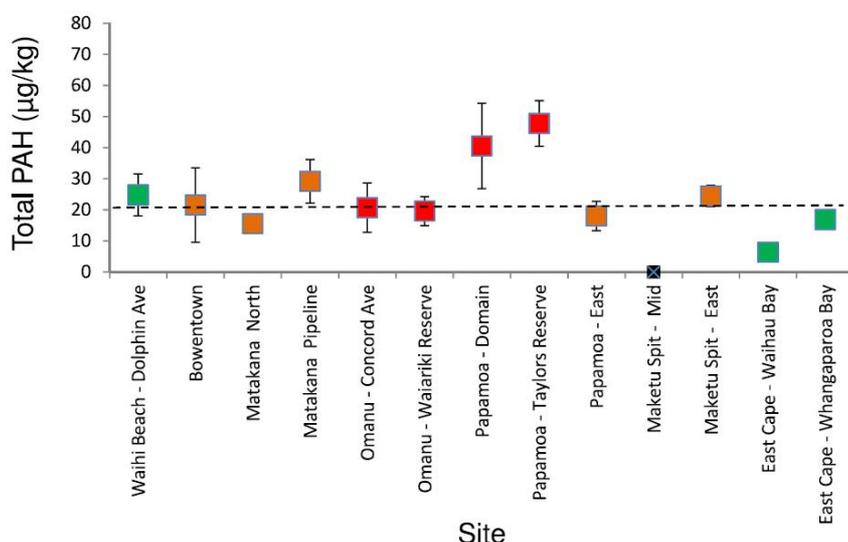
### Questions 53 – 55

There were approximately 1733 tonnes of oil onboard the *Rena* when she ran aground. Approximately 350 tonnes were not recovered from the wreck and most of this washed ashore on Matakana Island and the coastline from Mt Maunganui to Maketu between 9 and 11 October 2011. Surveys examining the effects of the oil and debris washed onto the surf beaches focused on the northern tuatua (*Paphies subtriangulata*), as this is one of the most common species found burrowing in the sand on the open coast surf beaches that were most heavily fouled by oil from the *Rena*, and they are an important kai moana species.

The figure at right shows the level of total PAH in the tissue of tuatua from Papamoa and Omanu beaches from October 5 2011 to 30 June 2012. Before impact total PAH levels (background) were about 0.7µg/kg at Papamoa beach and 0.2 µg/kg at Omanu Beach. These values were produced on a wet weight basis.



	Heavily oiled
	Moderately oiled
	Lightly oiled



The graph at left shows the total PAH levels in tuatua in winter 2012 from beaches from Waihi – East Cape. They are colour-coded to represent the degree of oiling. No winter PAH data was available for Maketū Spit - Mid (shore level). Results obtained from Waihi and Ōhope beaches are considered background levels and an average between these levels (20.6 µg/kg) is plotted as a dashed line. These values were produced on a dry weight basis.

### Question 53

Considering the levels of total PAH over time, which statement is **NOT** correct.

- A. Total PAH levels in the tissue of tuatua from both Papamoa and Ōmanu beaches peaked on the 18<sup>th</sup> October.
- B. Total PAH levels in the tissue of tuatua returned to about pre-impact levels by 30 June 2012.
- C. Total PAH levels in the tissue of tuatua declined rapidly following the initial impact.
- D. Total PAH levels in the tissue of tuatua from Ōmanu beach showed a minor elevation in early December 2011.
- E. Minor elevations in the total PAH levels in the tissue of tuatua from Papamoa and Ōmanu beaches occurred on different dates.

### Question 54

Total PAH levels in tuatua in winter 2012 were elevated above background levels at:

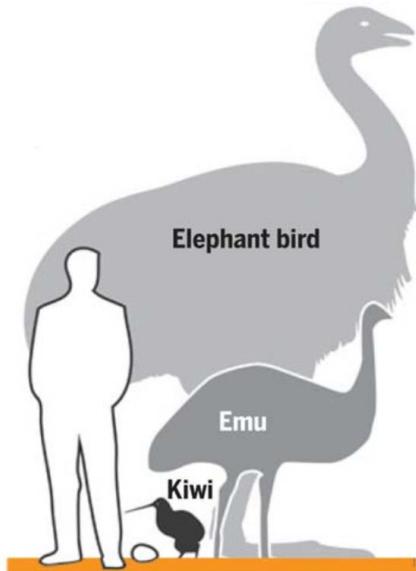
- A. Matakana Pipeline only.
- B. Papamoa Domain and Papamoa Taylors reserve only.
- C. Matakana Pipeline, Papamoa Domain and Papamoa Taylors reserve only.
- D. Matakana Pipeline, Papamoa Domain, Papamoa Taylors reserve and Maketu Spit only.
- E. Papamoa Domain, Papamoa Taylors reserve and Maketu Spit only.

### Question 55

From these results it can be concluded:

- A. Total PAH levels in tuatua are strongly related to the degree of oil fouling.
- B. Tuatua at beaches that were fouled by oil from the Rena show significant ongoing contamination with PAH.
- C. Total PAH levels in tuatua from Ōmanu Beach can be directly compared and show an increase of 103-fold.
- D. Tuatua communities on Bay of Plenty open surf beaches do not appear to be catastrophically affected by the *Rena* oil spill in the long term.
- E. None of the above is a valid conclusion.

## BIRDS OF A FEATHER – EVOLUTIONARY RELATIONSHIPS AMONGST THE RATITES



Our national bird, the kiwi, is a ratite, a group of flightless birds that includes the emu and cassowary in Australia and New Guinea, the ostrich in Africa, and the rhea in South America. There are also two recently extinct groups that include the largest birds ever known: our own moa and the elephant birds from Madagascar who reached heights of up to 3m. Ratites and tinamous (found in South America and weak fliers) belong to an ancestral group of birds called “palaeognaths” and are the sister group (closest relatives) to all other living birds, the “neognaths”.

The evolutionary relationships within the ratites have been the subject of considerable research as these birds are believed to have originated through vicariant speciation driven by the continental breakup of the supercontinent Gondwana. Vicariant speciation is the process by which new species are formed from the separation of the original population into two or more populations by a geographic barrier. Researchers at the Australian Centre for Ancient DNA, and the Allan Wilson Centre for Molecular Ecology in New Zealand have recently published a study in *Science* which examines ancient DNA and clarifies ratite evolution.

The maps at right show the position of continents during the Late Cretaceous and Tertiary. Continental landmasses are coloured according to the order in which they broke away from the remaining Gondwanan landmass: Africa and Madagascar (dark gray) split 100 to 130 Million years ago (Ma), followed by New Zealand (red; 60 to 80 Ma), then finally Australia, Antarctica, and South America (green; 30 to 50 Ma).

Source: Mitchell *et al.* *Science* 344, 898 (2014).

### Question 56

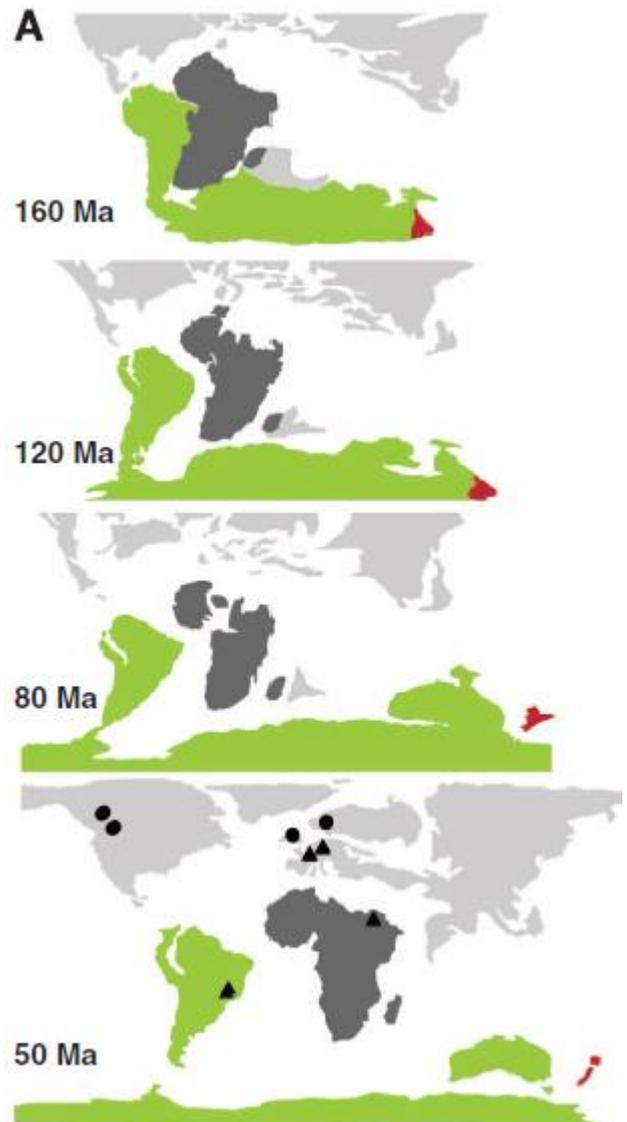
Which relationship amongst the palaeognaths might be expected if they are the result of vicariant speciation only?

- A. Ostrich and elephant birds are sister groups.
- B. The moa and emu are sister groups.
- C. Tinamous are most closely related to the cassowary.
- D. Rhea and cassowary are sister groups.
- E. None of the above are consistent with vicariant speciation.

### Question 57

Scientists discover a “new” fossil palaeognath from Antarctica, dated at 60 Million years old. Under a vicariant speciation model you would expect this fossil to be most closely related to ratites from:

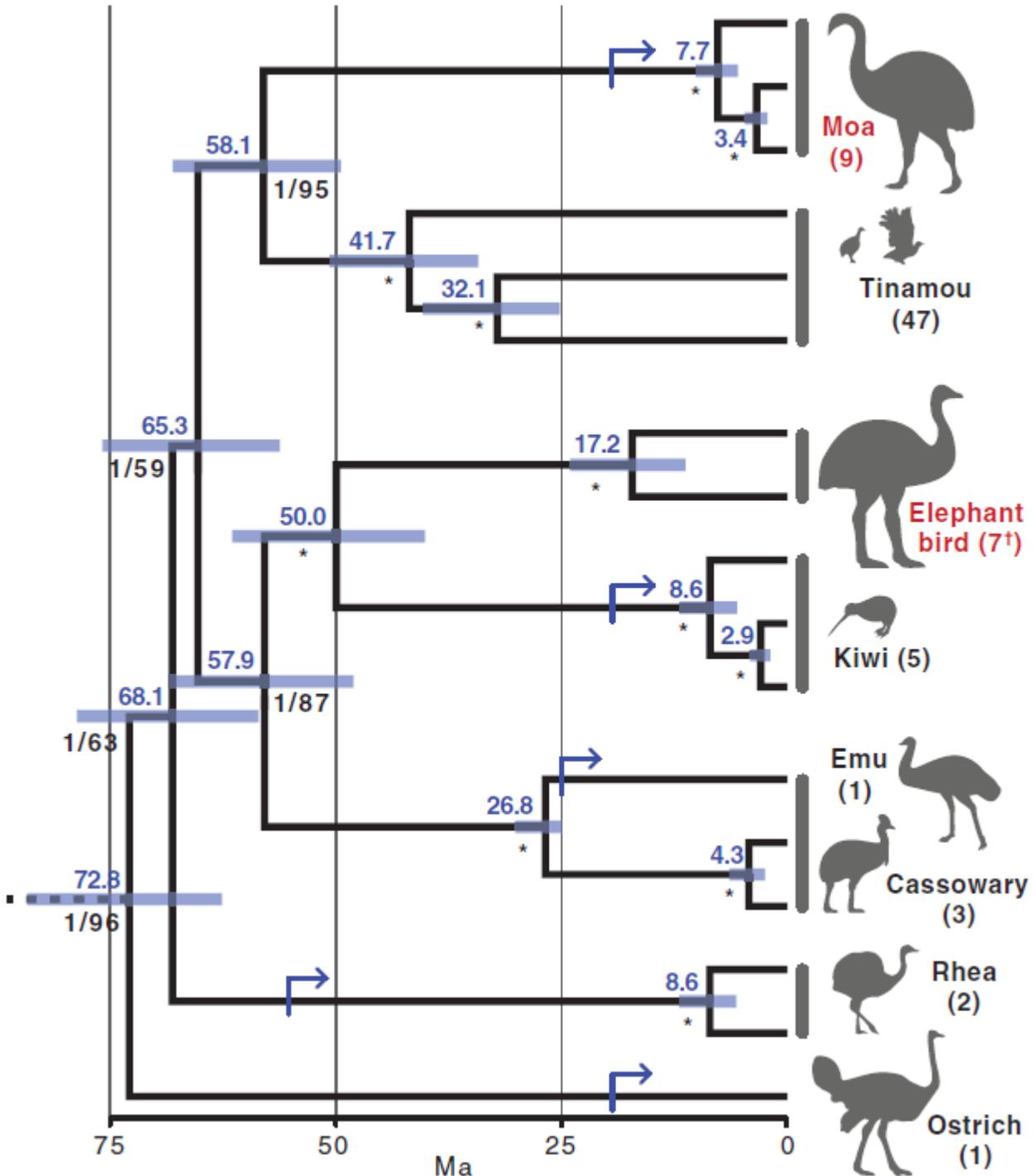
- A. Africa and Madagascar only.
- B. Australia and South America only.
- C. New Zealand only.
- D. Both A and B.
- E. Both A and C.



**Questions 58 - 63**

Evolutionary relationships or phylogeny can be represented by branching lines that end at groups of organisms on diagrams called cladograms. At the point of branching, a common ancestor is believed to have existed. Clades or groupings of organisms, are characterized by synapomorphies, characters present in the last common ancestor.

Mitchell *et al.* sequenced the mitochondrial genomes of two elephant birds and used these to infer relationships within the palaeognaths. These data are presented in the cladogram below. Divergence dates are given in the blue numbers above branches with the blue bars representing the 95% probability around that date. Blue arrows mark the minimum date for the evolution of flightlessness in lineages for which fossil evidence is available. The scale is given in millions of years before the present. Silhouettes indicate the relative size of representative taxa. Species diversity for each major clade is presented in parentheses, with extinct groups shown in red. The dagger symbol (†) indicates that the number of species is uncertain.



Source: Mitchell *et al.* Science 344, 898 (2014).

**Question 58**

At what minimum date is flightlessness thought to have arisen in the emu lineage?

- A. 55Ma
- B. 50Ma
- C. 25Ma
- D. 20Ma
- E. 15Ma

**Question 60**

How many species of elephant birds are known to have existed?

- A. Scientists are uncertain of the number
- B. 2
- C. 3
- D. 4
- E. 5

**Question 62**

This phylogeny suggests the closest relative of the kiwi is?

- A. Moa
- B. Tinamou
- C. Elephant bird
- D. Emu
- E. Rhea

**Question 59**

Assume that once flight is lost it cannot be regained. If both the ancestor of all palaeognaths (at 72.3 Ma) and the ancestor of elephant birds and kiwi (at 50.0 Ma) could fly, what is the minimum number of times flightlessness must have arisen among the palaeognaths?

- A. 3
- B. 4
- C. 5
- D. 6
- E. 7

**Question 61**

Tinamous and the moa last shared a common ancestor?

- A. 68.1Ma
- B. 65.3Ma
- C. 58.1Ma
- D. 41.7Ma
- E. 7.7Ma

**Question 63**

Considering these data what is the best conclusion/s?

- A. Vicariant speciation provides a poor explanation of the close relationship between elephant birds and kiwi.
- B. Madagascar and New Zealand have been directly connected in the geological past.
- C. Kiwi and elephant birds diverged after the breakup of Gondwana.
- D. A and B only.
- E. A and C only.

## SAVING THE MAUI'S DOLPHINS – A STORY OF BIOLOGY, POLICY & CONSERVATION



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[http://www.panda.org/wwf\\_news/?206249/NZ-govt-fails-Mauis-dolphins-on-global-stage](http://www.panda.org/wwf_news/?206249/NZ-govt-fails-Mauis-dolphins-on-global-stage)



<http://www.doc.govt.nz/conservation/native-animals/marine-mammals/dolphins/hectors-dolphin/docs-work/hectors-and-mauis-dolphin-incident-database/>

Maui's dolphin (*Cephalorhynchus hectori maui*) is one of the world's rarest dolphins and is found only on the west coast of the North Island of New Zealand (Resource Pack, Figure 1). It is a sub-species of Hector's dolphin (*Cephalorhynchus hectori*). The Maui's dolphin is protected by the West Coast North Island Marine Mammal Sanctuary (WCNIMMS) which restricts seabed mining activities, acoustic seismic survey work and commercial and recreational set netting. The boundaries of this sanctuary extend alongshore from Maunganui Bluff in Northland to Oakura Beach, Taranaki, in the south and from mean high water springs to the 12 nautical mile (nm) territorial sea limit. The total area of the sanctuary is approximately 1,200,086 hectares covering 2,164 km of coastline. (Resource Pack, Figure 1).

Maui's dolphin is 'critically endangered' (IUCN Red List), with the population dropping from around 1000 individuals in 1970 to 111 in 2004 according to research by Assoc. Prof. Dr Liz Slooten and others from Otago University. Recent research by the Department of Conservation (DOC) suggests there are now even fewer Maui's dolphins remaining. Maui's dolphins are relatively short-lived (approximately 25 years), and are slow breeders. Females do not have their first calf until they are about seven or eight years old, and have a new calf only every two to four years. This means the species may be threatened by even occasional deaths caused by human activity. Fishing, particularly set netting, is the greatest known human threat to Maui's dolphins and thought to be responsible for about 75 per cent of reported deaths with a known cause. Other human threats include marine tourism, vessel traffic, mining, construction, coastal development pollution, sedimentation, oil spills, plastic bags, marine farming and climate change.

In recent weeks the need to develop effective management strategies for this species to prevent its extinction has hit the news. Liz Slooten presented the latest research to the International Whaling Commission in May this year, showing that the current protection measures are not sufficient to avoid the extinction of Maui's dolphin. WWF-New Zealand, Greenpeace, and Forest & Bird and international conservation groups including NABU and WDC in 2012 and 2013 are all campaigning to protect the Maui's dolphin and hundreds of angry protesters marched to the office of the Energy and Resources Minister Simon Bridges' office in Tauranga to protest the government allowing oil exploration within the West Coast North Island Marine Mammal Sanctuary in their annual tender process 'Block Offer 2014' (Resource Pack, Figure 3). This government decision came just two weeks after the International Whaling Committee (IWC) criticised New Zealand for not taking the necessary steps to save the Maui's dolphin. The IWC noted that a 350 km<sup>2</sup> set net restriction had been added to the WCNIMMS but commented that these measures fell significantly short of those required to reverse the Maui's dolphin decline as recommended by the IWC in 2012 and 2013. The IWC reiterated its extreme concern about the continued decline of such a small population "as the human-induced death of even one dolphin would increase the extinction risk for this subspecies". In 2013 it strongly recommended that the NZ government should:

"take immediate management actions that will eliminate bycatch of Maui's dolphins. This includes full closures of any fisheries within the range of Maui's dolphins that are known to pose a risk of bycatch of small cetaceans (i.e. set net and trawl fisheries)". Ensuring full protection of Maui's dolphins in all areas throughout their habitat, together with an ample buffer zone, would minimise the risk of bycatch and maximise the chances of population increase". and "commit to specific population increase targets and timelines".

Because this recommendation was ignored by the NZ government, in 2014, the IWC recommended that the protected area should be extended south to Whanganui, offshore to 20 nautical miles and should include the harbours.

## Questions 64 - 68

The resource pack contains maps of Maui's and Hector's dolphin sightings from 1970 – July 2013, Protection measures for Maui's dolphins on the West Coast North Island and the 'Block Offer 2014' for the Offshore Release Area: Taranaki Basin 14TAR-R1. It also has a table of all Maui's dolphin sightings from Pariokariwa Point to New Plymouth and New Plymouth South to Cape Terawhiti. Much of this area is included in the Block Offer 2014' Taranaki Basin 14TAR-R1 area. This table is modified from the Maui's dolphin sightings database:

<http://www.doc.govt.nz/conservation/native-animals/marine-mammals/dolphins/mauis-dolphin/docs-work/mauis-dolphin-sightings/>

Conservation Minister Nick Smith was questioned in parliament about the decision to open part of the sanctuary for exploration. "The block offer is nowhere near where the Maui's live," Dr Smith said. "There hasn't been a single observation of a Maui's dolphin, and the oil and gas industry hasn't been involved in a single Maui's dolphin incident in Taranaki over the past 40 years despite 23 wells being drilled" (Source: <http://www.3news.co.nz/Greenpeace-get-23000-signatures-in-petition-to-sack-Bridges/tabid/423/articleID/349373/Default.aspx>).

### Question 64

Considering the recorded sightings of Maui's dolphins since 1970 (Resource Pack, Figure 1). What valid conclusion could Dr Smith have drawn?

- A. The block offer is nowhere near where the Maui's live.
- B. There has not been a single observation of a Maui's dolphin in the block offer area.
- C. The block offer covers some of the most important areas where Maui's dolphins live.
- D. The block offer overlaps with the southern end of the Maui's dolphin range.
- E. The block offer covers most of the area where the Maui's dolphins live.

### Question 66

Considering the data in Table 1 in the Resource Pack, how many Maui's dolphins have been sighted from Pariokariwa Point to New Plymouth and New Plymouth South to Cape Terawhiti

- A. 78
- B. 89
- C. 92
- D. 95
- E. This cannot be determined.

### Question 68

Determining the distribution and population size of Maui's dolphins from sightings has a number of problems. These include:

- A. The sampling effort is unequal so the lack of presence of a species could relate to a real absence or simply to a lack of sampling effort.
- B. Low or zero sampling effort could easily miss the presence of a low-density species such as Maui's dolphin.
- C. Misidentification of species, or misreporting of locations, can confound such studies.
- D. Environmental factors such as rough seas can decrease sampling effort and result in dolphins being 'missed'.
- E. All of the problems above (A-D) are inherent in using sighting data to determine the distribution and population size of Maui's dolphins.

### Question 65

Estimate the area of overlap between the West Coast North Island Marine Mammal Sanctuary and the 'Block Offer 2014' Taranaki Basin 14TAR-R1 using the information contained in Figures 2 and 3 in the resource Pack.

- A. 3000 km<sup>2</sup>
- B. 3000 nm<sup>2</sup>
- C. 1000 km<sup>2</sup>
- D. 1000 nm<sup>2</sup>
- E. 500 km<sup>2</sup>

### Question 67

What evidence suggests that Maui's dolphins do interact with the current oil and gas industry and may do so at increased levels if exploration occurs within the West Coast North Island Marine Mammal Sanctuary

- A. There have been four sightings of Maui's dolphins from oil platforms in Taranaki.
- B. Maui's dolphins have been sighted in Port Taranaki.
- C. Commercial fisherman have reported sightings of Maui's dolphins.
- D. Both A and B provide evidence.
- E. A, B and C provide evidence.

## Questions 69 - 75

Conservation of the critically endangered Maui's dolphin requires a good understanding of the trends in abundance and effective population sizes so that conservation actions can be planned and evaluated. DOC (2012) reported on the genetic monitoring of the Maui's dolphin using DNA profiles to estimate the current abundance and effective population size, as well as to document movements of individuals. The study collected 37 dart-biopsy samples in summer 2010 and a further 36 in summer 2011. DNA profiles were completed for each sample and the sex was identified. These profiles were used to identify individual Maui's dolphins and Hector's dolphin migrants, to describe individual movements, and to estimate the abundance, population trend and effective population size of Maui's dolphins for 2010–11, including comparison with data from a previous set of samples collected in 2001–07.

Based on the microsatellite genotyping, 26 individuals were identified from the 37 samples collected in 2010 (16 females, 10 males) and 27 individuals from 36 samples collected in 2011 (16 females, 11 males). Twelve individuals were sampled in both 2010 and 2011, and with the addition of one unique male washed up on a beach in 2010, this provided a minimum census of 42 individuals (25 females, 17 males) alive at some point during the two years of the survey. Of this total, two females were identified as West Coast South Island Hector's dolphin (*C. h. hectori*) migrants based on distinct mtDNA haplotypes and genotype-based population assignment procedures.

Population size can be estimated by the Lincoln-Petersen estimator:

$$N = [(n_1+1)(n_2+1)/(m_2+1)] - 1$$

Where  $N$  = abundance

$n_1$  = number of individuals sampled in occasion 1

$n_2$  = number of individuals sampled in occasion 2

$m_2$  = number of individuals sampled in both occasions 1 and 2

Individual movements of Maui's dolphins and a Hector's dolphin migrant (^) that were sampled more than once during 2010–11 are given in Table 2 in the Resource Pack.

An Expert Panel of New Zealand and international scientists, convened by the New Zealand government in 2012, estimated that five Maui's dolphins were killed in fishing gear each year – one in trawl fisheries and four in gillnet fisheries. The number of gillnet mortalities per year is estimated to have decreased from four to at best two per year as a result of the 350 sq. km set net restriction extension in the WCNIMMS. The Ministry of Primary Industries (MPI) and the Department of Conservation (DOC) reviewed the Maui's dolphin portion of the Threat Management Plan (TMP) in 2013. During the TMP review process it was highlighted that non-fishing-related threats such as seismic surveying, oil and gas exploration, vessel strikes, and disease also pose a serious risk to the long-term viability of Maui's dolphins. These threats represented 4.5% of the estimated dolphin mortalities. The importance of both the fishing and non-fishing risks needs to be assessed relative to the Potential Biological Removal (PBR) level which is defined as the number of human-caused deaths the stock can withstand annually. The PBR for Maui's dolphins is one dolphin in 10 – 23 years or 0.044 – 0.1 per year.

For Maui's dolphin the impact of seismic surveying was combined within all mining and oil activities. This was estimated to contribute to the equivalent of 0.10 deaths per year (95% confidence interval 0.01-0.46), with a 61.3% likelihood of exceeding the PBR. In terms of seismic surveying, the greatest concern is noise in the marine environment. Noise leading to trauma was scored at 0.01 deaths per year (95% CI: <0.01-0.13) and a likelihood of exceeding the PBR of 8.8%, while non-trauma noise effects was scored at 0.03 deaths per year (95% CI: <0.01-0.23) and a likelihood of exceeding the PBR of 28.6%.

(<http://www.fish.govt.nz/en-nz/Environmental/Hectors+Dolphins/default.htm>)

The Minister of Conservation has proposed the following measures:

- Making the Code of Conduct for Minimising Acoustic Disturbance to Marine Mammals from Seismic Survey Operations a mandatory standard by reference under section 28 of the Marine Mammal Protection Act.
- Developing a voluntary code of conduct with the inshore boat racing community to minimise the potential for vessel strike, and
- Ensuring that disease investigations are a priority in the Maui's dolphin Research Advisory Group.

There has been no recommendation to prevent set net and trawl fishing throughout the range of Maui's dolphins as to do so would need to extend fishing restrictions as far south as Whanganui, out to the 100 m depth contour, and include all harbours.

### Question 69

Use the Lincoln-Petersen estimator to calculate the population size of the Maui's dolphin.

- A. 57
- B. 55
- C. 61
- D. 104
- E. 107

### Question 71

The maximum distance known to have been travelled by a Maui's dolphin within a single year is?

- A. 17.88 km
- B. 26.44 km
- C. 46.30 km
- D. 78.62 km
- E. 80.43 km

### Question 73

The greatest risk for the survival of Maui's dolphin remains?

- A. Trawl fishing
- B. Set netting
- C. Seismic surveying
- D. Mining and oil activities
- E. Noise leading to trauma

### Question 75

Considering all the scientific evidence you have available about the Maui's dolphin, what would you recommend that the government does to protect this critically endangered dolphin?

- A. The extension to the set netting restricted areas together with the new codes of conduct for acoustic surveying and boat racing is sufficient.
- B. Ban set netting and mining and oil activities within the West Coast North Island Marine Mammal Sanctuary.
- C. Ban set netting throughout the range of Maui's dolphins including south to Whanganui, out to the 100m depth contour and within all harbours.
- D. Prevent all mining and oil activities within the West Coast North Island Marine Mammal Sanctuary.
- E. Ban trawl fishing, set netting, and mining and oil activities throughout the range of Maui's dolphins including south to Whanganui, out to the 100m depth contour and within all harbours.

### Question 70

What proportion of the Maui's dolphin population sampled in 2010 and 2011 is female?

- A. 45.5%
- B. 41.8%
- C. 59.5%
- D. 54.7%
- E. Unable to be determined.

### Question 72

The major identified risks to Maui's dolphins are:

1. Trawl fishing
2. Set netting
3. Seismic surveying
4. Mining and oil activities
5. Noise leading to trauma
6. Non-trauma noise effects

Which of these risks are estimated to be above the PBR and could result in gradual extinction of the Maui's dolphins if the current rates are allowed to continue.

- A. 1, 2, 3, 4, 5 and 6
- B. 2, 3, 4, 5 and 6 only.
- C. 1, 2 and 4 only.
- D. 1, 2, 4 and 6 only.
- E. 2, 4 and 6 only.

### Question 74

Trawl fisheries contributes 1 death per year. This exceeds the estimate PBR by:

- A. Between 10 – 22.72 times.
- B. 10 times.
- C. 22.72 times.
- D. 0.1 times.
- E. 0.04 times.

We all have an obligation to learn about our planet and to protect it from harm. NZIBO hopes you have enjoyed this exam and have learnt a little about the biological scientists working to understand and protect our wonderful planet here in New Zealand. We wish you well with your biology studies this year, regardless of whether you are selected for the tutorial programme. Thank you for taking the time to sit this exam.



# NZ INTERNATIONAL BIOLOGY OLYMPIAD

2014 – 15 National Entrance Exam

## ANSWER KEY

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## NATIONAL ENTRANCE EXAMINATION – August 2014

### Resource Pack

**Figure 1:** Maui's and Hector's dolphin sightings from 1970 – July 2013.

**Figure 2:** Protection measures for Maui's dolphins on the West Coast of the North Island.

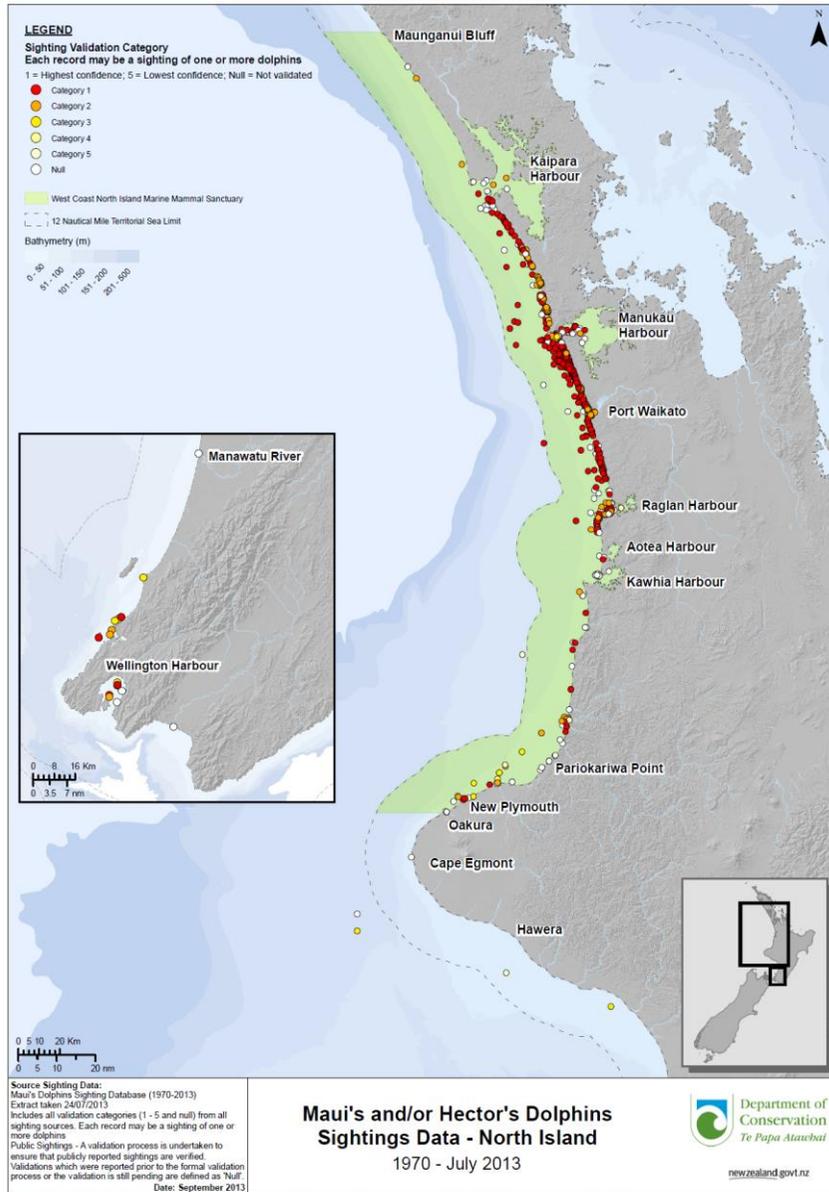
**Figure 3:** Map of the 'Block Offer 2014' for the Offshore Release Area: Taranaki Basin 14TAR-R1.

**Table 1:** Maui's dolphin sightings from Pariokariwa Point to New Plymouth and New Plymouth South to Cape Terawhiti.

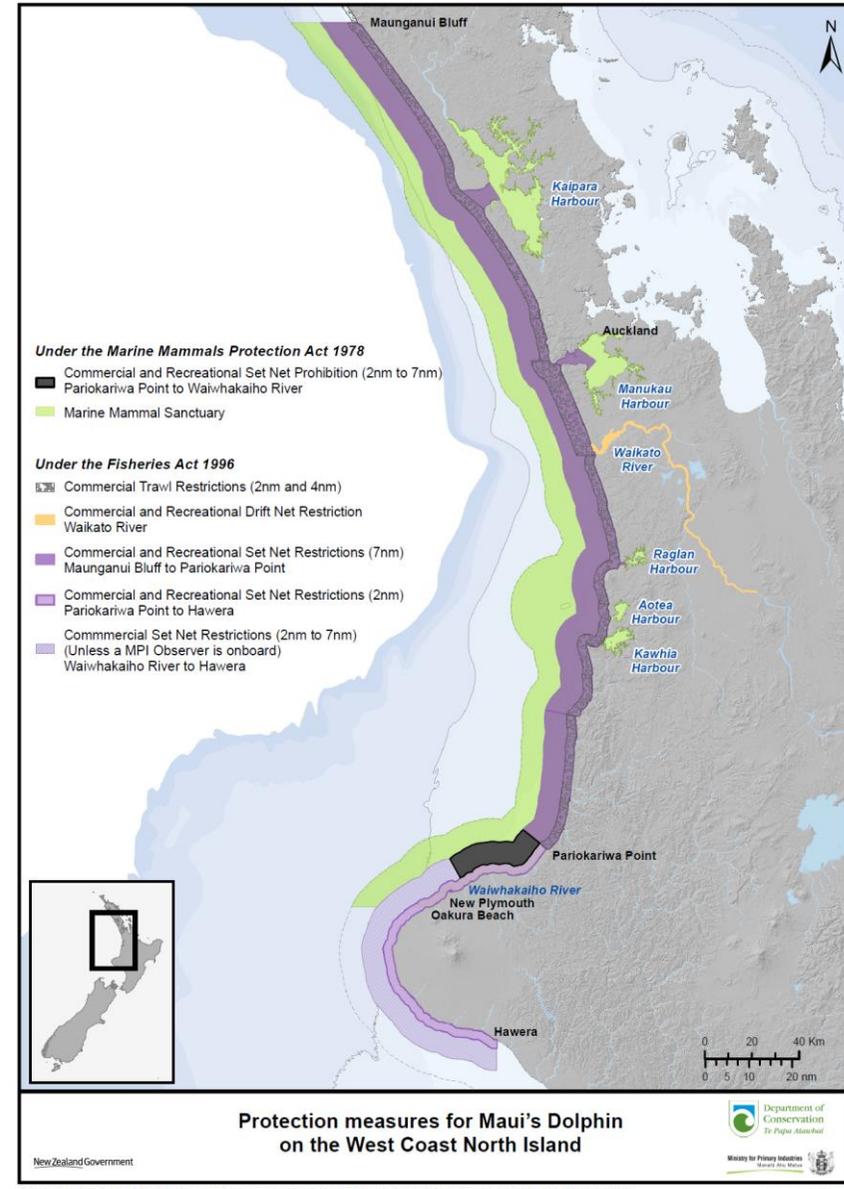
**Table 2:** Individual movements of Maui's dolphins and a Hector's dolphin migrant (^) that were sampled more than once during 2010–11, as identified by genotype recapture.



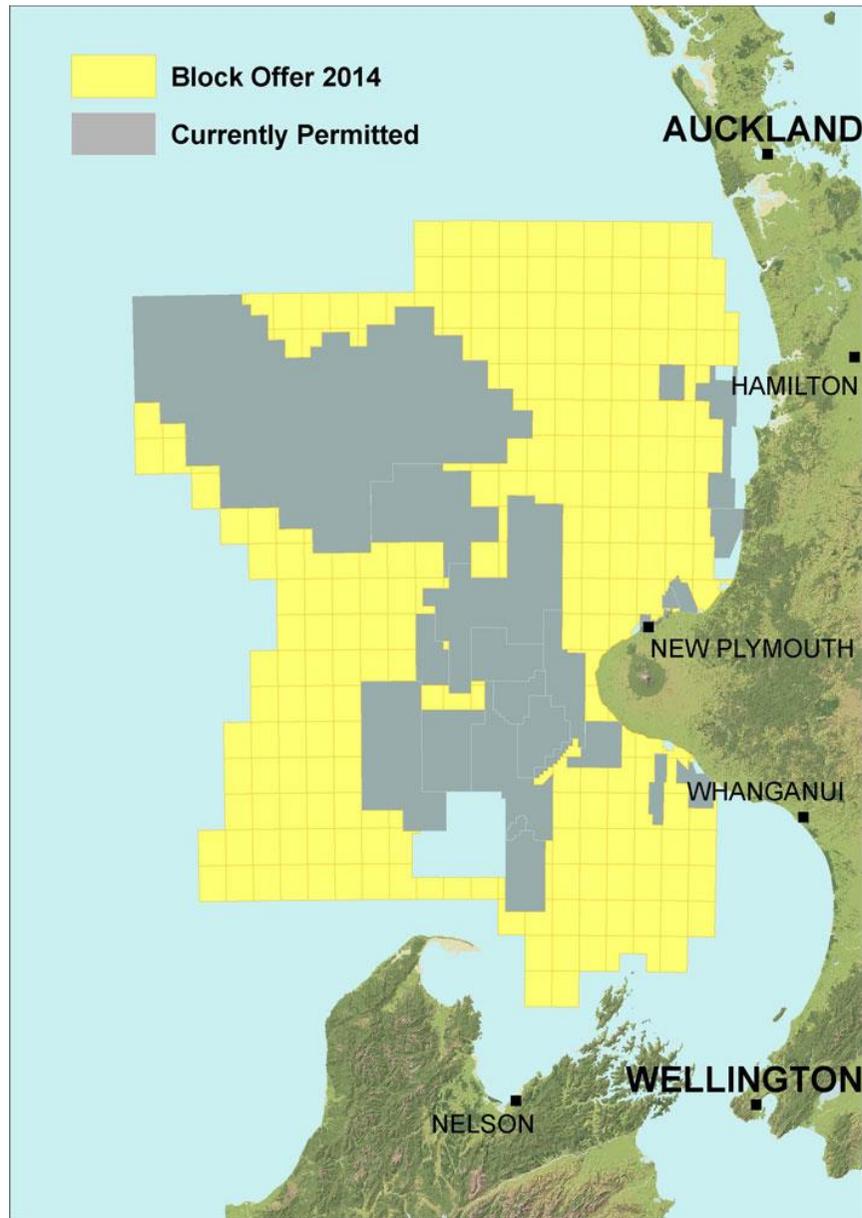
**Figure 1:** Maui's and Hector's dolphin sightings from 1970 – July 2013.



**Figure 2:** Protection measures for Maui's dolphins on the West Coast of the North Island.



**Figure 3:** Map of 'Block Offer 2014' for the Offshore Release Area: Taranaki Basin 14TAR-R1. Total area 54,920.92 km<sup>2</sup>. This is one of the areas of petroleum exploration permits released for annual tender by the New Zealand Government in 2014. This area is off the west coast of the North Island, stretching from the coast of Auckland to the northern tip of the South Island. Two permits were awarded in the offshore Taranaki Basin in 'Block Offer 2013'.



**Table 1:** Maui's dolphin sightings from Pariokariwa Point to New Plymouth and New Plymouth South to Cape Terawhiti. This area is included in 'Block Offer 2014' Taranaki Basin 14TAR-R1 area.

Platform	Date event observed	Latitude (DwC)	Longitude (DwC)	Location (DwC)	Description	Number adults	Number juveniles
Platform not specified	17/04/1970	-39.05156	174.06917	New Plymouth		3	0
Platform not specified	30/04/1974	-38.92729	174.46316	Waititi Beech		2	0
Platform not specified	01/09/1976	-38.98918	174.22061	Off Waitara, Taranaki		1	0
Platform not specified	01/02/2001	-39.11013	173.94153	Oakura beach		1	0
Commercial fishing vessel	16/01/2004	-39.0465	174.01125	Off Saddleback Island Port Taranaki	Four sighted by commercial fisherman.	4	0
Commercial fishing vessel	16/01/2004	-39.04472	174.00634	Sugarloaf Islands NP	Commercial fisherman.	4	0
Land	18/01/2004	-38.9795	174.30855	Off Turangi Road.	One sighted swimming around cray pots near shore 10m of water.	1	0
Private vessel	20/01/2004	-38.9799	174.30837	Off Turangi Road.		3	0
Commercial fishing vessel	21/01/2004	-38.9889	174.22825	Off Waitara, Taranaki		3	0
Other vessel	22/01/2004	-39.11405	173.9466	Oakura beach	Sightings by two different groups of surfers.	2	0
Other vessel	22/01/2004	-39.1137	173.947	Oakura beach	Two sighted. Sightings by two different groups of surfers.	1	0
Private vessel	19/05/2005	-38.91598	174.47128	Waititi Beach	Flat sea, dolphins swimming around boat.	10	0
Offshore oil platform	31/08/2006	-38.91245	174.27074	Pohokura Drilling Rig, Urenui.	Four sighted with bottlenose dolphin. Observer was radio operator and one of his job was unofficial marine mammal observer.	4	0
Platform not specified	01/01/2007	-39.05692	174.03757	New Plymouth harbour	Mother and calf sighted	1	1
Private vessel	01/02/2007	-39.054983	174.04206	Port Taranaki, New Plymouth		1	0
Platform not specified	01/02/2007	-39.05498	174.03564	Port Taranaki, New Plymouth		1	0
Private vessel	16/02/2007	-39.06	174.04	Port Taranaki, New Plymouth	Seen by Skipper and crew in Port Taranaki. Photographed on phone.	1	0
Offshore oil platform	28/04/2008	-38.907467	174.26903	Pohokura Platform Bravo		7	0
Private vessel	18/02/2009	-38.96925	174.22568	Airedale reef, Waitara	1km offshore	2	0
Private vessel	02/12/2009	-39.0443	174.0946	Fitzroy Beach, Taranaki		2	0
Private vessel	10/12/2009	-39.0549	174.0483	Port Taranaki, New Plymouth	Dolphin followed a boat into the harbour at New Plymouth.	1	0
Private vessel	10/12/2009	-38.9934	174.1833	Off Waitara, Taranaki	Positive ID. We have a bit of a checklist for things we go through to confirm sightings.	1	0
Private vessel	30/01/2010	-39.0666	173.9834	Just outside marine reserve	Travelling, came up to our boat and rode the bow wave for a short distance.	5	0
Private vessel	06/02/2010	-38.9835	174.2264	North of Waitara River mouth	Definitely saw one, maybe a 2nd but couldn't be sure.	1	1
Private vessel	14/03/2011	-38.85	174.36	Off Mimi Urenui Bay	Definitely had the rounded dorsal, cruising on the surface solo.	1	0
Private vessel	02/10/2011	-38.43135	174.35396	Mohakatino	Jumped twice 10m from boat. Not a common dolphin but not enough conclusive evidence to say that it was a Maui's dolphin	1	0
Private vessel	18/02/2012	-39.938	174.88395	Between Kai Iwi beach and Whanganui Bar	Dolphin jumped out of water 10m from boat so clear look. 3 other dolphins within 20-30m of boat, one was clearly smaller than the others	3	1
Private vessel	24/03/2012	-39.801283	174.29118	Off Patea, South Taranaki	Boat anchored, fishing. Dolphins swam around boat.	4	0
Private vessel	01/04/2012	-38.941	174.2347	Off Waitara, Taranaki	Dolphins were porpoising, heading to shore seen 20m from boat. Been going out of Waitara for 70y, never seen this type before.	8	0
Offshore oil platform	19/04/2012	-39.626667	173.45087	Maui A Offshore Oil Platform	Crane boom was out over water. Every now and then the swell/wave would pass over hook and Maui's dolphin was sighted in wave.	1	0
Private vessel	24/07/2012	-38.767693	174.46699	Mokau		1	0
Private vessel	11/01/2013	-38.987983	174.09532	Off Bell Block	Saw the dolphins briefly alongside then they disappeared.	4	0
Offshore oil platform	23/11/2013	-40.0333	173.2439	Mania 2 well site, drilling vessel called Kan Tan IV	Roundish stubby dorsal fin. Had a really good look from above, never seen one like it before. Travelling west.	1	0
Non-motorised coastal activity	17/12/2013	-39.046786	174.04185	Port Taranaki, New Plymouth	Rounded and unmistakable dorsal fin. Heading out to sea, travelling. Rolled over twice.	1	0
Private vessel	18/01/2014	-39.048019	174.04168	Port Taranaki, New Plymouth	Swam in front of the boat. I stopped the boat then it turned back, so I got a really good look at it.	1	0
Non-motorised coastal activity	18/01/2014	-39.046219	174.03232	Northwest of Moturoa Island	Black and rounded fin. Came from behind observer. Heading north. It swam past the side he was fishing.	1	0

Modified from the Maui's dolphin sightings database:  
<http://www.doc.govt.nz/conservation/native-animals/marine-mammals/dolphins/mauis-dolphin/docs-work/mauis-dolphin-sightings/>

**Table 2:** Individual movements of Maui's dolphins and a Hector's dolphin migrant (^) that were sampled more than once during 2010–11, as identified by genotype recapture. Samples from the same individual are grouped in blocks with the ID code in bold (an individual's first sample code is used as its ID code). Distances observed between recapture locations ('Distance (km)') within and across years were measured as straight-line distances using the distance calculator (<http://jan.ucc.nau.edu/~cvm/latlongdist.html>).

\* = Sample pair used for calculating the maximum straight-line distance between recaptures.

SAMPLE CODE	DATE	LOCATION	LATITUDE (°S)	LONGITUDE (°E)	SEX	WITHIN 2010		WITHIN 2011		MAXIMUM ACROSS 2010–11	
						DISTANCE (km)	TIME SPAN	DISTANCE (km)	TIME SPAN	DISTANCE (km)	TIME SPAN
<b>NI56</b>											
NI10-14	7-Feb-10	S. Manukau	37.228167	174.615667	F	17.88	9 days			18.59	367 days
NI10-31*	16-Feb-10	N. Raglan	37.376717	174.692650							
NI11-12*	18-Feb-11	N. Raglan	37.223450	174.609350							
<b>NI10-04</b>	5-Feb-10	S. Manukau	37.162028	174.575389	F	0.91	2 days			n/a	n/a
NI10-12	7-Feb-10	S. Manukau	37.165217	174.584783							
<b>NI10-05</b>	6-Feb-10	S. Manukau	37.194750	174.592861	F	0.65	1 hr	0.34	2 min	8.10	373 days
NI10-07	6-Feb-10	S. Manukau	37.197861	174.596500							
NI10-08*	6-Feb-10	S. Manukau	37.198833	174.598167							
NI11-03	14-Feb-11	S. Manukau	37.133183	174.568550							
NI11-04*	14-Feb-11	S. Manukau	37.130717	174.566233							
<b>NI10-06*</b>	6-Feb-10	S. Manukau	37.196056	174.592778	M					3.12	377 days
NI11-13	18-Feb-11	N. Raglan	37.220900	174.609050							
<b>NI10-11</b>	7-Feb-10	S. Manukau	37.163567	174.583667	F					4.20	372 days
NI11-05	14-Feb-11	S. Manukau	37.129067	174.564583							
<b>NI10-13</b>	7-Feb-10	S. Manukau	37.181250	174.592333	F					0.88	372 days
NI11-02	14-Feb-11	S. Manukau	37.176150	174.584817							
<b>NI10-16</b>	7-Feb-10	S. Manukau	37.207550	174.604450	M					5.29	373 days
NI11-07	15-Feb-11	S. Manukau	37.163867	174.581033							
<b>NI10-17</b>	8-Feb-10	N. Manukau	36.757267	174.376350	F	1.27	42 min			46.30	372 days
NI10-18	8-Feb-10	N. Manukau	36.757267	174.376350							
NI10-19*	8-Feb-10	N. Manukau	36.755367	174.362417							
NI11-06*	15-Feb-11	S. Manukau	37.138217	174.565733							
<b>NI10-20</b>	8-Feb-10	N. Manukau	36.737783	174.362467	M	11.07	1 day			11.07	1 day
NI10-22	9-Feb-10	N. Manukau	36.651500	174.300833							
<b>NI10-21</b>	9-Feb-10	N. Manukau	36.652667	174.301667	F	11.33	2.5 hr	78.62	19 days	80.43	375 days
NI10-23*	9-Feb-10	N. Manukau	36.568167	174.231000							
NI11-18*	19-Feb-11	S. Manukau	37.222083	174.615183							
NI11-36	10-Mar-11	N. Manukau	36.583767	174.237067							
<b>NI10-24^</b>	11-Feb-10	S. Manukau	37.360233	174.685983	F	14.03	13 days	7.44	3 days	37.67	356 days
NI10-37^*	24-Feb-10	Raglan	37.483067	174.721283							
NI11-08^*	15-Feb-11	S. Manukau	37.163950	174.579717							
NI11-11^	18-Feb-11	N. Raglan	37.225767	174.611600							
<b>NI10-26</b>	11-Feb-10	S. Manukau	37.362500	174.683667	F	26.44	5 days			26.44	5 days
NI10-29	16-Feb-10	N. Raglan	37.592000	174.759500							
<b>NI10-27*</b>	11-Feb-10	S. Manukau	37.362500	174.687500	M	18.81	5 days			18.81	5 days
NI10-34*	16-Feb-10	N. Raglan	37.526100	174.740917							
NI11-31	9-Mar-11	N. Raglan	37.440833	174.696833							
<b>NI10-28*</b>	16-Feb-10	N. Raglan	37.591833	174.759000	M			3.17	9 days	18.57	9 days
NI11-29*	28-Feb-11	N. Raglan	37.432533	174.696717							
NI11-35	9-Mar-11	N. Raglan	37.459467	174.708267							



## NATIONAL ENTRANCE EXAMINATION – August 2012

**Examination Date:** Wednesday 8 August 2012

**Total Time allowed:** 2 hours.

This examination consists of 75 questions. Students are advised to allocate equal time to each question (1 ½ minutes per question with 7.5 minutes for checking of answers). Marks will not be deducted for incorrect answers.

**Equipment:** pen, pencil, eraser, ruler, and calculator.

**Please immediately return the completed answer sheets (retain a copy) to:**

Dr Heather Meikle  
Secretary, NZIBO333  
c/PNGHS  
Fitzherbert Avenue  
PALMERSTON NORTH 4410



MINISTRY OF  
RESEARCH  
SCIENCE+  
TECHNOLOGY  
MORST  
TE HĀKAITI PŌHĀKAU

PEARSON



the ROYAL  
SOCIETY of  
NEW ZEALAND



THE UNIVERSITY  
OF AUCKLAND  
FACULTY OF SCIENCE



MASSEY UNIVERSITY  
TE KUNENGA KI PŪREHUROA

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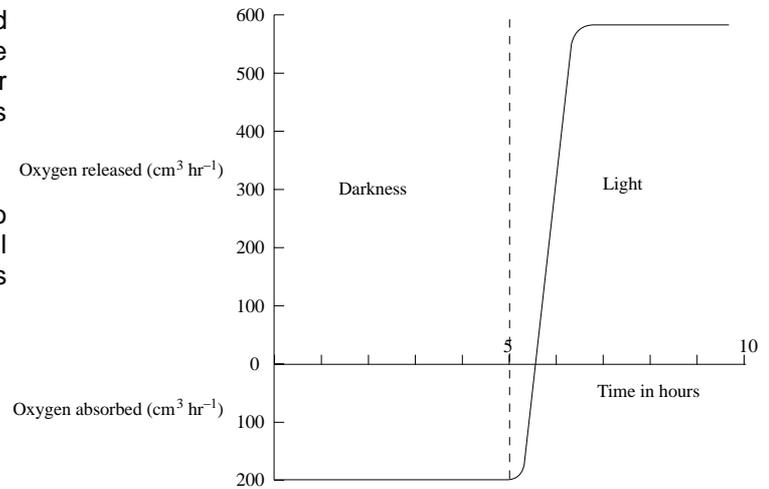
## Section A

### Question 1

An experiment on gas exchange in a water plant, collected data about the rate of oxygen uptake and release. The plant was in darkness for 5 hours and then illuminated for 5 hours, while the temperature was constant. The results are shown in the graph.

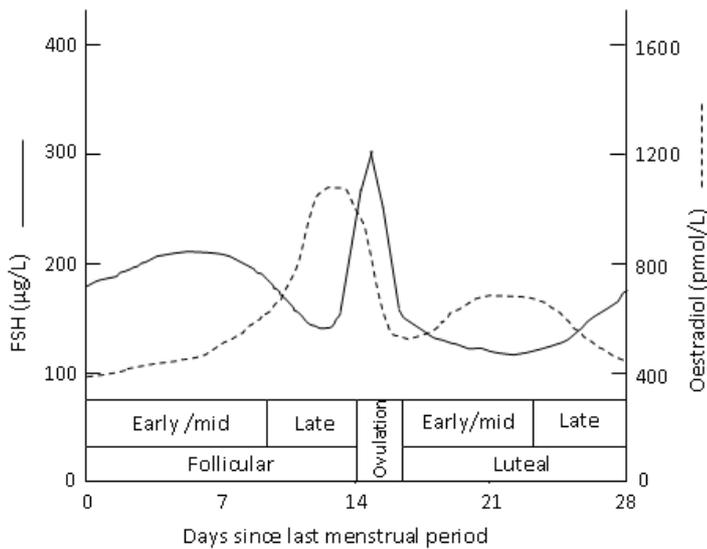
If it is assumed that changes in light intensity have no effect on the rate of respiration, the best estimate of total oxygen produced by photosynthesis in the last two hours of the experiment is:

- A.  $600 \text{ cm}^3$
- B.  $800 \text{ cm}^3$
- C.  $1200 \text{ cm}^3$
- D.  $1600 \text{ cm}^3$
- E.  $1800 \text{ cm}^3$



### Question 2

This is a graph of the menstrual cycle showing the hormones FSH and oestradiol. The labels at the bottom refer to the phase of the cycle.



Which of the following sections of the graph shows a region during early/mid luteal phase?

- A.
- B.
- C.
- D.
- E.

### Question 3

A suspension of microscopic green algae was divided into two equal samples. Each was given the same total amount of light energy. Sample I was exposed to continuous light. Sample II was exposed to light flashes of  $10^{-5}$  seconds duration followed by dark periods. Photosynthesis took place in both samples, but more occurred in Sample II. From *this evidence* we may conclude that

- A. More photosynthesis occurs in the dark than in the light.
- B. Some part of the photosynthetic process can occur in darkness.
- C. Photosynthesis requires darkness as well as light.
- D. Photosynthesis is a very rapid process.
- E. Photosynthesis involves enzymes as well as light.

### Question 4

The following table shows various inhalational anaesthetic agents with comparison between pungency, potency, onset and blood-gas solubility. Potency is measured by minimal alveolar concentration (MAC), which is the concentration of vapour required to produce immobility on surgical stimulus in 50% of patients. A high MAC indicates a low potency. Onset is the time it takes for the effects of a drug to be observed after administration.

Anaesthetic Agent	Pungency	Potency (MAC)	Onset	Blood-gas Solubility
Nitrous oxide	Non-pungent	101%	Rapid	Low
Halothane	Non-pungent	0.86%	Slow	Intermediate
Isoflurane	Pungent	1.1%	Medium	Intermediate
Sevoflurane	Non-pungent	1.7%	Rapid	Low
Desflurane	Pungent	6.0%	Rapid	Low

Which of the following statements is true?

- A. Nitrous oxide has a high potency and rapid onset.
- B. Sevoflurane and Desflurane are both pungent agents with rapid onsets.
- C. Halothane has a high potency and low blood-gas solubility.
- D. Halothane and Isoflurane are both highly potent with intermediate blood-gas solubility.
- E. Desflurane has a very low potency and rapid onset.

### Question 5

The following question relates to organisms from the planet Orti.

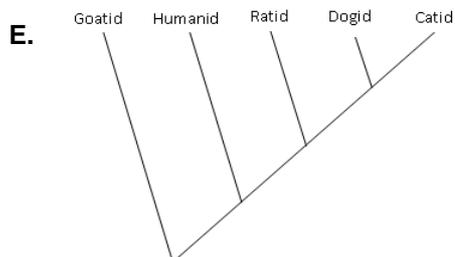
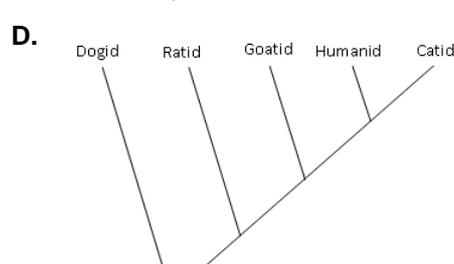
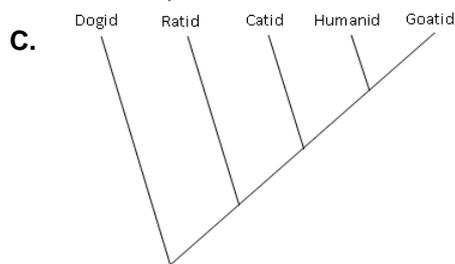
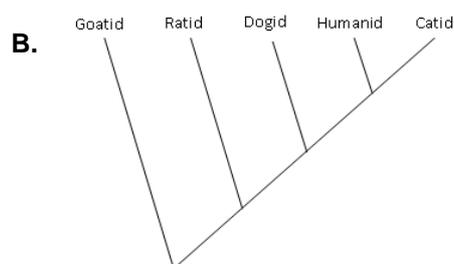
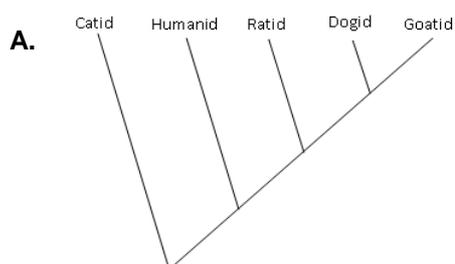
Dogids, ratids, catids and humanids have red spots.

Catids and humanids both have blue skin.

Ratids and goatids have yellow ears.

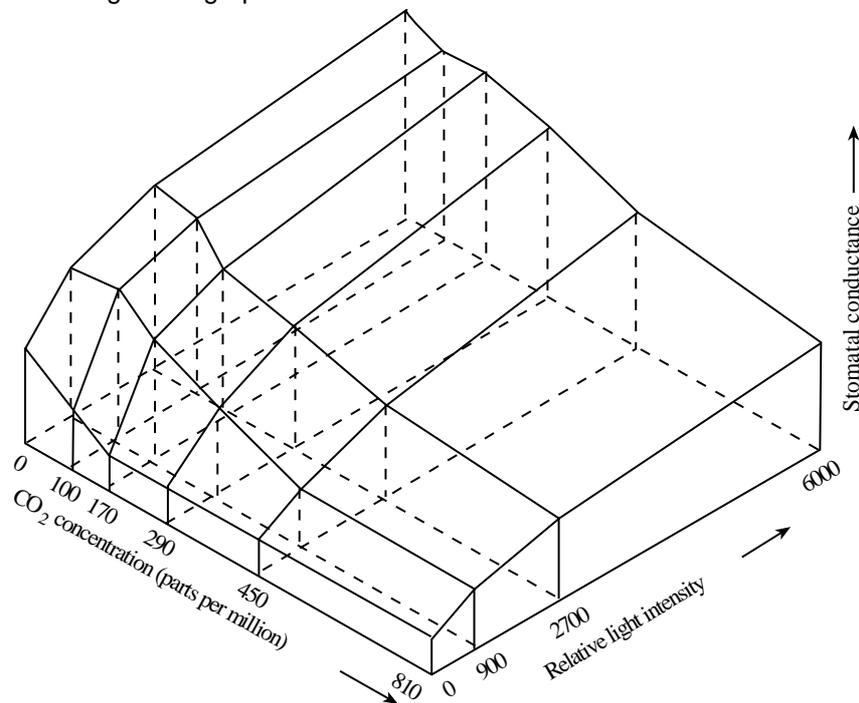
Humanids, dogids and catids have green ears.

Which of the following groups represents a possible evolution of the above characteristics, provided that each characteristic only evolved once?



### Question 6

Measurements of the rate of diffusion through stomata ('stomatal conductance') were made under various CO<sub>2</sub> concentrations, and the following stereograph was drawn.



Which one of the following is a valid deduction from the stereograph?

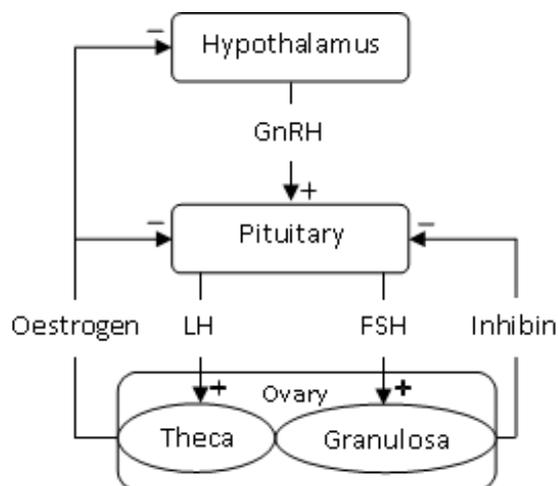
- A. Stomatal conductance is maximal when conditions for photosynthesis are optimal.
- B. Increasing light intensity increases stomatal conductance at all CO<sub>2</sub> levels shown.
- C. Stomatal conductance is unaffected by an increase in CO<sub>2</sub> concentration from 170 to 810 p.p.m.
- D. Changes in CO<sub>2</sub> concentration have a greater influence on stomatal conductance than changes in light intensity.
- E. Changes in light intensity have a greater influence on stomatal conductance than changes in CO<sub>2</sub> concentration.

### Question 7

This diagram shows the female hypothalamic-pituitary-gonadal axis. Hormones are secreted from each of the organs. A "+" indicates a stimulation of secretion from the organ and a "-" indicates a decrease in secretion.

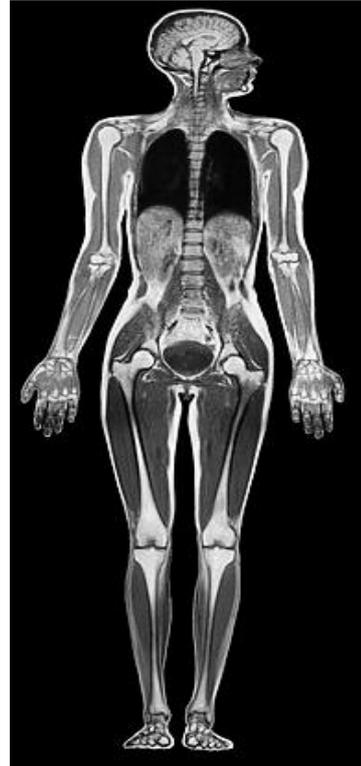
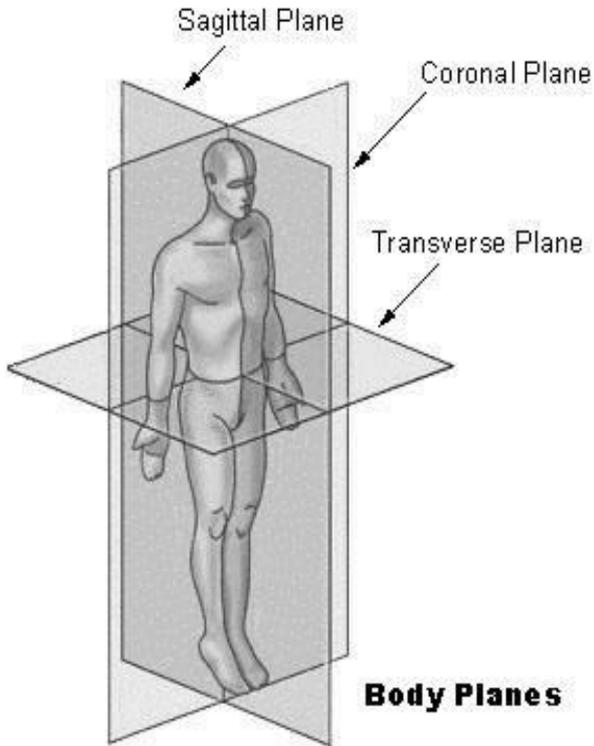
According to the diagram, a decrease in GnRH will cause:

- A. A decrease in oestrogen secretion.
- B. An increase in inhibin secretion.
- C. A decrease in GnRH secretion.
- D. An increase in FSH secretion.
- E. An increase in LH secretion



### Question 8

The diagram on the left illustrates the different body planes anatomists and radiologists use when talking about structures within the human body.



Which plane would the picture on the RIGHT represent?

- A. Sagittal plane.
- B. Coronal plane.
- C. Transverse plane.
- D. Oblique plane.
- E. None of the above.

### Question 9

A count was made of the number of cells showing different stages of mitosis in a zone of an onion root tip. The following results were obtained.

Stage	Percentage of total number of dividing cells
prophase	85.0
metaphase	7.7
anaphase	2.9
telophase	4.4

From this it can be deduced that:

- A. Prophase takes much longer than the other stages.
- B. The division process was just starting.
- C. Telophase is the shortest phase in mitosis.
- D. The sample used for the count was too small.
- E. The area investigated was very close to the root tip.

**Question 10**

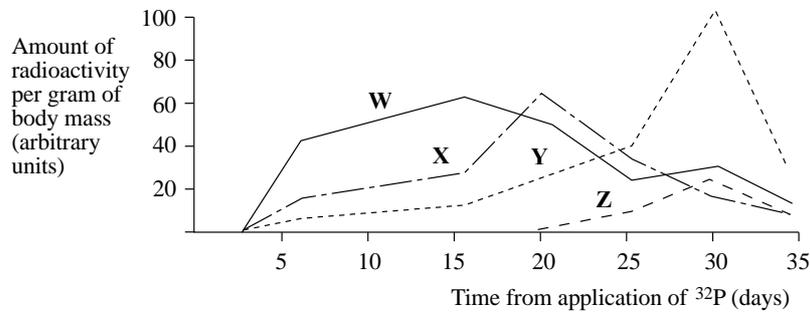
An 70 kg adult male has approximately 42 L of water in his body. Of this volume, 55% of the water is found within the cells and 45% of water is found outside the cells. For the water found outside the cells, 83.3% is found outside the blood vessels.

What is the approximate amount of water found within the blood vessels?

- A. 5.26 kg
- B. 6.43 kg
- C. 3.16 L
- D. 3.86 L
- E. 16.86 L

**Question 11**

Radioactive phosphate ( $^{32}\text{PO}_4$ ) was applied to a plot of natural grassland. During the next 35 days, the radioactive content of samples from four species of arthropod was measured. The graph shows the relative amounts of radioactivity found in the four species, W, X, Y and Z.

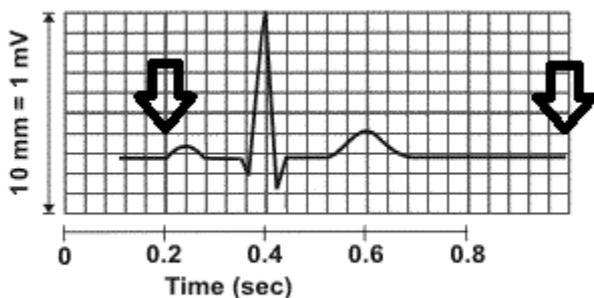


Which one of the rows A – E represents the organisms in the graph?

	<b>W</b>	<b>X</b>	<b>Y</b>	<b>Z</b>
<b>A.</b>	decomposer	herbivore	herbivore	carnivore
<b>B.</b>	herbivore	carnivore	decomposer	herbivore
<b>C.</b>	carnivore	herbivore	decomposer	herbivore
<b>D.</b>	herbivore	herbivore	decomposer	decomposer
<b>E.</b>	herbivore	herbivore	carnivore	decomposer

**Question 12**

The following diagram is what a nurse saw on a patient's ECG trace, which measures the electrical impulse passed by the heart in one heartbeat. The first arrow on the left signifies the beginning of the beat and the second arrow on the right signifies the end of the beat.



How many beats per minute did the nurse find in this patient?

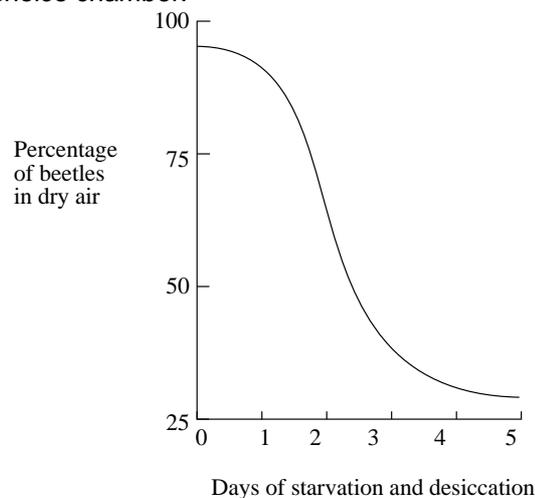
- A. 100 beats per minute.
- B. 75 beats per minute.
- C. 60 beats per minute.
- D. 54 beats per minute.
- E. 48 beats per minute.

### Question 13

The graph shows the results of an experiment in which adult beetles of a species of *Tribolium* were starved and desiccated and then offered a choice of moist and dry air in a choice chamber.

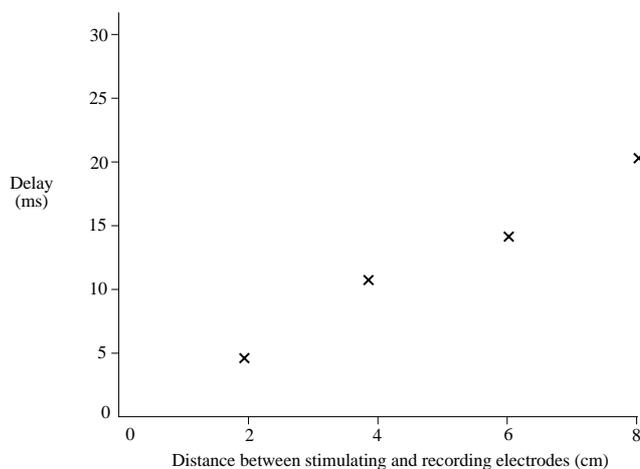
The **BEST** interpretation of these results is that

- A. The treatment reduces the beetles' response to humidity differences.
- B. The treatment reverses the beetles' normal preference for dry air.
- C. The stimulus of hunger overrides the stimulus of humidity.
- D. The stimulus of humidity overrides the stimulus of hunger.
- E. Desiccation leads to ALL beetles choosing a moist environment.



### Question 14

In an experiment to measure the speed of conduction of a nerve impulse along a giant axon, the distance between the stimulating and recording electrodes was varied and the delay between stimulus and response was recorded for each distance. The results are shown in the graph below.



From these results the mean speed of conduction was found to be

- A.  $2.0 \text{ cm s}^{-1}$ .
- B.  $2.5 \text{ cm s}^{-1}$ .
- C.  $0.5 \text{ m s}^{-1}$ .
- D.  $4.0 \text{ m s}^{-1}$ .
- E.  $6.0 \text{ m s}^{-1}$ .

### Question 15

The data below show how the incubation period of trout eggs in well-aerated water varies with temperature.

Temperature, °C	2	5	10	15
Incubation period (days)	205	118	4	27

The incubation period at 8 °C would be approximately

- A. 66 days
- B. 61 days
- C. 56 days
- D. 51 days
- E. 42 days

### Question 16

A new medication, named "Beclopa" is currently undergoing trials to determine its effectiveness in lowering the blood pressure in patients presenting with hypertension (which is the increase in blood pressure above the normal level). The trials were done on two groups of patients (children and the elderly), where each group was divided into half (without the patient's knowing) and given either a pill containing Beclopa or a pill containing water (the control). The table below shows the percentage of patients who showed a significant decrease in blood pressure.

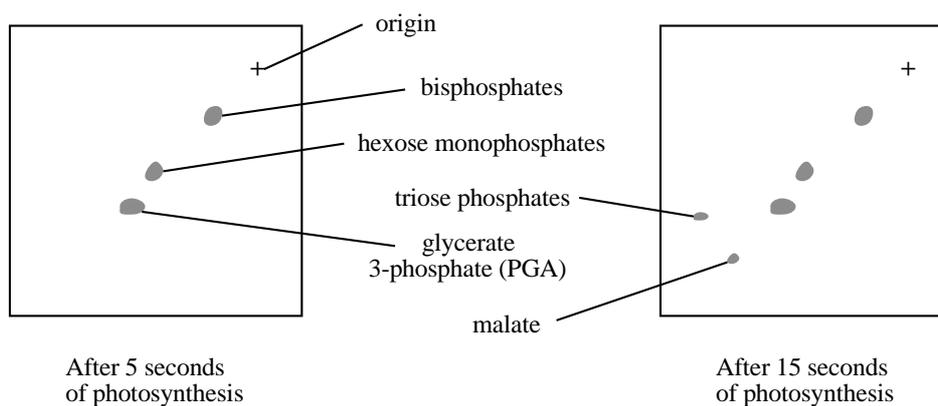
	Patients given pills with Beclopa	Patients given pills with water
Children	10%	11%
The elderly	80%	10%

Which of the following is true?

- A. Beclopa was more effective for the children than the elderly patients.
- B. Beclopa causes a decrease in blood pressure for all patients.
- C. Beclopa raises blood pressure in children.
- D. Beclopa has no effect on blood pressure in children.
- E. None of the above.

### Question 17

Two cultures of algae were exposed to  $^{14}\text{CO}_2$  for 5 seconds and 15 seconds respectively. They were then killed and the soluble products of photosynthesis extracted and used to produce the two chromatograms shown below.



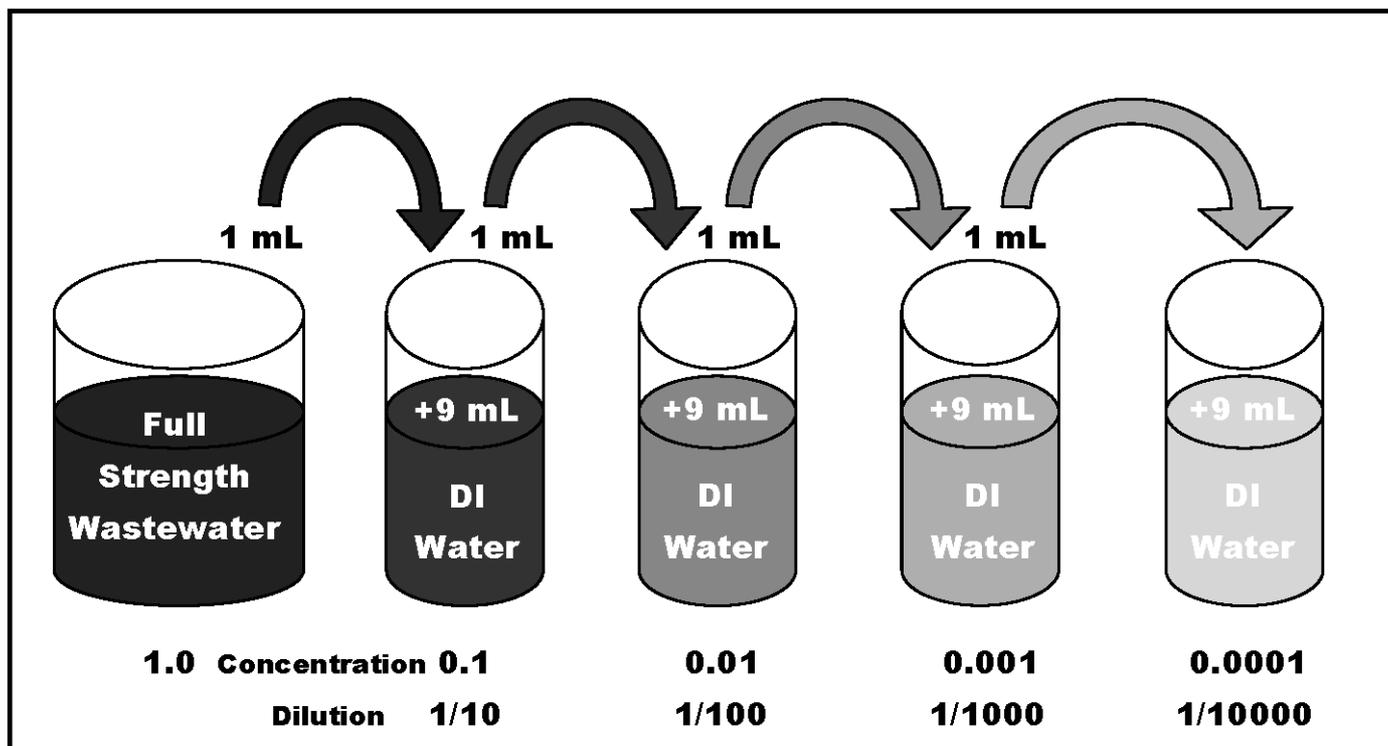
Which one of the following statements is a correct inference from the data?

- A. Glycerate 3-phosphate is the first product of  $\text{CO}_2$  fixation.
- B. Malate is the last product of  $\text{CO}_2$  fixation.
- C. Hexose monophosphates are unstable and break down into glycerate 3-phosphate.
- D. Glycerate 3-phosphate is converted to triose phosphate.
- E. Triose phosphates are formed after glycerate 3-phosphate.

## Questions 18 & 19

Many laboratory procedures involve the use of dilutions. If a solution has a 1/10 dilution the number represents 1 part of the sample added to 9 parts of diluent. The dilution factor equals the final volume divided by the sample volume.

A serial dilution is any dilution in which the concentration decreases by the same quantity in each successive step. Serial dilutions are multiplicative. Multiple dilution series use different dilution factors at each step. An example of a serial dilution of wastewater with a dilution factor of 10 is given in the diagram below (DI, dilutant).



### Question 18

In a haematology laboratory, a blood glucose of 800 mg/dL was obtained. (Note: dL is a SI unit of volume, the deciliter. 1dL = 100mL). According to the manufacturer the highest glucose result that can be measured accurately on this particular instrument is 500 mg/dL. The sample must therefore be diluted. The serum was diluted by taking 5mL of serum and adding to 95mL of blood diluting fluid and retested. The result obtained was 35 mg/dL. What was the blood glucose level of this patient?

- A. 800 mg/dL
- B. 700 mg/dL
- C. 665 mg/dL
- D. 400 mg/dL
- E. 350 mg/dL

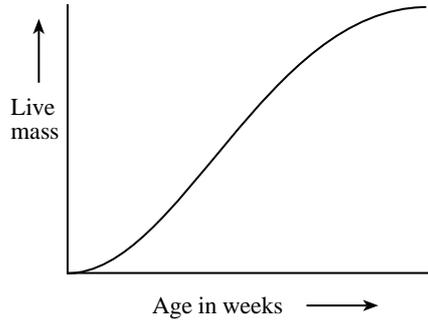
### Question 19

A multiple dilution series was performed on a sample from a dairy farm's effluent pond. The sample was diluted initially by placing 25 mL of effluent into 75 mL of water. This solution was serially diluted by; 1/2, 1/5, and 1/10. The final sample had 80 faecal coliform cells per mL. How many faecal coliform cells were in the original sample from the effluent pond?

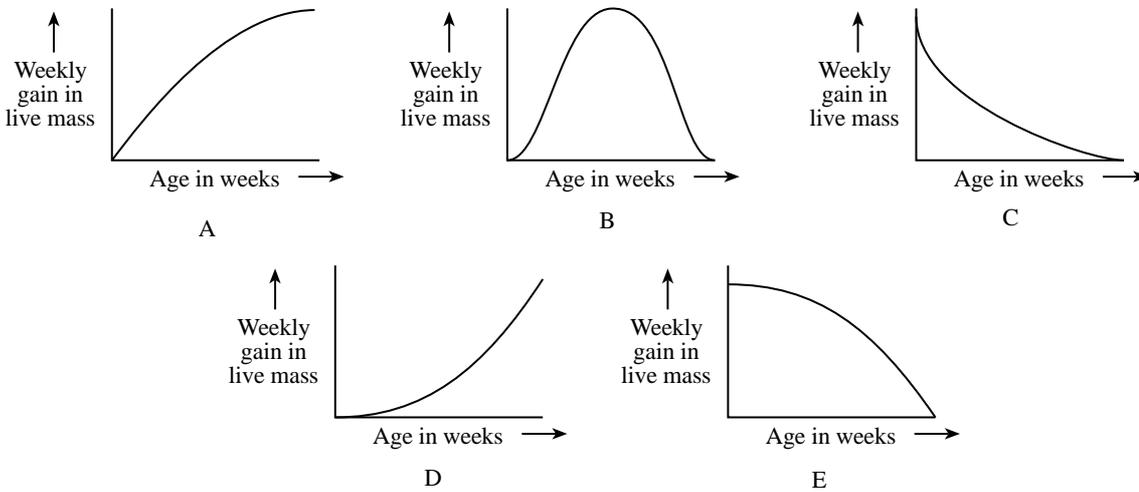
- A. 800,000 cells per mL
- B. 234,000 cells per mL
- C. 80,000 cells per mL
- D. 32,000 cells per mL
- E. 3,200 cells per mL

**Question 20**

The graph shows how the live mass of a sheep changes as it develops.

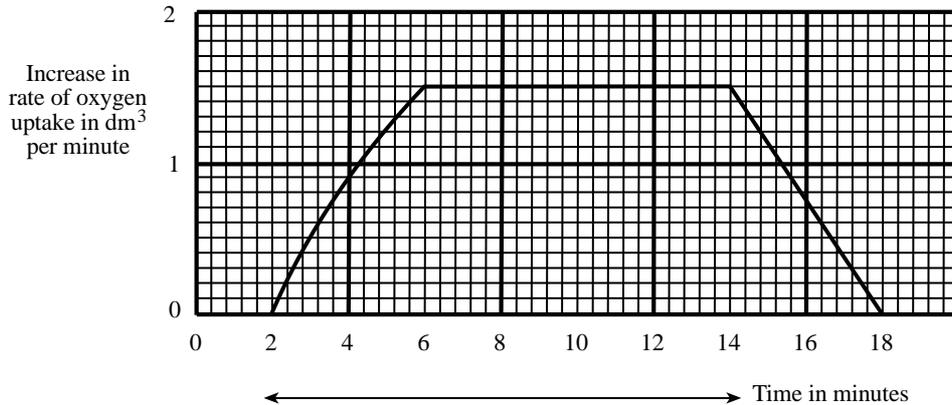


Which one of the following graphs (A – E) correctly shows the rate of change of live mass of the sheep over the same period?



**Question 21**

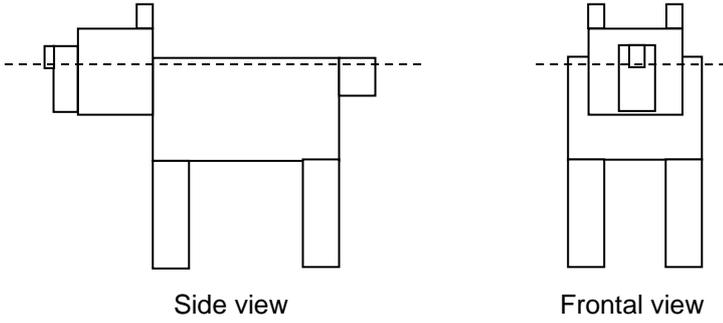
The graph shows the effect of exercise on the rate of oxygen uptake.



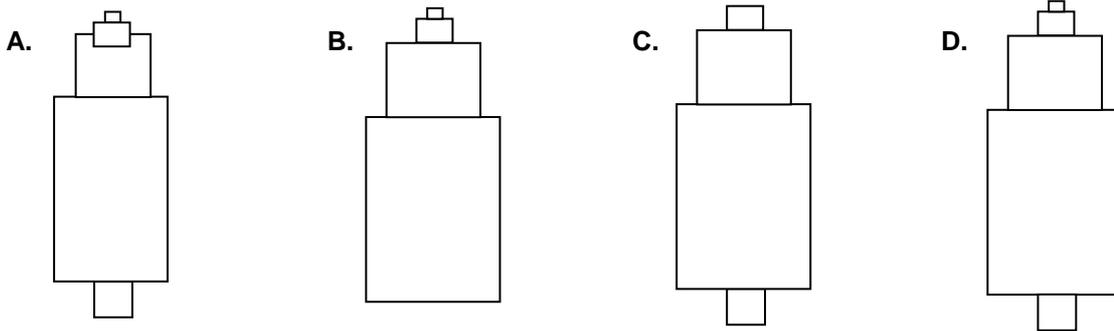
The total additional volume of oxygen used due to the exercise is approximately

- A. 12 dm<sup>3</sup>
- B. 15 dm<sup>3</sup>
- C. 18 dm<sup>3</sup>
- D. 20 dm<sup>3</sup>
- E. 24 dm<sup>3</sup>

**Question 22**

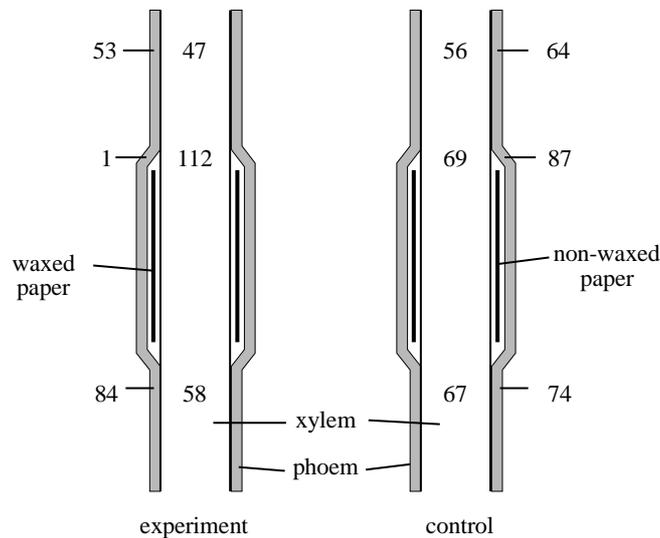


Which of the following shows a cross section through the dashed line?



**Question 23**

The phloem and xylem of an experimental shoot were carefully separated along part of their lengths, and a cylinder of waxed paper was placed between them. A control shoot was prepared using non-waxed paper. The base of each shoot was then placed in a solution containing a radioactive isotope of potassium. After five hours the radioactivity of different shoot regions was determined. The figures in the diagram give the location and concentration of radioactive potassium in parts per million.



The best interpretation of these results is that the transport of potassium ions:

- A. Is upward through the phloem.
- B. Is prevented by the insertion of paper cylinders around the xylem.
- C. Occurs longitudinally through both the xylem and the phloem.
- D. Occurs longitudinally through the phloem only.
- E. Occurs laterally from the xylem to the phloem.

**Question 24**

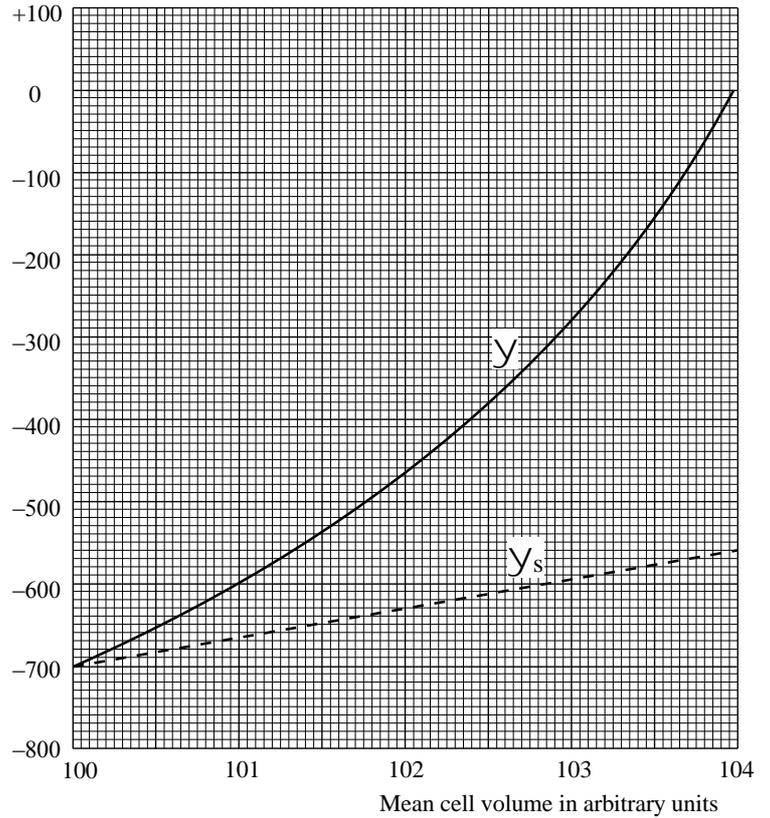
The graph shows the relationship between the volume, water potential ( $\Psi$ ) and solute potential ( $\Psi_s$ ) of plant cells immersed in a series of sucrose solutions of decreasing concentration. The cells were allowed to reach equilibrium with the bathing solutions, so that water was being neither lost nor gained, before the measurements were made.

Pressure potential  $\Psi_p$  is mechanical pressure. It increases as water enters a cell because the water present inside the cell exerts an outward pressure that is opposed by the structural rigidity of the cell wall. By creating this pressure, the plant can maintain turgor.

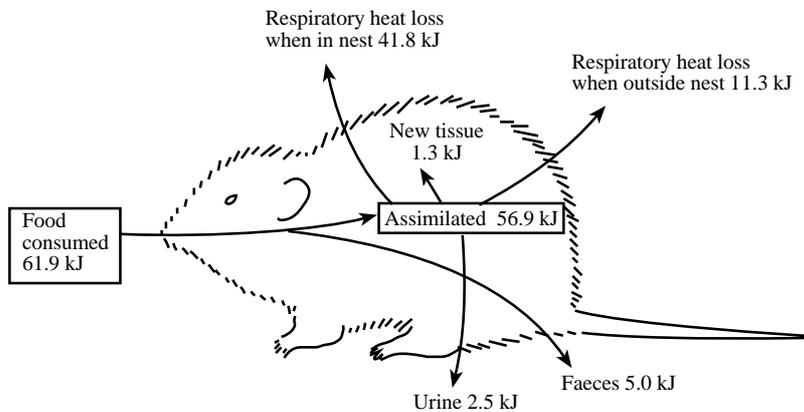
Water potential ( $\Psi$ ) = pressure potential ( $\Psi_p$ ) + solute potential ( $\Psi_s$ )

When the volume of the cell is 103 units, the pressure potential of the cell ( $\Psi_p$ ) is

- A. - 320 kPa
- B. + 320 kPa
- C. - 590 kPa
- D. - 880 kPa
- E. + 880 kPa



**Question 25**



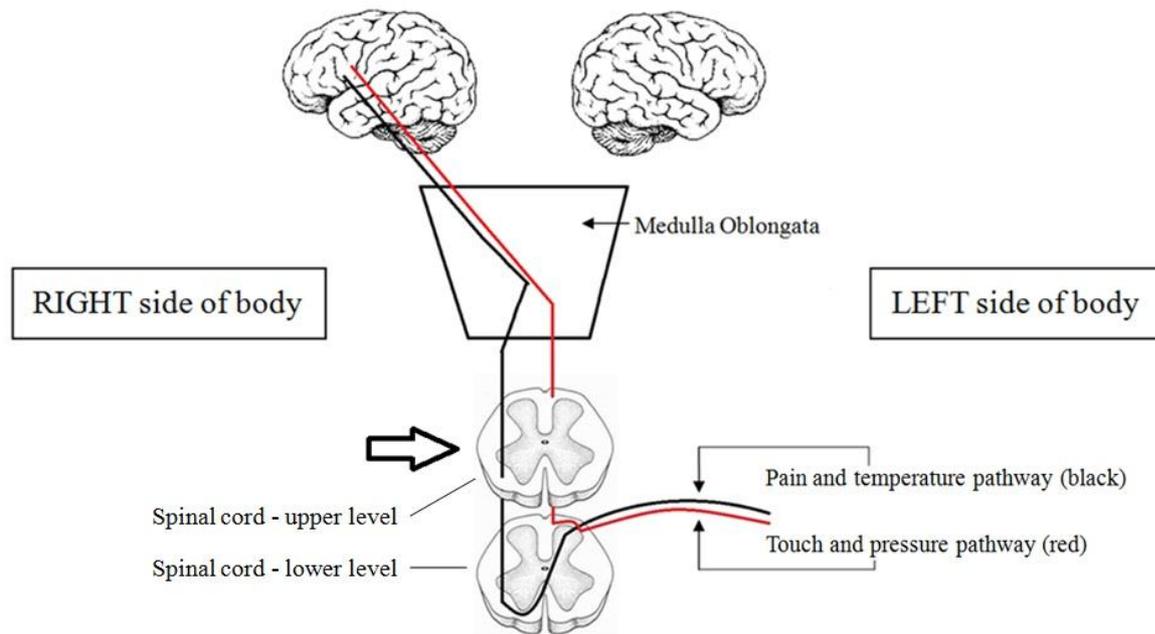
The diagram shows the daily energy budget of a small rodent weighing 23 g living in captivity during the summer.

The information in the diagram suggests that:

- A. Less than 1% of the food eaten is used for new growth.
- B. In captivity the vole spends most of its time in its nest.
- C. The rate of heat loss is lower when the vole is active.
- D. The vole's metabolism is adapted to warm weather conditions.
- E. The vole converts food into flesh more efficiently when in its nest.

## Questions 26 & 27

The following diagram represents the pathways conveying the sensory information in the human body to the sensory part of the brain.



In brief, the pathway conveying touch and pressure (shown in grey) passes from the left side of the body to the spinal cord and ascends to the medulla oblongata, where it crosses over to the other side and reaches the sensory regions of the right brain. For the pain and temperature pathway (shown in black), the sensory information passes from the left side of the body to the right side of the spinal cord before ascending up into the medulla and finally onto the right part of the brain. The same process occurs for pain and temperature, and touch and pressure pathways from the right side of the body.

### Question 26

From this information, what would happen if the right side of the spinal cord were cut (i.e. damaged) at the level indicated by the arrow?

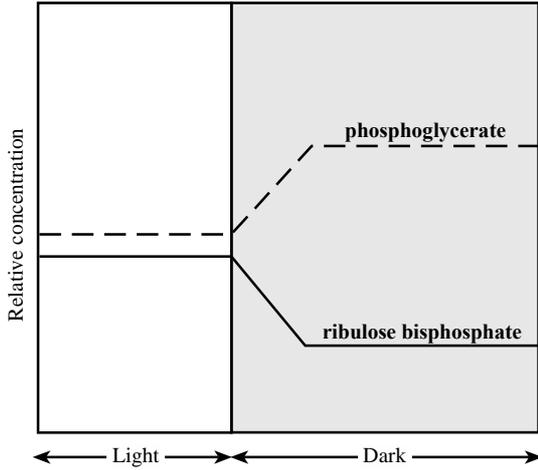
- There would be a loss in touch and pressure on the right side of the body and a loss in pain and temperature sensation on the left side of the body below that level.
- There would be a loss in touch and pressure sensation on the left side of the body below that level only.
- There would be a loss in touch and pressure on the left side of the body and a loss in pain and temperature sensation on the right side of the body below that level.
- There would be a loss in touch and pressure on the left side of the body and a loss in pain and temperature sensation on the left side of the body.
- There would be a loss of all sensation below that level, both touch and pressure and pain and temperature.

### Question 27

Following from the previous question, what would happen if the medulla oblongata was completely damaged?

- There would be no loss of sensations.
- There would be no sensations coming from the left side of the body only.
- There would be no sensations coming from the right side of the body only.
- There would be a complete loss of sensation.
- None of the options is correct.

**Question 28**



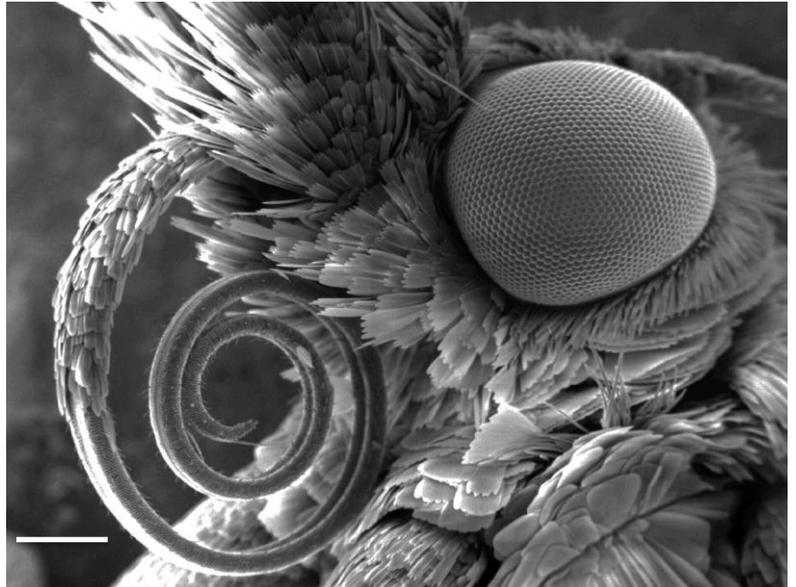
Which one of the following features of the graph does **NOT** provide support for the hypothesis that ribulose biphosphate is converted to phosphoglycerate? The concentration of the compounds

- A. Have similar concentrations at the start of the experiment.
- B. Respond immediately to the changed conditions.
- C. Achieve a new steady concentration at the same time.
- D. Have the same rate of response, one negative and the other positive.

The graph above shows the effects of a change from light to dark conditions on the relative concentrations of phosphoglycerate and ribulose biphosphate in a plant.

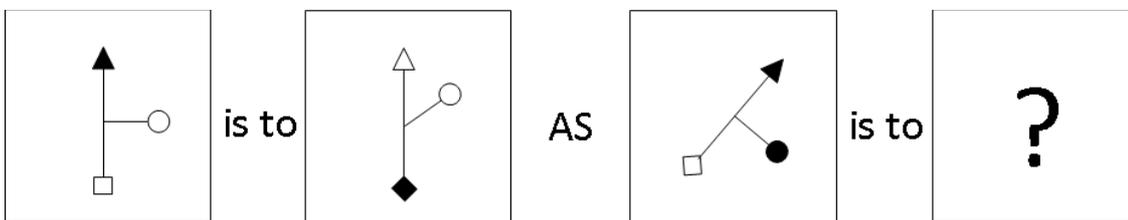
**Question 29**

The SEM photomicrograph of a moth at right shows the compound eye in great detail. What is the best estimate of the maximum horizontal width of this eye, given that the scale bar represents 200  $\mu\text{m}$ ?



- A. 550  $\mu\text{m}$
- B. 600  $\mu\text{m}$
- C. 650  $\mu\text{m}$
- D. 700  $\mu\text{m}$
- E. 750  $\mu\text{m}$

**Question 30**

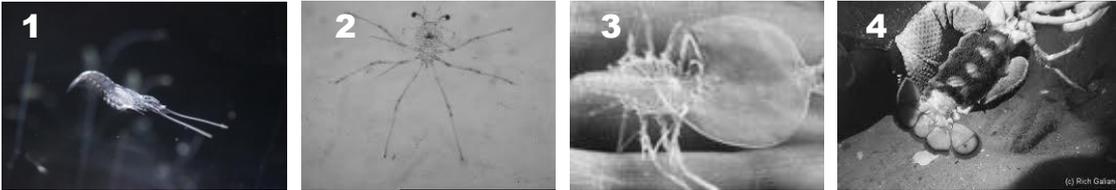


- A.
- B.
- C.
- D.
- E.

### Question 31

The New Zealand crayfish, *Jasus edwardsii*, has a complex life cycle. The female attaches the fertilized eggs to her abdomen. The eggs hatch as a small spidery creature called a naupliosoma larva and are released by the female. The naupliosoma swims to the surface and moults, transforming into a leaf-like larva, known as a phyllosoma. In this form, the crayfish larva spends an extended period floating in ocean currents that carry it far from shore. At the end of this time, the final moult transforms the larva into a miniature transparent version of the adult called a puerulus larva. The puerulus swims back to the coast and settles, becoming a small coloured adult.

Place the photos of the crayfish life stages below into the correct order.



Photos are from <http://www.teara.govt.nz/en/crabs-crayfish-and-other-crustaceans/media> and [www.wilderness.org.au](http://www.wilderness.org.au)

- A. 1, 2, 3, 4
- B. 1, 3, 2, 4
- C. 2, 3, 1, 4
- D. 4, 3, 2, 1
- E. 4, 2, 3, 1

### Question 32

Imagine there is giant jellyfish. The jellyfish weighs 10 kg, and is 99% water by weight. The jellyfish washes up on the beach and the water evaporates from the jellyfish until it reaches 98% water by weight. How much does the jellyfish now weigh?

- A. 9.9 kg
- B. 9.8 kg
- C. 9 kg
- D. 8 kg
- E. 5 kg

### Question 33

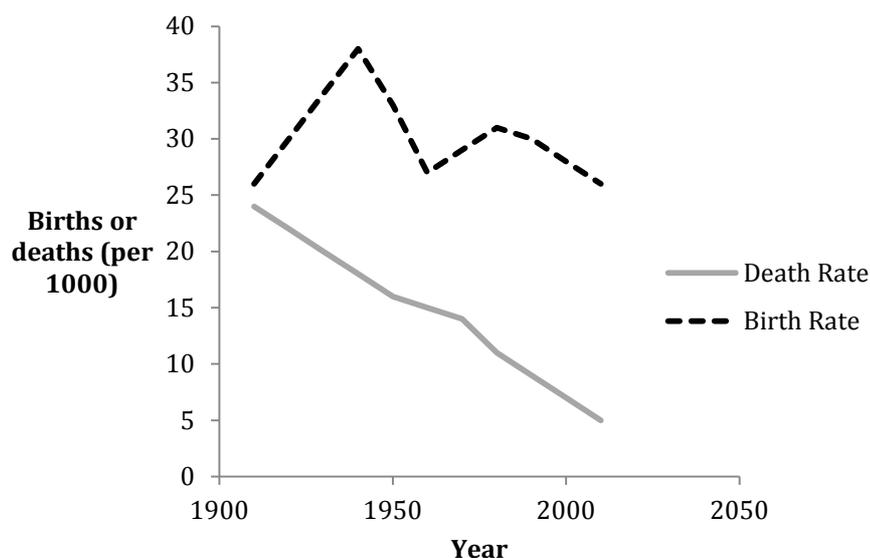
Spines and thorns on plants look similar, and both provide protection from herbivores. However, not all plants with spines or thorns have descended from a recent common ancestor. Spines are modified leaves, and thorns are modified stems.

Which of the following statements best describes how this information provides evidence for evolution by natural selection?

- A. It shows that different organisms sometimes look alike.
- B. It shows that herbivores are the strongest selection force on organisms.
- C. It shows that a variety of structures can be effective in protecting an organism from herbivores.
- D. It shows that environmental pressures can cause unrelated species to change in similar ways.
- E. It shows that spines and thorns provide the best protection from herbivores.

### Question 34

The graph shows the birth rate and death rate for a population over a 100-year period.

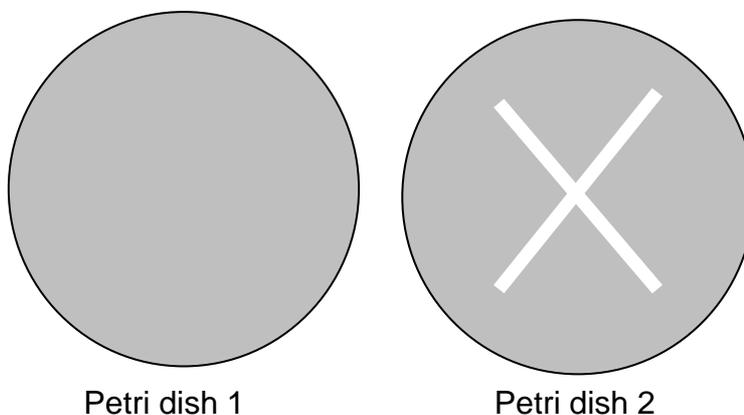


Assuming equal emigration and immigration, from 1900 to 2000, the population has

- A. Increased
- B. Decreased
- C. Stayed the same
- D. Increased until 1930, then decreased
- E. Fluctuated over the years

### Question 35

A student filled two Petri dishes with a clear cornstarch gel, then marked the letter "X" invisibly onto the gel in Petri dish 1 with a damp cotton swab. He then placed saliva from his mouth onto a second cotton swab and used that swab to mark the letter "X" invisibly onto the gel in Petri dish 2.



Fifteen minutes later, the student rinsed both Petri dishes with a dilute solution of iodine to indicate the presence of starch. The entire surface of Petri dish 1 turned blue-black, indicating starch. Most of the surface of Petri dish 2 was blue-black, except that the letter "X" was clear, as shown above.

The most probable explanation of the clear "X" is that?

- A. The starch in the gel was absorbed by the damp cotton swab.
- B. The iodine reacted with a chemical in the saliva and broke down.
- C. A chemical in the saliva broke down the starch in the gel.
- D. The saliva prevented the iodine from contacting the starch in the gel.
- E. The cotton swab removed the iodine from the areas it touched.

**Question 36**

The pea weevil is a type of insect. The table below shows the average time it takes for pea weevil eggs to hatch at different temperatures.

Temperature (°C)	Average Hatching Time (days)
11	38
14	20
16	16
18	10
22	10
24	7
25	5
27	5
28	7

Based on the data, which of the following climatic conditions would promote the highest population growth rate in pea weevils?

- A. Cold springs with temperatures from 11°C to 16°C
- B. Moderate summers with temperatures from 25°C to 27°C
- C. Heat waves in which the temperature is sustained well above 28°C
- D. Overnight frosts after which the temperature warms from 0°C to 11°C
- E. Cold winters with the temperatures below 11°C

**Question 37**

Partial amino acid sequences for a particular protein in three animal species are shown below. Each letter in the sequence stands for an amino acid. For example, Q stands for glutamine, and L stands for leucine.

Which of the following statements best explains how these sequence data are used as evidence to determine evolutionary relationships?

- A. All species translate the amino acid sequences of their proteins in a similar way.
- B. The species that are most closely related have the most similar amino acid sequences.
- C. Individual organisms acquire changes in their amino acid sequences over their lifetimes.
- D. The organisms that evolved at the same time in geologic history have identical amino acid sequences.

Species	Amino Acid Sequence
Green junglefowl (bird)	QHEPHERKRM
Nile crocodile (reptile)	SHDPAQQKRL
Domestic chicken (bird)	QHEPHKRKRM

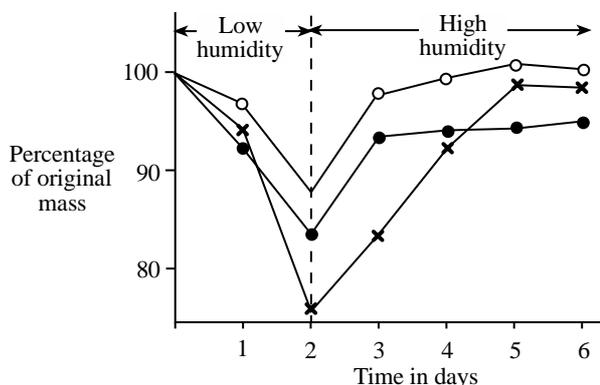
**Question 38**

Mary's father has five daughters: 1. Nana, 2. Nemu, 3. Nino, 4. Nomi. What is the name of the fifth daughter?

- A. Nune
- B. Nume
- C. Nunu
- D. Numu
- E. Mary

### Question 39

The graph shows changes in mass of three individual sheep ticks when they were removed and kept for two days at low humidity and then four days at high humidity.



The best deduction from these data is that

- A. At high humidity ticks absorb water from the atmosphere.
- B. At day 6 the ticks have recovered their body water.
- C. The loss of mass during the first two days is due to starvation.
- D. Individual ticks contain different amounts of water.
- E. Individual ticks lose water at the same rate when held in low humidity conditions.

### Question 40

Measurements were made on the growth of young spruce trees in a pure stand and in a mixture with pine trees. The density of trees in both stands was the same. The effect of providing the plants with a calcium and nitrogen source (basic slag) was also investigated at the same time. The results of these investigations on twelve-year old trees are shown in the table.

	Mean height of spruce trees in centimeters in:	
	Pure stand of spruce	Mixed stand of spruce and pine
Not treated	60	100
Basic slag applied after planting	95	130

Using only these data, which is the **BEST** interpretation?

- A. Spruce and pine are in competition with each other.
- B. The growth of pine is decreased by the presence of spruce.
- C. Calcium ions stimulate the growth of spruce more in mixed stands.
- D. The growth of spruce is increased by the presence of pine
- E. Pine trees grow faster with the addition of basic slag.

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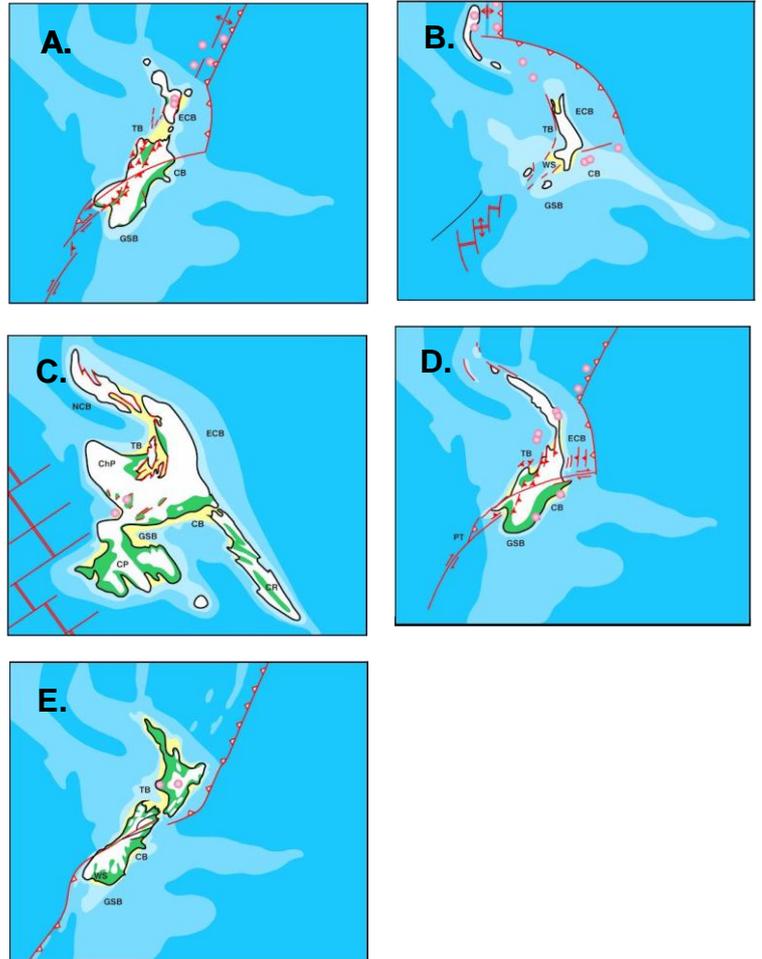
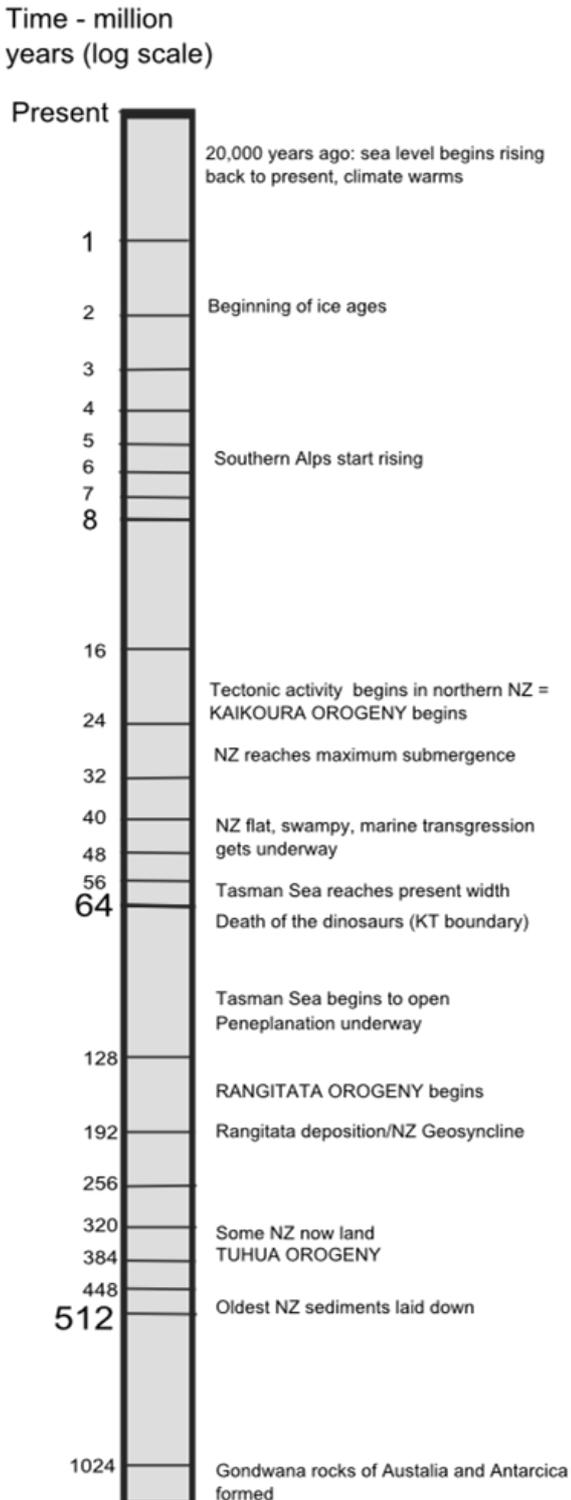
**Section B**

**ZEALANDIA**

New Zealand is the terrestrial part of a submerged continent called Zealandia, formed over a period of 500 million years. It was once part of the Gondwana supercontinent, and split off 80-60 million years ago when the Tasman Sea formed. New Zealand's complex geological history is mirrored in the complex patterns of evolution seen in New Zealand's flora and fauna.

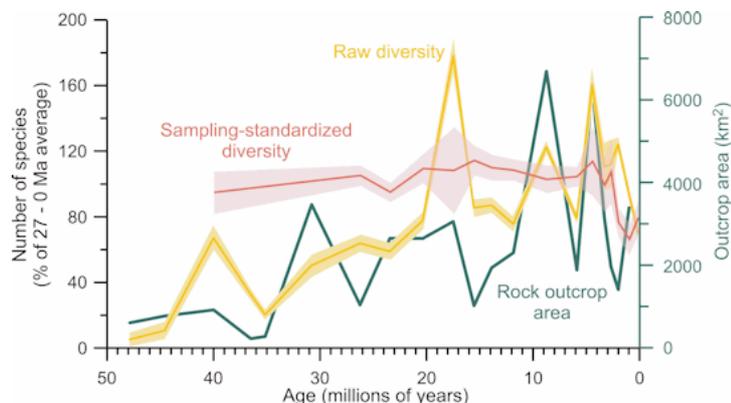
**Question 41**

Using the information from the geological timeline at left, place the paleo-geographical maps (A-E) of New Zealand below into the correct order.



- A. B C A D E
- B. B A C D E
- C. C B D A E
- D. C A B D E
- E. C D B A E

GNS scientist, James Crampton, and his research team have been using NZ's extensive, though imperfect, fossil record of molluscs (clams and snails) together with molecular data of living species to study evolution and the patterns of marine biodiversity change over the past 50 million years in the New Zealand region.



The graph shows the diversity of New Zealand molluscs over the past 50 million years in relation to rock outcrop area.

**Question 42**

This graph demonstrates that

- A. Diversity has increased over the last 50 million years.
- B. Diversity has remained more-or-less constant throughout the last 50 million years.
- C. Diversity has fluctuated significantly over the last 50 million years.
- D. Diversity has fluctuated widely but with an underlying increase over the last 50 million years.
- E. Diversity remained relatively constant for much of the last 50 million years but declined over the past few million.

The research team sequenced the genome of 11 species of New Zealand snails and compared this molecular information with detailed mathematical description of the shape of the shell and outline of the shell opening. The relationships between these species are shown in the cladograms below. A cladogram uses branching lines that end at groups of organisms. At the point of branching, a common ancestor is believed to have existed. Clades or groupings of organisms, are characterized by synapomorphies, characters present in the last common ancestor.

**Question 43**

Which species is inferred to be most closely related to *Alcithoe benthicola*?

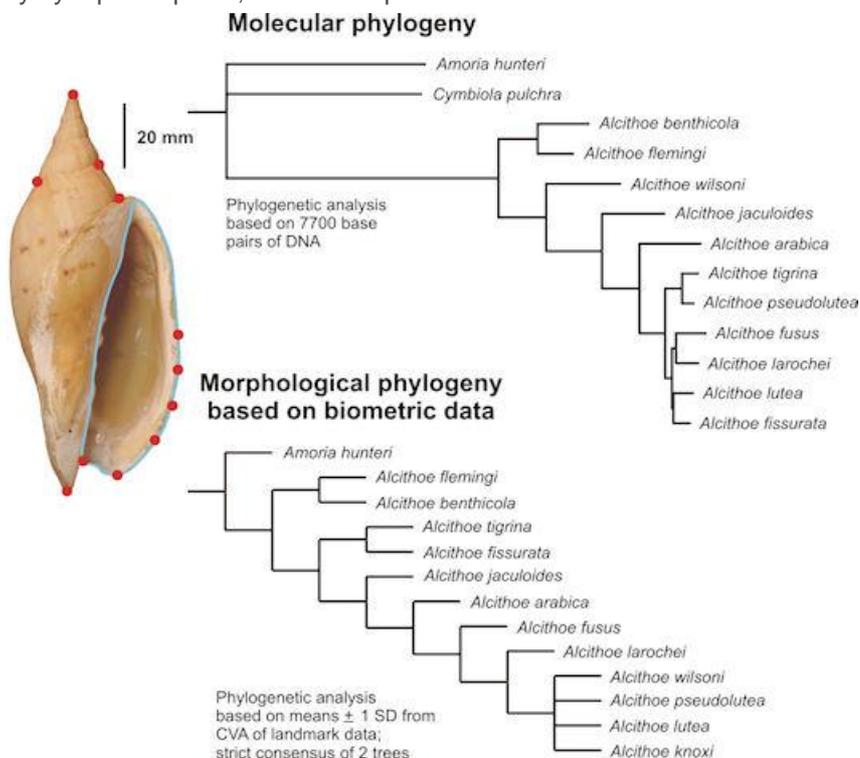
- A. *Alcithoe flemingi*
- B. *Alcithoe tigrina*
- C. *Alcithoe wilsoni*
- D. *Amoria hunteri*
- E. *Alcithoe fissurata*

**Question 44**

The results indicate significant congruence (agreement) between molecular and structural inferences.

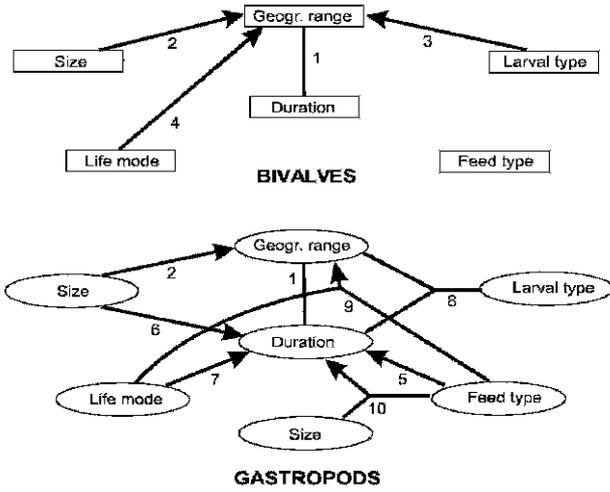
Which species is incongruent when these two phylogenies are compared?

- A. *Alcithoe benthicola*
- B. *Alcithoe wilsoni*
- C. *Alcithoe arabica*
- D. *Amoria fusus*
- E. *Amoria hunteri*



**Question 45**

There is consensus that factors such as geographic range influence species survivorship (species duration) in the fossil record with species with large geographical ranges surviving for longer periods. There is less agreement about the influence of factors such as body size and larval type. Crampton *et al.* 2010 looked at a variety of biotic influences on species duration. The relationships between duration, geographic range and these other traits are illustrated below for both bivalves (clams) and gastropods (snails).



- Key to interactions**
- 1 Widespread = long
  - 2 Large = widespread
  - 3 Planktotr. = widespread
  - 4 Epifaunal = widespread
  - 5 Carnivorous = long
  - 6 Large = long
  - 7 Infaunal = long
  - 8 Planktotr.+widespr. = long
  - 9 Infaunal+carniv. = widespr.
  - 10 Large+carniv. = long

From these relationships it can be inferred that in gastropods:

- A. There is a direct relationship between a planktotrophic larval phase and a large geographical range.
- B. Larval type influences species survivorship but not geographical range.
- C. A planktotrophic larval phase has no influence on geographical range.
- D. A planktotrophic larval phase is associated with large range size and long duration in a three-way interaction.
- E. Larval type has no influence on species survivorship.

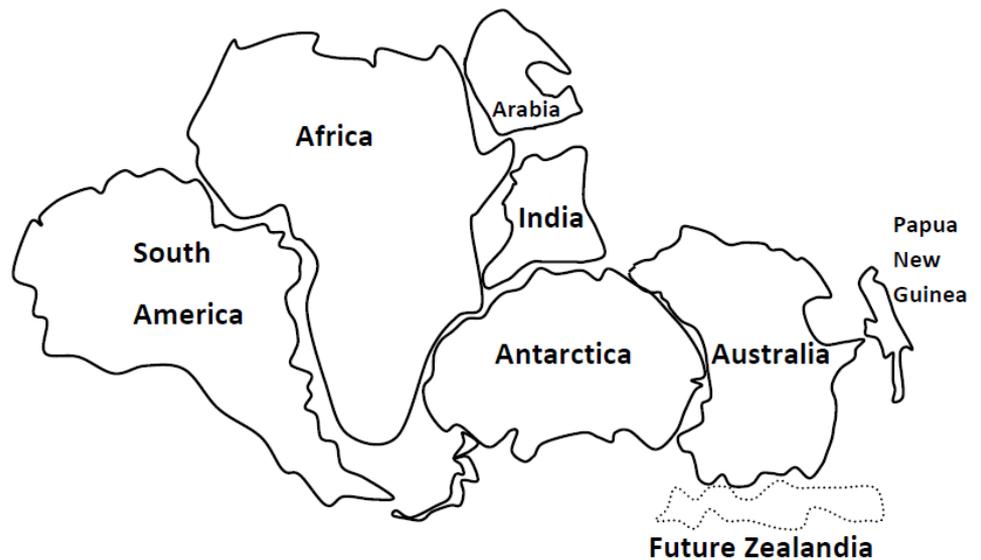
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## RATITE EVOLUTION

Ratites are named for their flat “raft-like” sternum that lacks a keel and thus cannot provide sufficient anchorage for flight muscles to effectively generate the power required to fly. Cassowary (Australia and Papua New Guinea), Emu (Australia), Rhea (South America), Ostrich (Africa), Kiwi (New Zealand), and extinct Moa (New Zealand) are all examples of ground dwelling, flightless ratites. Given their large, flightless nature, biologists have proposed that they have all descended from a common ancestor present in ancient Gondwana before it broke apart. The exact timing and evolutionary origin of the Moa and Kiwi in New Zealand have been greatly debated in the scientific literature.

### Geological History of Gondwana

- 180 mya Africa breaks free from Antarctica and India
- 130 mya South America breaks free of Africa
- 80 mya Zealandia breaks free
- 60 mya New Zealand separates from Australia
- 40 mya Australia separates from Antarctica
- 30 mya South America breaks from West Antarctica (Antarctica freezes over)



### Flying Cousins

Ratites are one of only two groups of birds belonging to the “old jaw” *Paleognaths* originating in Gondwana, the other comprises the 47 living Tinamou species of Central and South America. Tinamou species are generally ground dwelling, though they do have wings that allow for limited flight.

It is generally accepted that loss of flight in birds is due to the development of successful foraging behaviours and diminished predation on eggs and nests.

### Fossil Evidence

Examination of the oldest known Moa fossils, dating from 19 million years ago, determined they had thickened leg bones and no wing structures at all. At least two species of flightless Moa were present in New Zealand at this time.

The oldest Tinamou fossils in South America are 10 million years old.

The oldest Kiwi fossil dates back 1 million years. Though diminished in size, kiwis have wings and flight feathers. Kiwis are the only known bird to have nostrils at the end of their beaks and the only ratite with two functioning ovaries.

### Question 46

Scientists have proposed that Moa and Kiwi share an immediate common ancestor. Which of the following statements would **BEST** support this hypothesis?

- A. They are both found in New Zealand.
- B. They are both flightless birds.
- C. Kiwi and Moa are not found outside of New Zealand.
- D. Without help, Kiwi are likely to go extinct.
- E. Oldest Kiwi fossils are much younger than the oldest Moa fossils.

### Question 47

According to the estimated break up of Gondwanaland the **BEST** hypothesis is that?

- A. Ostrich and Cassowary are the most distantly related ratites.
- B. Tinamou and Cassowary are the most distantly related ratites.
- C. Kiwi evolved from Moa.
- D. Tinamou and Moa are the most closely related ratites.
- E. Moa evolved from Ostriches.

### Question 48

Proportional to their body size, Kiwi have the largest egg of all the ratites. Which of the following inferences about Kiwi is **LEAST** likely to be true?

- A. Kiwi have evolved from a much larger species.
- B. Having two ovaries allows them to produce larger eggs.
- C. Kiwi have been flightless for a very long time.
- D. Larger eggs allow for better survival of Kiwi chicks.
- E. Larger eggs evolved after flightlessness.

### Question 49

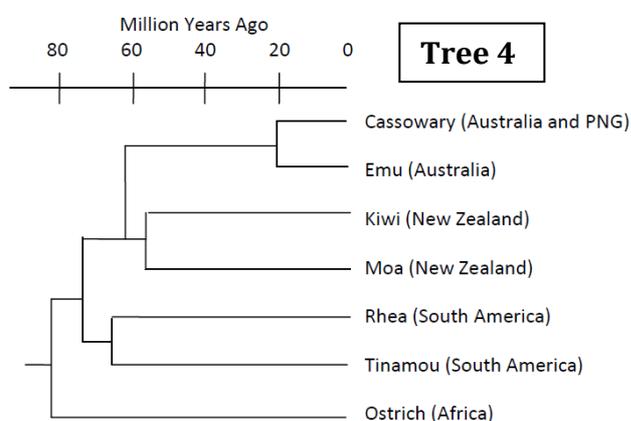
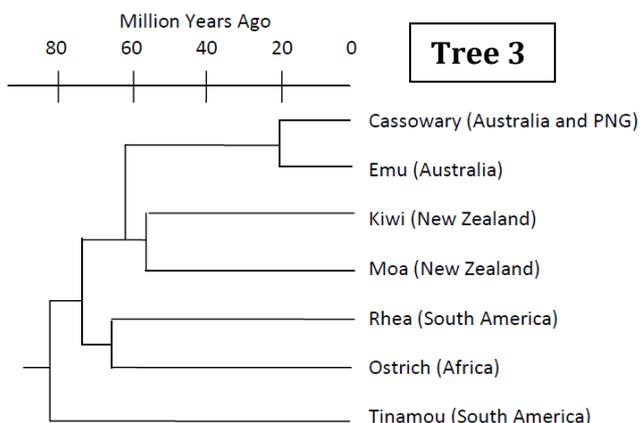
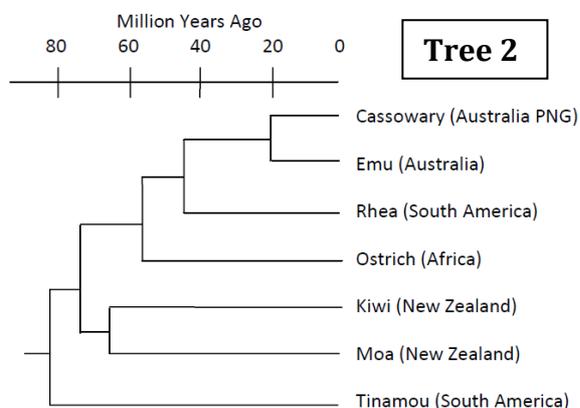
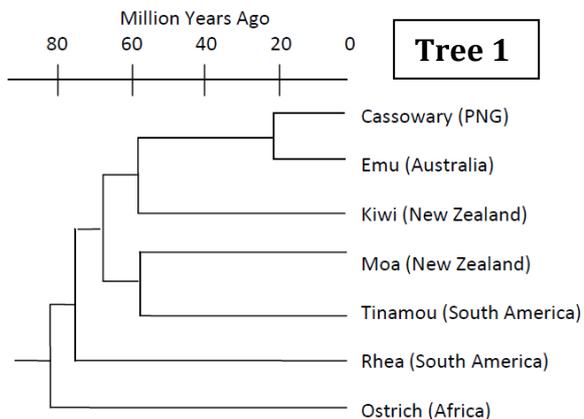
Tinamou are the only group of Paleognath birds that have the ability to fly. Which of the following is **LEAST** likely to account for their flying ability?

- A. A common ancestor became isolated from other Paleognaths prior to them becoming flightless.
- B. The rich biodiversity of South America provided a selective advantage for flying.
- C. Possessing wings provide benefits for Tinamou that are unrelated to flying.
- D. Possessing wings allows Tinamou to escape from ground dwelling predators.
- E. Tinamou evolved from a flightless bird that regained the ability to fly.

## Continued on next page

### Questions 50 - 53

Geological analysis suggests the initial separation of New Zealand from Gondwana took place approximately 80 million years ago. However, it is hypothesised that full separation was not complete until 60 million years ago. Some scientists propose that a common ancestor of the Moa and the Kiwi (a proto-Moa) floated away from Gondwana during this time. Others propose that Moa and Kiwi arrived in New Zealand at two different times. Four possible phylogenetic trees, describing different possible evolutionary relationships within the ratites, are shown below. Use these trees to answer the following questions.



#### Question 50

Which tree is most consistent with present day locations of Paleognath species?

- A. Tree 1
- B. Tree 2
- C. Tree 3
- D. Tree 4

#### Question 52

Which tree would support the hypothesis of a proto-Moa ancestor flying to New Zealand?

- A. Tree 1
- B. Tree 2
- C. Tree 3
- D. Tree 4

#### Question 51

Which tree incorporates mitochondrial DNA evidence showing that the Cassowary shared a common ancestor with Kiwi 60 mya and with Moa 70 mya.

- A. Tree 1
- B. Tree 2
- C. Tree 3
- D. Tree 4

#### Question 53

Which of the following provides the **BEST** evidence for two distinct migrations?

- A. Moa fossils are much older than Kiwi fossils.
- B. DNA analysis estimates that Moa and Kiwi each evolved into flightless species approximately 60 mya.
- C. Mitochondrial evidence suggests that Kiwi and Moa split from a common ancestor 80 mya.
- D. Moa have no wings, Kiwi still possess flight feathers.

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**DEAR ENEMIES & NASTY NEIGHBORS**

“Dear Enemy, I curse you, and hope that something slightly unpleasant happens to you, like an onion falling on your head.”

**Blackadder I, The Archbishop**

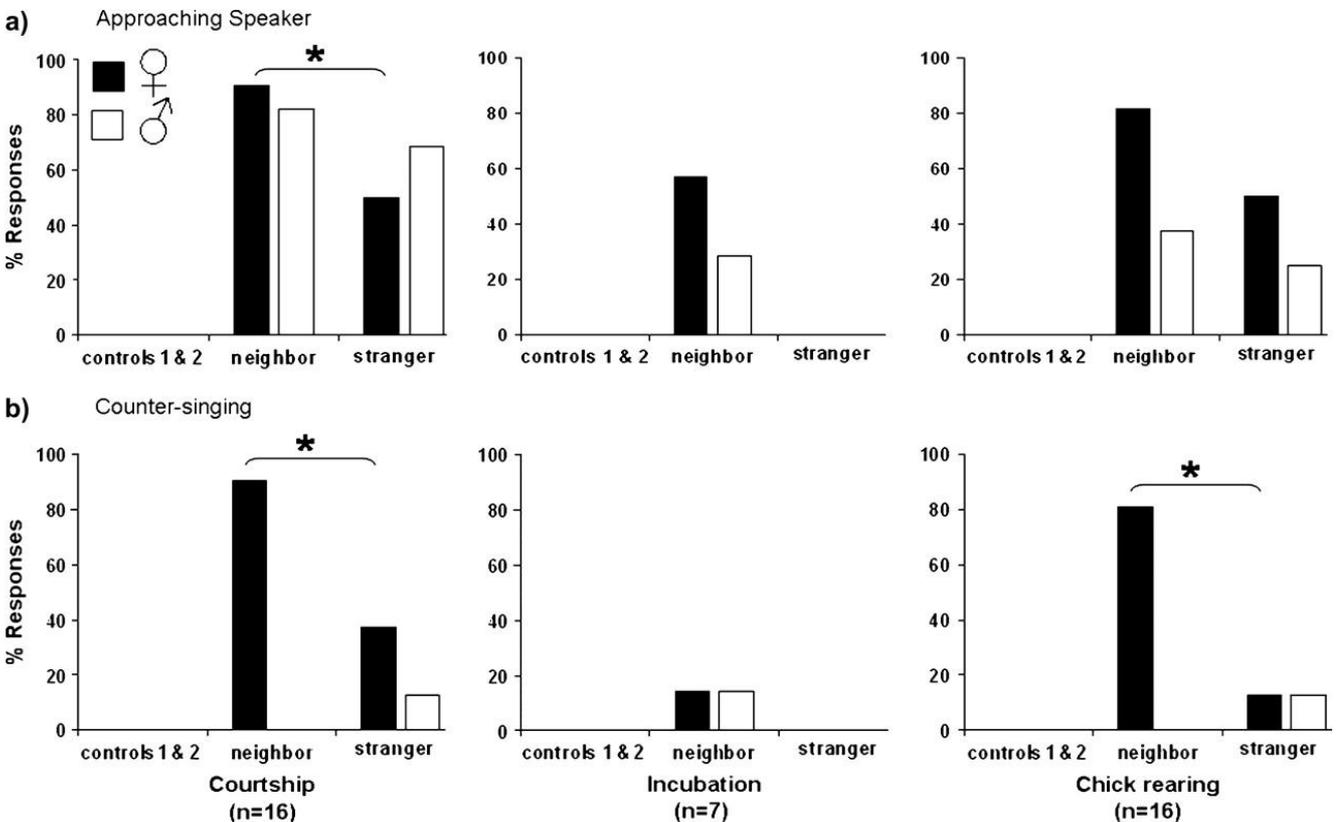
Many species show territorial behaviour (actively defending an area containing resources) allowing the species to monopolise resources such as food or mates. Territoriality is costly in terms of energy and time so some species reduce these costs by being less aggressive towards their neighbours than towards unfamiliar strangers, the so called “dear enemy” hypothesis. The converse are “nasty neighbours” in which species are more, not less aggressive towards their neighbours.



Dr Brunton’s research group, at the Institute of Natural Sciences at Massey University, has been studying the behaviour of the New Zealand bellbird, (*Anthornis melanura*) on Tiritiri Matangi Island. Both sexes sing prolifically and are known to use vocalisations to recognise individuals. Male and female bellbirds counter-sing in response to the vocalisations of their neighbours in a territorial behaviour that may lead to chasing of an individual bird intruding on a territory.



The researchers used speakers to play the song of neighbouring females or stranger females at different breeding stages. They recorded the responses of male and female bellbirds, including counter-singing and whether the birds approached the speaker. An asterisk indicates significant differences between the response to neighbours and strangers. Due to small sample sizes, the responses to the neighbours versus strangers were not tested during the incubation stage. Control 1 was silence, control 2 played back the song of a different species.



Using the information and the graphs above answer **Questions 54 – 58** on the following page.

### Question 54

The average percentage of female bellbirds responding to playback of neighboring female song by counter-singing over the entire breeding season was?

- A. 90%
- B. 82%
- C. 77%
- D. 62%
- E. Unable to be determined

### Question 55

During courtship, male bellbirds respond how much more frequently to the sound of a stranger female by approaching the speaker than by counter-singing?

- A. 88%
- B. 68%
- C. 56%
- D. 22%
- E. 20%

### Question 56

Considering the differences in the behaviour of male and female bellbirds towards playback of female song, which of the following can be concluded from this research?

- A. Territorial male bellbirds are more likely to move towards a female intruder than their female partner.
- B. Female bellbirds were most territorial during courtship and chick rearing.
- C. Male bellbird territorial behaviours of all types are strongest during courtship.
- D. During the incubation period female bellbirds are more likely to counter-sing in response to an intruding female than are males.
- E. There were no significant differences between the territorial behavior of male and female bellbirds.

### Question 57

Female bellbird counter-singing occurs at a much lower frequency during incubation. Which of the following is the **MOST** plausible explanation for this change in behaviour over the breeding season?

- A. Male bellbirds are likely to eat eggs that they discover so females remain quiet when incubating.
- B. Noise from the incubating female bellbird may attract predators to the nest resulting in a loss of eggs.
- C. Female bellbirds do not require any resources whilst incubating so they have no need to exhibit territorial behaviours.
- D. During incubation male bellbirds leave the area so females do not need to counter-sing.
- E. During chick rearing the female bellbirds need to communicate with their young so counter-singing increases.

### Question 58

This research provides evidence for which of the following statements?

- A. The female bellbird responses support the “dear enemy” hypothesis.
- B. The female bellbird responses support the “nasty neighbours” hypothesis.
- C. The male bellbird responses support the “dear enemy” hypothesis.
- D. The male bellbird responses support the “nasty neighbours” hypothesis.
- E. Both male and female bellbird responses support “dear enemy” hypothesis.

## AVOIDING FREEZING IN ANTARCTICA

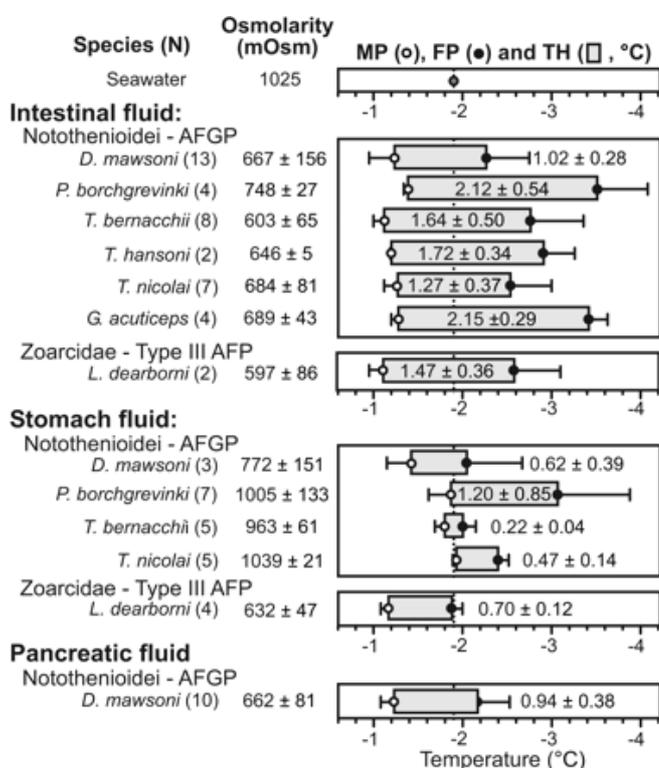
The research group of Associate Professor Clive Evans at the University of Auckland has an active Antarctic Programme investigating how fish avoid freezing in the frigid waters of the Southern Ocean surrounding Antarctica.

Seawater temperature hovers close to its freezing point of around  $-1.93^{\circ}\text{C}$  throughout the year but most marine fish freeze at about  $-0.7^{\circ}\text{C}$  so they cannot survive in the icy Antarctic waters. Notothenioid fishes (icefish) thrive in this freezing environment because they are able to produce antifreeze glycoproteins (AFGPs). AFGPs bind to and inhibit the growth of minute ice crystals that occasionally enter the fish, thus preventing their body fluids from freezing. This key evolutionary innovation allowed the icefish to colonize the frigid waters of the Southern Ocean some 5-15 million years ago.



### Questions 59 - 61

Icefish risk freezing of the intestinal tract by swallowing ice in ingested seawater or food. This suggests that AFGPs should be present in the stomach and intestinal fluids to decrease the risk of freezing initiated by ingested ice. In the diagram below, the activity of antifreeze in these fluids is examined by measuring the difference between melting and freezing points in degrees Celsius, a measure of thermal hysteresis (TH). TH is represented by the gray box.



Cheng C C *et al.* PNAS 2006;103:10491-10496

### Question 59

Examining this data, in which fluid is the TH particularly large

- Intestinal fluid only
- Stomach fluid only
- Pancreatic fluid only
- Both intestinal and stomach fluid
- All gastrointestinal fluids show equally high levels of TH

### Question 60

The species of fish is written in italics on the left hand side of the diagram. Which species shows the greatest TH of the intestinal fluid?

- D. mawsoni*
- P. borchgrevinki*
- T. bernacchii*
- G. acuticeps*
- L. dearborni*

### Question 61

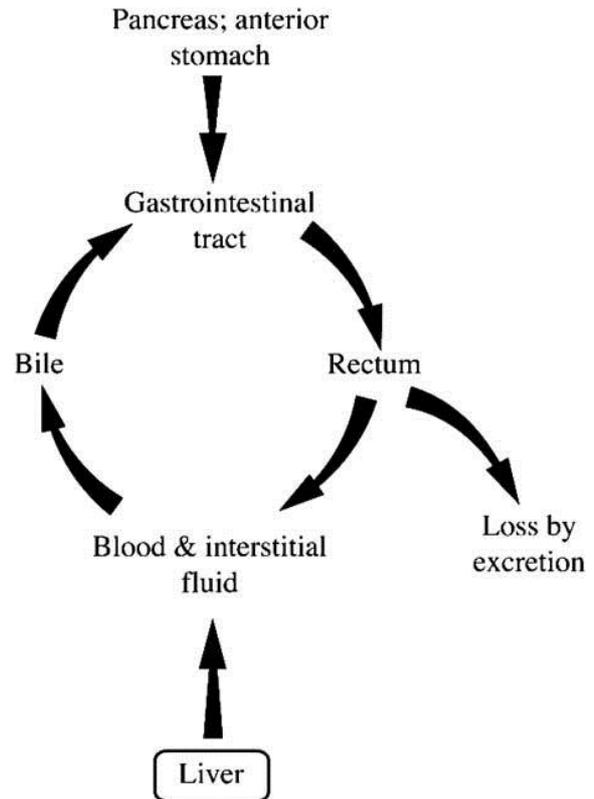
Which species has the lowest intestinal fluid freezing point (FP)?

- D. mawsoni*
- P. borchgrevinki*
- T. bernacchii*
- G. acuticeps*
- L. dearborni*

## Questions 62 – 63

Interestingly, a recent paper by Evans *et al.* 2012 in Antarctic Science suggests that both Antarctic icefish and Arctic cods have evolved essentially identical AFGPs, which are synthesized and recycled in similar ways. This is an example of convergent evolution (where distantly related organisms independently evolve similar traits) in response to the identical problem of how to deal with internal ice in freezing environments.

AFGPs are synthesized in the exocrine pancreas in both groups of fish. They are then discharged into the gastrointestinal tract (gut) to inhibit the growth of ingested ice. AFGPs bound to ice are lost with the faeces or if unbound, absorbed from the gut in the rectum. AFGPs circulate in the blood and interstitial fluids where they are available to bind to ice crystals that may form. It is thought that AFGPs are phagocytosed by macrophages (engulfed by the cell) and build up in the macrophages of the spleen where they remain bound to ice crystals until a warming event occurs. AFGPs in the blood are ultimately secreted into the bile and re-enter the gut when bile is secreted for digestion. Arctic cods, unlike the Antarctic icefish, also synthesize AFGP in the liver.



### Question 62

Describe one possible pathway of an AFGP molecule that encounters an ice crystal formed in the interstitial fluid of an Antarctic icefish in August (winter).

- Binds to the ice crystal in the interstitial fluid, enters the bile, is secreted into the gut, passed into the rectum and lost in the faeces.
- Binds to the ice crystal in the interstitial fluid, enters the blood and circulates to the liver, enters the bile, is secreted into the gut with the bile, passed into the rectum and lost in the faeces.
- Binds to the ice crystal in the interstitial fluid, enters the blood, is engulfed by macrophages, is stored in the spleen until a warming event occurs, is released from the ice crystal as it melts, circulates in the blood.
- Binds to an ice crystal in the blood, circulates to the liver, enters the bile, is secreted into the gut with the bile, passed into the rectum and then absorbed from the gut in the rectum to circulate in the blood.
- Binds to an ice crystal in the blood, enters the bile, is secreted into the gut with the bile, passed into the rectum where the ice melts and then absorbed from the gut in the rectum to circulate in the blood.

### Question 63

Which of the following statements is **NOT** correct?

- Ice ingested with food is attached to an AFGP molecule and excreted with the faeces.
- In winter, ice bound to AFGPs accumulated in the macrophages of the spleen.
- AFGPs are recycled, conserving energy.
- AFGPs are found in interstitial fluid, blood, pancreas and gut fluids.
- Antarctic icefish synthesize AFGPs in both the exocrine pancreas and the liver.

## MARINE BIODIVERSITY – THE CENSUS OF MARINE LIFE

The Census of Marine Life (2000–2010) is the largest global research programme on marine biodiversity. Its findings have recently been integrated in an article authored by Mark Costello who is based at Leigh Marine Laboratory, University of Auckland (PLoS ONE 5(8): e12110). The study found that many habitats were poorly sampled and that there are major gaps in our knowledge of marine organisms worldwide that limit our ability to understand species of economic and ecological importance.

### Question 64 - 66

The table below gives the number of endemic plants, invertebrates, and vertebrates reported for specific geographic regions. Endemic species are those found only in one specific geographical area.

NRIC region	Plants	Invertebrates	Fish	Other vertebrates	Total	Number of species	% endemics
Antarctica	—	—	—	—	3,700	8,200	45
Australia	—	7987	1298	—	9,286	32,889	28
Baltic	1	0	0	0	1	5,865	2
Caribbean	—	868	704	1	1,573	12,046	13
China	142	1387	70	2	1,601	22,365	7
Japan	—	1508	364	0	1,872	32,777	6
Mediterranean	171	844	80	3	1,098	16,845	7
New Zealand	225	6014	278	43	6,560	12,780	51
South Africa	—	3269	280	—	3,549	12,715	28
Total	538	21,639	3,074	49	25,300	150,617	17

doi:10.1371/journal.pone.0012110.t004

Note: - means no specific data is available.

### Question 64

Which area has the greatest proportion of endemic species?

- A. Antarctica
- B. Australia
- C. Japan
- D. New Zealand
- E. South Africa

### Question 65

Which area has the greatest proportion of endemic invertebrates?

- A. Antarctica
- B. Australia
- C. Japan
- D. New Zealand
- E. South Africa

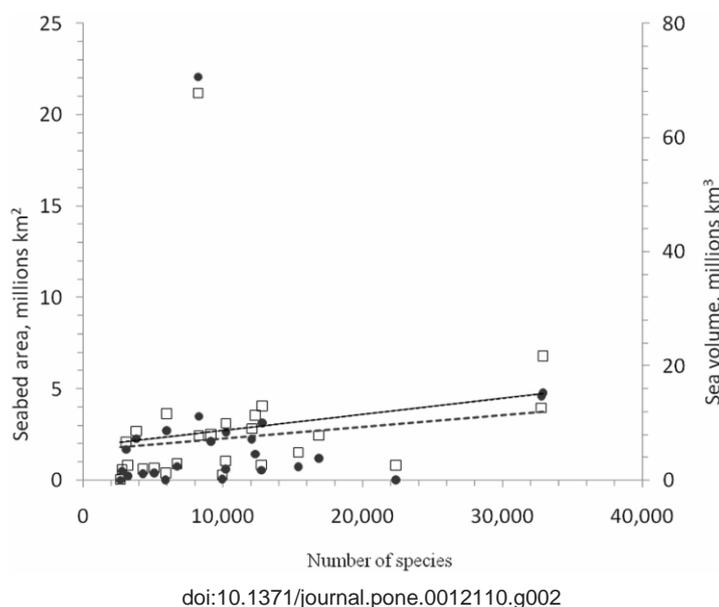
### Question 66

Which of the following statements is **INCORRECT**?

- A. Antarctica has no endemic fish.
- B. Australia has the greatest number of reported marine species.
- C. The Baltic has low endemism.
- D. Japan has no endemic other vertebrates reported.
- E. South Africa has a high proportion of marine invertebrates that are endemic.

### Question 67

The geographic regions with the most recorded species were Australia and Japan, each reporting over 32,000 species. However, South Korea, China, South Africa, Baltic Sea and Gulf of Mexico had the most species per unit area. The graph shows the relationship between total number of recorded species in each region to sea volume (solid dots, dashed line, millions km<sup>3</sup>), and seabed area (squares, solid line, millions of km<sup>2</sup>) with linear trend lines shown. The Southern Ocean, Antarctica, is the outlier at top left of graph.



From this information you can conclude:

- A. There are always more marine species in regions with a larger seabed area.
- B. Antarctica has an extremely low number of marine species given the sea volume and seabed area in this region.
- C. Australia and Japan had approximately the same number of species per seabed area.
- D. South Korea is represented by the square furthestmost to the right on the graph.
- E. There are always more marine species in regions with a larger sea volume.

### Question 68 - 69

The Census of Marine Life also examined the global threats to marine biodiversity and these are summarized in the table below.

	Overfishing	Habitat loss	Pollution	Alien species	Temperature	Hypoxia	Acidification	Total	Median
Mediterranean	5	5	4	5	5	2	1	27	5.0
Gulf of Mexico	5	5	5	4	2	3	1	25	4.0
China	5	5	5	2	2	3	1	23	3.0
Baltic	4	3	4	3	4	3	1	22	3.0
Caribbean	4	4	4	4	2	2	2	22	4.0
USA Southeast	4	4	3	3	3	2	3	22	3.0
Brazil and Tropical West Atlantic	4	4	3	3	3	3	2	22	3.0
Humboldt Current and Patagonian Shelf	4	3	3	3	2	4	2	21	3.0
North Indian Ocean	3	4	4	3	3	2	2	21	3.0
Tropical East Pacific	3	3	3	3	3	3	2	20	3.0
South Africa	3	2	4	4	2	4	1	20	3.0
New Zealand	4	3	2	4	2	1	3	19	3.0
Atlantic Europe	4	2	4	2	4	1	2	19	2.0
USA Northeast	4	3	3	2	3	2	1	18	3.0
Japan	3	3	3	2	3	1	2	17	3.0
Canada (all)	2	4	2	2	5	0	1	16	2.0
Australia	3	3	2	3	2	0	1	14	2.0
Antarctica	2	2	2	0	1	0	2	9	2.0
Total	66	62	60	52	51	36	30		
Median	4.0	3.0	3.0	3.0	3.0	2.0	2.0		

Each threat was scored from 1 to 5 (minimum to maximum) across a comparative scale among different regions. Some regions (e.g., Australia) reported only known threats rather than predicted threats. Table is sorted by reported greatest threats and areas with greatest impacts. Median values of each threat and for each region are also reported.  
doi:10.1371/journal.pone.0012110.t005

### Question 68

Worldwide, the greatest threat to marine biodiversity is?

- A. Overfishing
- B. Habitat loss
- C. Pollution
- D. Alien species
- E. Temperature

### Question 69

The region whose marine biodiversity is under the most threat from temperature changes such as global warming is?

- A. Mediterranean only
- B. Mediterranean and Canada
- C. Mediterranean and Baltic
- D. Canada and Baltic
- E. Canada only

## NEW ZEALAND & BEYOND – MARINE PLASTIC POLLUTION, A GLOBAL ISSUE

Canterbury Museum ornithologist Paul Scofield, who does autopsies on 400 muttonbirds caught accidentally by fishing boats every year, has shown that most New Zealand seabirds have plastics in their stomachs. He has also found red Coke bottle tops, cigarette lighters, pieces of fishing buoys and other plastic material in Albatross colonies on Campbell Island, 700 km south of Bluff. He has also seen albatross chicks that have died because they had so much plastic in their stomachs there was no room for food.

Marine plastic pollution is a major threat to seabirds and of growing concern worldwide. Seabirds that feed on the surface of the ocean by dipping or scavenging, such as albatross, are at greatest risk. They can mistake pieces of plastic for their normal food of squid, crustaceans such as krill, fish eggs (typically attached to floating pumice and seeds) and fish larvae. Types of plastic ingested by albatross include single-use “user” plastic e.g. bottle caps, plastic toys, cigarette lighters, light sticks, industrial pellets known as nurdles, and fishing floats. Seabirds such as the albatrosses also eat fishing line.

Albatross feed their chicks by regurgitating food into the chick’s mouth. Plastics ingested in error by the adults are also fed to their chicks in this way. Albatross chicks regurgitate a bolus of indigestible remains just before they leave the nest to begin their ocean-going adult life. This bolus should contain the indigestible remains of fish (50%), squid (32%), crustacea (5%) and stomach oil (10%). In recent years studies have shown albatross bolus’ to contain natural indigestible materials, primarily squid beaks, and un-natural indigestible materials such as plastics. If the parents are feeding lots of plastics to the chicks the chicks grow more slowly as they become easily satiated (full feeling). Chicks can become so full of plastic that they are unable to regurgitate a bolus and die. (Information in this section is from: Oikonos, Ecosystem Knowledge. [http://www.oikonos.org/projects/oceanstewardship\\_projects.htm](http://www.oikonos.org/projects/oceanstewardship_projects.htm) and approved for educational use)



A recently dead Laysan Albatross chick with its belly full of plastic.

Photo: Claire Johnson/NOAA



Rinsing 306 pieces of plastic debris from the stomach of the albatross chick.

Photo: Claire Johnson/NOAA

Using the information provided in this paper, together with that provided **IN YOUR RESOURCE PACK**, answer the following questions.

**Question 70**

Squid possess hardened beaks used for gripping and ripping apart their prey. These beaks are extremely hard and indigestible. They are commonly found in the stomachs of seabirds and marine mammals that prey on the squid. Typically, these organisms regurgitate the indigestible beaks rather than allowing them to pass through the gut to be excreted with the faeces.



Count the number of “Extra large plastic fragments” in Bolus 1 and **record your answer on your answer sheet**.

**Question 71**

We can investigate the composition of a bolus in detail and then compare how similar different bolus' are using a Percent Similarity Index (PSI). Total PSI values of 100 indicate 100% overlap; values of >80% can be considered similar.

Bolus 3 and 4 have been analysed for you and the results recorded in the table. You are to calculate the PSI by choosing the smallest value of the percent numerical abundance (% NA) for each item and entering this value in the PSI column at right. The first PSI value for squid beaks has been done for you. The PSI values are then summed to obtain overall PSI (dark grey box at bottom right). Record your value for the overall PSI (rounded to the nearest whole number) on your answer sheet.

	Bolus #3		Bolus #4		PSI
	Count	%NA	Count	%NA	
<b>Squid beaks</b>	47	37.0	63	43.4	37.0
<b>Fishing line</b>	4	3.1	3	2.1	
<b>Whole Plastic Items</b> eg bottle caps	2	1.6	5	3.4	
<b>Extra large plastic fragments</b> (≥50 mm)	0	0	0	0	
<b>Large plastic fragments</b> (≥.20 mm and < 50 mm)	4	3.1	6	4.1	
<b>Medium plastic fragments</b> (< 20 mm and ≥10 mm)	5	3.9	8	5.5	
<b>Small plastic fragments</b> (<10 mm)	62	48.8	55	37.9	
<b>Other</b>	4	3.1	4	2.8	
<b>TOTAL</b>	127		145		

Note: % numerical abundance (NA) for each item in each bolus is calculated as follows: % NA = count/total\*100

### Question 72

Calculate the length of the piece of white plastic second from the top in Bolus 2. Record this value on your answer sheet.

### Question 73

You will note when looking at the dissected bolus' that coloured plastic is more common than transparent and that much of the plastic is red or orange, rather than blue. What is the **LEAST LIKELY** inference that can be drawn from these observations?

- A. Albatross select specific colours, mistaking them for prey items such as crustaceans.
- B. Albatross are non-selective feeders and consume plastic debris in proportion to its abundance.
- C. Transparent items are harder to see and are therefore seldom consumed by albatross.
- D. Coloured plastic items are more easily seen and therefore consumed by albatross.
- E. Blue plastic items are harder to see and are therefore seldom consumed by albatross.

### Question 74

About 80% of marine debris comes from sources on land and much of this debris is plastic. Charles Moore from Algalita Marine Research Foundation first published an article about marine debris in the November 2003 issue of the Journal Natural History. He showed that the dominant feature in the North Pacific Ocean is the North Pacific Gyre, a large water mass that is rotating in a clockwise direction and can trap debris originating from across the Pacific. Floating debris accumulates in the "eastern garbage patch", an area the size of Texas. There is approximately 250 g of plastic for every 100 m<sup>2</sup> of sea surface in the "eastern garbage patch".

Scientists use satellite telemetry to track the movement of albatross. IN 2004 9 albatross where fitted with satellite tags and their position recorded from July to October.

With reference to Figure 3 in your Resource Pack, which Albatross is likely to have ingested the MOST plastic debris?

- A. bfal\_36634 (red)
- B. bfal\_36635 (peach)
- C. bfal\_36636 (blue)
- D. bfal\_36639 (lime green)
- E. bfal\_36641 (pink)

## Question 75

Three factors influence the incidence of seabird ingestion of plastics: (1) foraging mode, (2) habitat use and (3) body size. Far-ranging species that feed opportunistically at the sea surface are most susceptible to plastic ingestion. Surface feeders have a greater rate of plastic ingestion. Diving birds also eat plastic but are not as susceptible as surface feeders. Oceanic species - which commonly range over vast areas in search of broadly distributed prey – seem more prone to plastic ingestion than coastal species – which target dense aggregations of fish and zooplankton prey. Finally, because larger seabirds consume larger prey items, large-bodied species often ingest larger plastic fragments.

Seabirds in New Zealand come from four orders:

- Sphenisciformes – penguins
- Procellariiformes – albatrosses, shearwaters and other petrels
- Pelecaniformes – shags, gannets and their kin
- Charadriiformes – terns, gulls and skuas.

Penguins live only in the southern hemisphere. Of all the birds, penguins are the most accomplished divers, with some species capable of reaching depths of 100 metres or more. Their small wings or flippers, stiff oily plumage, dense bones and thick fat deposits are all adaptations to diving. They catch fish, crustaceans (such as krill) and squid by underwater pursuit.

The order Procellariiformes has about 124 species around the world. They range in size from tiny 35-gram storm petrels to huge albatrosses weighing in at 9 kilograms, with a 3.5 metre wingspan. These birds find all their food at sea, and most species come to land only to breed. Petrels and shearwaters are adept divers – some shearwaters regularly dive to 60 metres. Storm petrels, prions and albatrosses obtain their food close to the water's surface.

Shags pursue their prey under water, using their feet to propel themselves whereas gannets sight fish while flying overhead and capture them by plunging into the water.

Most members of the order Charadriiformes are not marine species. Gulls and some terns take a large proportion of their food ashore or from freshwater habitats. However, some tern species and all skuas are largely marine, and both of these groups have New Zealand representatives. Marine terns such as the white-fronted tern (*Sterna striata*) feed by dipping – hovering above the water then dropping to catch surface-shoaling fish. Skuas are well-known predators of eggs, chicks and small birds at seabird colonies but they do in fact take a large proportion of their food at sea, often by harassing smaller seabirds and forcing them to regurgitate their food. (information from Te Ara The encyclopedia of New Zealand).

Which of the following New Zealand seabirds would be at **MOST** risk of harm from marine debris?

- A. Little Blue penguins
- B. Shearwaters
- C. Storm petrels
- D. Australasian gannet
- E. Skua

We all have an obligation to learn about our planet and to protect it from harm. NZIBO hopes you have enjoyed this exam and have learnt a little about the biological scientists working in New Zealand to understand and protect our wonderful planet. We wish you well with your biology studies this year, regardless of whether you are selected for the tutorial programme. Thank you for taking the time to sit this exam.



# NZ INTERNATIONAL BIOLOGY OLYMPIAD

2012 – 13 National Entrance Exam

## ANSWER KEY

Name: *(print clearly)* \_\_\_\_\_

School: *(print clearly)* \_\_\_\_\_

### Instructions:

- Write your **NAME** and **SCHOOL** in the space provided above.
- Answer **ALL** 75 questions.
- Use a pencil to shade in the answers you consider correct as shown below or enter a value in the space provided.

	A	B	C	D	E
x					

- If you make a mistake, carefully rub out your answer and enter your new choice.

	A	B	C	D	E
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### Enter a value

70	1
71	88 NOT 88.4
72	10.8 cm

	A	B	C	D	E
73					
74					
75					



# National Entrance Exam 2012-13 Resource Pack

**Figure 1.** Dissected Albatross Bolus # 1

**Figure 2.** Dissected Albatross Bolus # 2

**Figure 3.** Map of the North Pacific showing the location of the “eastern garbage patch” and nine tracked Black-footed Albatross.



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NEW ZEALAND



THE UNIVERSITY  
OF AUCKLAND  
FACULTY OF SCIENCE



MASSEY UNIVERSITY  
TE KUNENGA KI PŪREHUROA

Bolus 1

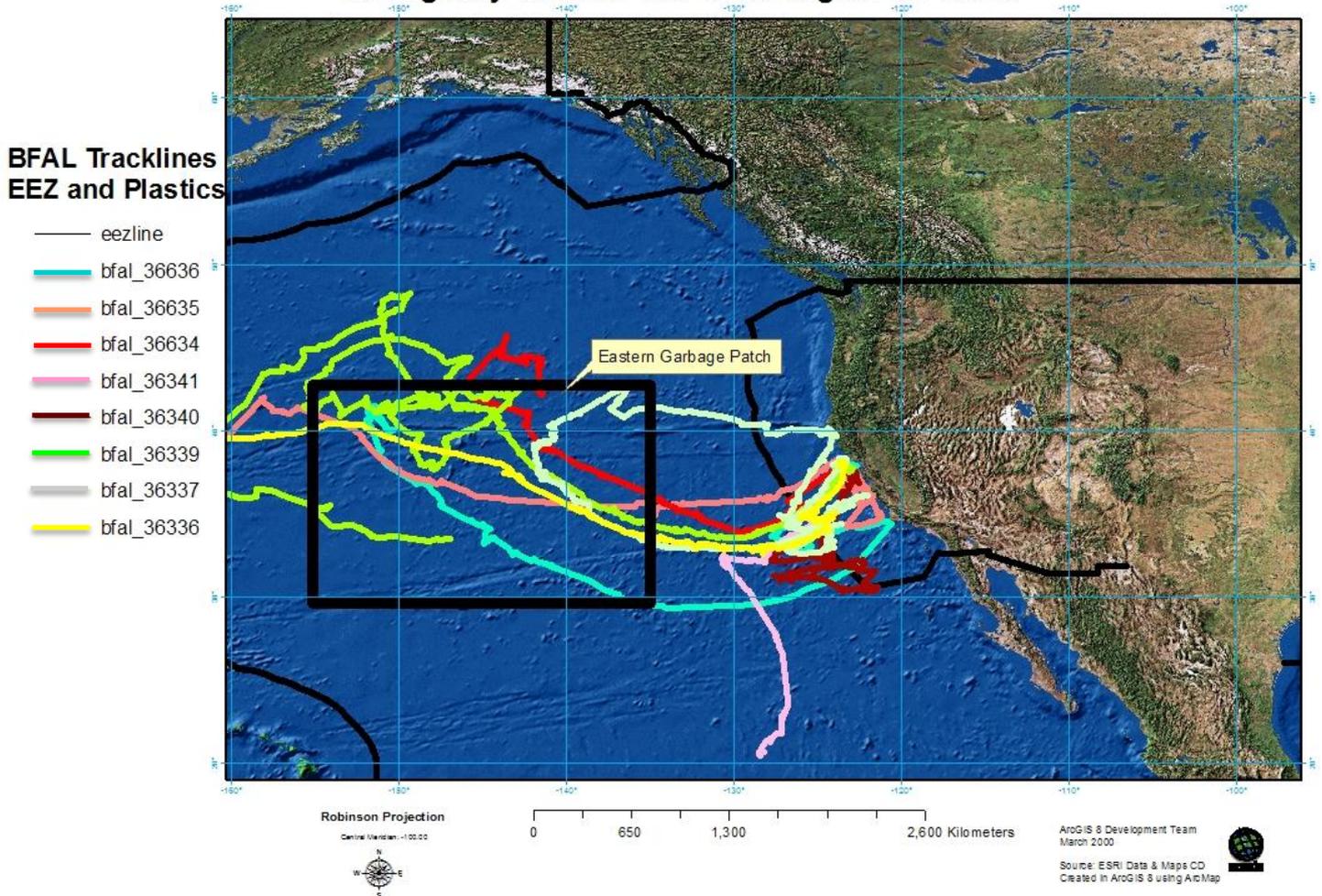


Bolus 2



Map of the North Pacific showing the location of the “eastern garbage patch” and nine tracked Black-footed Albatross.

### Locations of nine tracked Black-footed Albatross during July-October 2004 and Region of Plastic



Plastic zone data courtesy of Algalita Marine Research Foundation (AMRF). See [www.algalita.org](http://www.algalita.org)

## 2010 – 11 New Zealand International Biology Olympiad Programme



### SELECTION EXAMINATION – 23 February 2011

This examination consists of 75 multi-choice questions on tutorials 1 – 5; Cell Structure & Function, Ecology, Plant Anatomy & Physiology, Animal Behaviour, and Genetics & Evolution (75 marks).

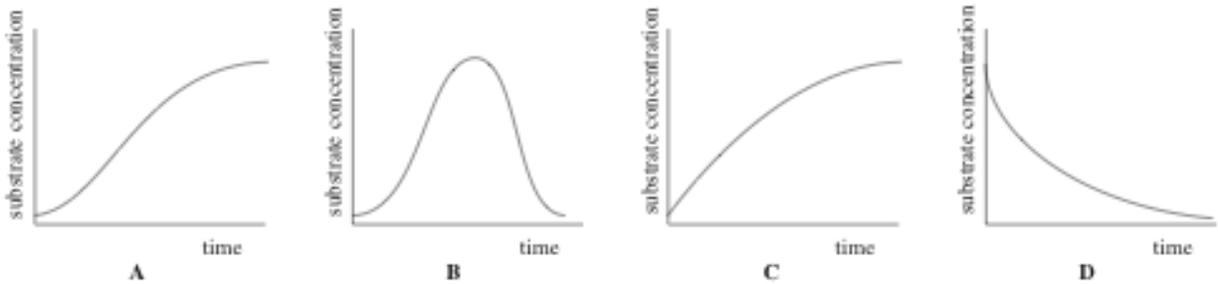
**Time allowed:** 2 hours.

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**Tutorial 1 – Cell Structure & Function (10 marks)**

**Q1.** Which one of the following graphs best represents the changes in substrate concentration during the course of an enzyme reaction *in vitro*?



**Q2.** Which of the following correctly lists the flow of membrane lipids and proteins through the organelles of the endomembranous system of a eukaryotic cell.

- A. Rough ER → smooth ER → transport vesicles → Golgi → plasma membranes
- B. Nuclear envelope → rough ER → smooth ER → transport vesicles → Golgi → transport vesicles → plasma membranes
- C. Nuclear envelope → rough ER → transport vesicles → smooth ER → transport vesicles → Golgi → plasma membranes
- D. Nuclear envelope → rough ER → transport vesicles → smooth ER → transport vesicles → Golgi → transport vesicles → plasma membranes
- E. Rough ER → smooth ER → transport vesicles → Golgi → transport vesicles → plasma membranes

**Q3.** During an investigation of mitochondrial metabolism, isolated mitochondria were maintained in a solution of 0.4 molar sucrose. The sucrose solution was used

- A. as a respiratory substrate
- B. to buffer the pH of the medium
- C. as a carbon source of Krebs (tricarboxylic acid) cycle intermediates
- D. to prevent the mitochondrial membranes rupturing

**Q4.** Part of the citric acid cycle is represented below.



If the enzyme responsible for the conversion of succinate to fumarate became inactive, which one of the following would **NOT** occur?

- A. some accumulation of succinate
- B. a halt in the production of malate
- C. gradual disappearance of fumarate
- D. continued conversion of  $\alpha$  -ketoglutarate
- E. an increase in the concentration of  $\alpha$  -ketoglutarate

**Q5.** Plasmolysis occurs when living plant cells such as those of the onion bulb scale epidermis, are placed in strong sugar solution. After plasmolysis, which one of the following occupies the region between the plasma membrane and the cell wall?

- A. sugar solution
- B. pure vacuolar sap
- C. diluted vacuolar sap
- D. water
- E. air

**Q6.** In the Hill reaction, methylene blue may be reduced by illuminated isolated chloroplasts. The donor of electrons is

- A. Water
- B. Chlorophyll
- C. Oxygen
- D. ATP
- E. NADP

- Q7.** Contractile vacuoles are found in a wide variety of unicellular organisms, but not in the cells of mammals. This is because mammalian cells
- have membranes that are not selectively permeable
  - are generally surrounded by solutions with the same solute potential
  - have ionic pumps
  - expend energy to maintain cell volume
  - are more osmotically resistant to osmotic stress
- Q8.** Which one of the following steps represents the essential link between the light-dependent and light-independent stages of photosynthesis?
- photolysis of water and photophosphorylation
  - carbon dioxide fixation
  - activation of chlorophyll molecules
  - production of reduced electron carriers and photophosphorylation
  - reduction of phosphoglycerate
- Q9.** In chloroplast lamellae, the photosystems comprise proteins and are embedded in a phospholipid bilayer. To extract the two photosystems in a functional state the best treatment would be to
- use a mild detergent
  - boil and cool the chloroplast
  - denature the membrane proteins with acid
  - reduce the chlorophyll molecules by illumination
  - separate by differential centrifugation
- Q10.** Four important steps in meiosis are
- |     |                                   |
|-----|-----------------------------------|
| I   | pairing of homologous chromosomes |
| II  | chromatids moving apart           |
| III | division of the centromeres       |
| IV  | replication of DNA                |

The correct order of these steps is

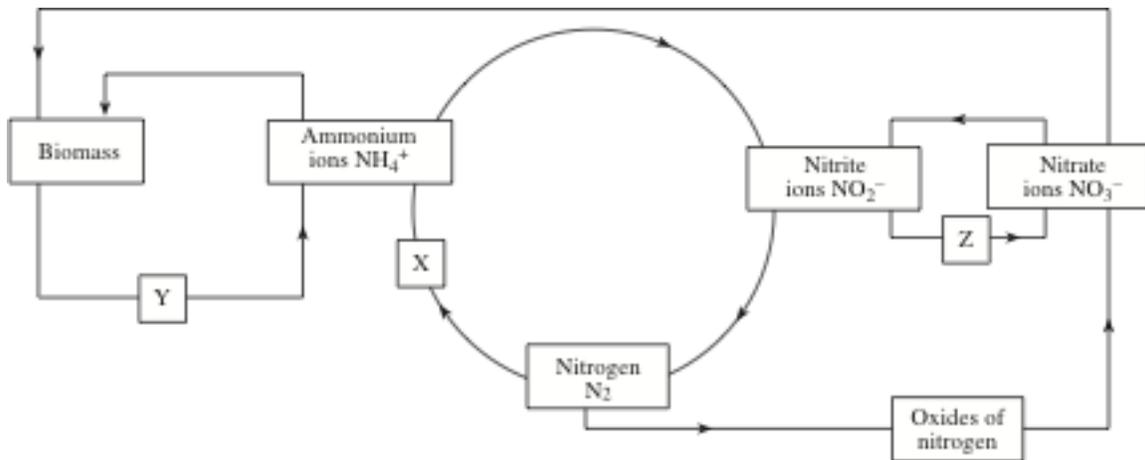
- IV → I → II → III
- IV → III → I → II
- IV → II → I → III
- IV → I → III → II
- I → II → IV → III

**Tutorial 2 – Ecology (13 marks)**

- Q11.** When an animal population is being estimated by the capture-recapture technique, which one of the following would lead to the size of the population being underestimated?
- a higher predation of marked than of unmarked animals
  - a greater attraction of marked than of unmarked animals to traps
  - an immigration of animals into the area between samplings
  - a high but proportionately equal mortality of both marked and unmarked animals
  - emigration of a higher proportion of marked than unmarked individuals from the sampling area

**QUESTIONS CONTINUED ON THE NEXT PAGE**

**Q12.** The diagram below represents the nitrogen cycle.



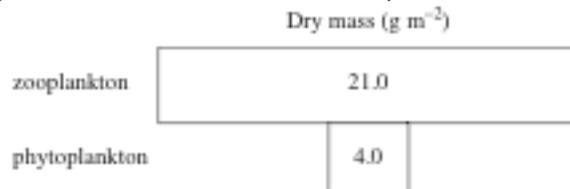
Which one of **A to E** correctly identifies the events happening at points X, Y and Z in the cycle?

	X	Y	Z
<b>A.</b>	Non-biological nitrogen fixation	Decay by microorganisms	Nitrification
<b>B.</b>	Biological nitrogen fixation	Nitrification	Denitrification
<b>C.</b>	Non-biological nitrogen fixation	Decay by microorganisms	Denitrification
<b>D.</b>	Non-biological nitrogen fixation	Nitrification	Denitrification
<b>E.</b>	Biological nitrogen fixation	Decay by microorganisms	Nitrification

**Q13.** Which one of the following assumptions is not necessary in order to estimate the size of an isolated mouse population, using the capture/mark/recapture method?

- A.** Marked and unmarked mice are randomly distributed in the population
- B.** Recaptured mice are a random sample of the population
- C.** There is no difference in the survival of marked and unmarked mice
- D.** Marked and unmarked mice have the same reproductive success
- E.** Marked and unmarked mice are equally likely to be recaptured

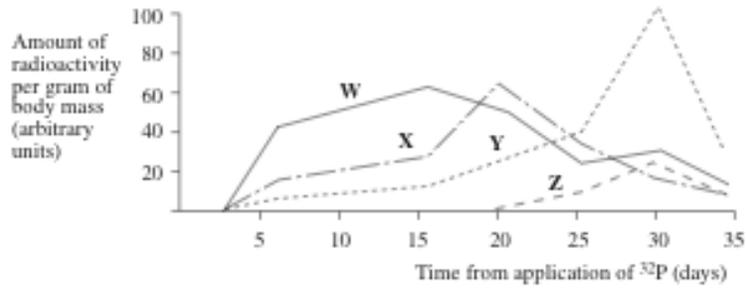
**Q14.** The diagram represents a pyramid of biomass based on samples taken from marine plankton.



Which one of the following statements best explains this inverted pyramid?

- A.** The sampling technique was incorrect
- B.** The whole of the phytoplankton material is not eaten by the zooplankton
- C.** The productivity of the zooplankton must be higher than that of the phytoplankton
- D.** The productivity of the phytoplankton must be higher than that of the zooplankton
- E.** The zooplankton must be recycling energy

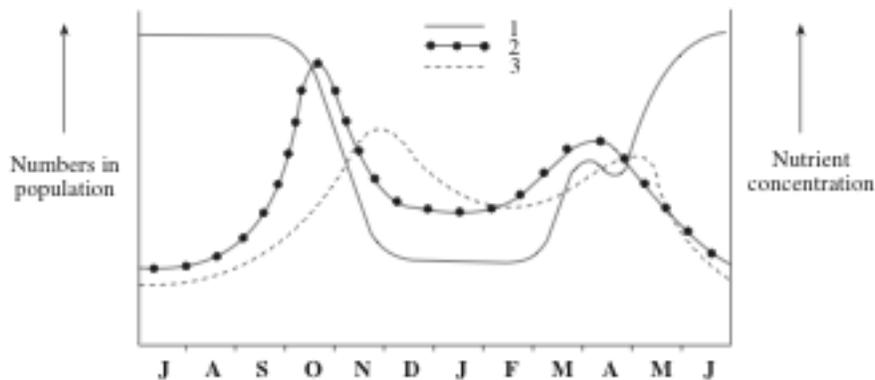
**Q15.** Radioactive phosphate ( $^{32}\text{PO}_4$ ) was applied to a plot of natural grassland. During the next 35 days, samples of four species of arthropod were investigated for radioactive content. The graph shows the relative amounts of radioactivity found in the four species, W, X, Y and Z.



Which one of the rows **A – E** represents the organisms in the graph?

	<b>W</b>	<b>X</b>	<b>Y</b>	<b>Z</b>
<b>A.</b>	decomposer	herbivore	herbivore	carnivore
<b>B.</b>	herbivore	carnivore	decomposer	herbivore
<b>C.</b>	carnivore	herbivore	decomposer	herbivore
<b>D.</b>	grasses	herbivore	carnivore	decomposer
<b>E.</b>	herbivore	herbivore	carnivore	decomposer

**Q16.** The graph refers to the surface layers of the Tasman Sea. It shows the seasonal changes in numbers of phytoplankton and zooplankton, and in inorganic nutrient concentration.



Which one of the following sequences correctly represents the passage of nutrients through the ecosystem?

- A. 1 → 2 → 3
- B. 1 → 3 → 2
- C. 2 → 1 → 3
- D. 2 → 3 → 1
- E. 3 → 2 → 1

**Q17.** Which one of the following conditions is essential to maintain a large, balanced fresh-water community?

- A. The number of autotrophs must be greater than the number of heterotrophs
- B. The productivity of the plants must be greater than the productivity of the animals
- C. The energy lost by the plants must not exceed the energy lost by the animals
- D. The number of carnivores must not exceed the number of herbivores
- E. The total biomass of the autotrophs must exceed the total biomass of the heterotrophs

- Q18.** Increasing the supply of food from a limited area of land could best be achieved by increasing the
- gross production of the producers
  - net production of the producers
  - rate of energy turnover of the producers
  - net production of the primary consumers
  - density of the primary consumers
- Q19.** The stellate barnacle, *Elminius modestus*, is found in the midlittoral zone of New Zealand's estuaries and sheltered rocky shores. The barnacle is hermaphroditic, though it requires cross-fertilization. It reaches sexual maturity about 8 weeks after settling and an average sized animal produces about 1800-4000 eggs (Barnes & Barnes, 1968). The generation time is short and up to 12 successive broods are produced, 2 weeks apart. The nauplius larvae hatch and develop into cypris larvae which are attracted to places where adult conspecifics are present, settling and maturing into the adult barnacle.

The dispersion pattern and type of survivorship curve shown by this species is

- Clumped, I
  - Uniform, I
  - Clumped, II
  - Clumped, III
  - Uniform, III
- Q20.** Which of the following is **NOT** a density-dependent factor that influences population density
- Competition
  - Disease
  - Drought
  - Toxic waste
  - Predation
- Q21.** 10 different Australian honeyeaters are found in the Mount Lofty Ranges near Adelaide, South Australia. The species differ in beak length with shorter beaked species feeding chiefly on insects and longer -beaked species feeding more often on flowers. Insect eating species may glean insects from leaves and bark or capture them in the air. The co-existence of these species in the same habitat is an example of
- Competition
  - Resource partitioning
  - Character displacement
  - Competitive exclusion

- Q22.** The following table shows the interaction between pairs of species

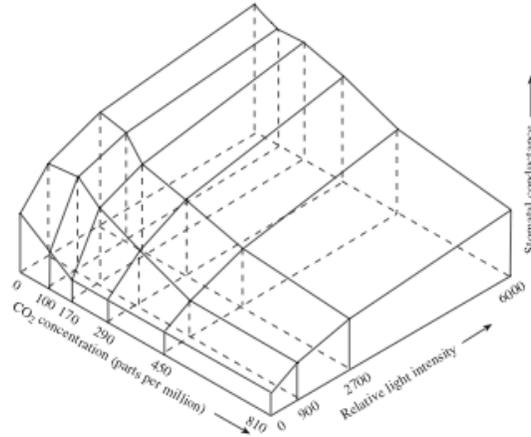
Pair	Species 1	Species 2
1	0	+
2	-	+
3	+	+
4	+	-
5	+	-

Which one of the following gives the correct type of interactions for species 1 – 5

- mutualism, parasitism, commensalism, herbivory, predation
  - mutualism, parasitism, commensalism, predation, herbivory
  - commensalism, parasitism, mutualism, herbivory, predation
  - commensalism, herbivory, parasitism, mutualism, predation
- Q23.** Which of the following factors is likely to increase species diversity in a forest community?
- Moderate levels of disturbance
  - Stable conditions with low disturbance
  - Human protection of the community to prevent disturbance
  - Intensive human disturbance
  - Frequent natural disturbance such as fires and floods

**Tutorial 3 – Plant Anatomy & Physiology (19 marks)**

**Q24.** Measurements of the rate of diffusion through stomata ('stomatal conductance') were made under various CO<sub>2</sub> concentrations, and the following stereograph was drawn.



Which one of the following is a valid deduction from the stereograph?

- A. Stomatal conductance is maximal when conditions for photosynthesis are optimal
- B. Increasing light intensity increases stomatal conductance at all CO<sub>2</sub> levels shown
- C. Stomatal conductance is unaffected by an increase in CO<sub>2</sub> concentration from 170 to 810 p.p.m
- D. Changes in CO<sub>2</sub> concentration have a greater influence on stomatal conductance than changes in light intensity
- E. Changes in light intensity have a greater influence on stomatal conductance than changes in CO<sub>2</sub> concentration

**Q25.** The table shows the amount of plant hormone that passes through short segments of young stems when it is applied either to the end nearest to the shoot-tip or to the end furthest from the shoot tip. Three experiments were carried out under different conditions as indicated below.

Site of hormone application	Amount of hormone passing through stem (arbitrary units)		
	At 3 °C	At 25 °C	At 25 °C + cyanide
basal end	3.3	3.8	3.9
apical end	3.5	15.9	4.2

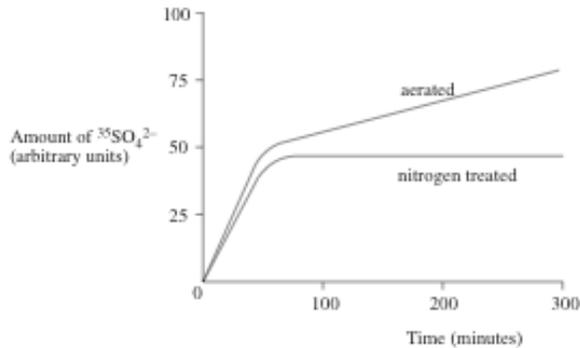
The best interpretation of these results is that

- A. the hormone used was auxin
- B. the hormone shows unidirectional transport
- C. active transport of the hormone occurs
- D. diffusion accounts for the transport of the hormone
- E. diffusion speeds up with rise in temperature

**Q26.** When plant cells from the zone of elongation are compared with those from the apical meristem, they have

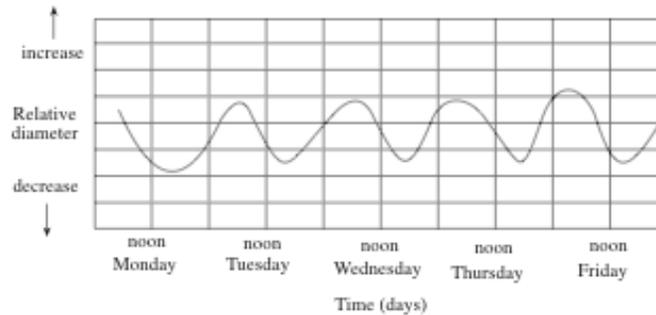
- A. a larger surface area to volume ratio
- B. a higher proportion undergoing mitosis
- C. a larger nuclear to cytoplasmic ratio
- D. more prominent vacuoles
- E. a larger number of ribosomes

- Q27.** In photosynthesis, light is most directly involved in
- reduction of  $\text{CO}_2$  to phosphoglycerate
  - synthesis of starch
  - release of oxygen from  $\text{CO}_2$
  - splitting of water
  - regeneration of ribulose biphosphate
- Q28.** Portions of roots were immersed in culture solutions containing radioactive sulfur as  $^{35}\text{SO}_4^{2-}$ . One set was aerated and a second set had nitrogen bubbled through it. The amount of  $^{35}\text{SO}_4^{2-}$  in the roots was measured at intervals and the results are shown in the graph below.



- From these results the *best* conclusion is that
- the nitrogen interferes with ATP production
  - passive diffusion of  $^{35}\text{SO}_4^{2-}$  occurs between the solution and the roots
  - the uptake of  $^{35}\text{SO}_4^{2-}$  is an active process
  - the uptake of  $^{35}\text{SO}_4^{2-}$  involves both active and passive processes
- Q29.** Which one of the following can only be explained by mass flow of solutes through the phloem?
- Sap is exuded when a sieve tube element is pierced
  - The phloem conducts heat longitudinally only in the direction in which solutes are being transported
  - Movement through the phloem ceases when living cells in the stem are killed by heat
  - Metabolic inhibitors stop solute flow through the phloem
  - A sudden reduction in sap pressure causes precipitation of p-protein
- Q30.** Phloem tissue, taken from the storage root of carrot plants, and cultured on a nutrient medium, will produce completely new carrot plants. This is possible because the phloem cells
- are not fully differentiated
  - synthesise the necessary growth hormone
  - are genetically totipotent
  - are normally meristematic
  - retain the capacity to divide after differentiation
- Q31.** In still air, the transpiration rate is low because
- stomata open more when the diffusion gradient changes.
  - the concentration gradient of water molecules is reduced
  - the water molecules move more slowly
  - root pressure is reduced
  - water molecules are more strongly attracted to each other
- Q32.** The light reaction of photosynthesis can be made to occur experimentally in the absence of
- water
  - carbon dioxide
  - chlorophyll
  - ADP
  - NADP

**Q33.** The relative diameter of a tree trunk was measured over a period of several days. The results are shown in the graph.



The best hypothesis to explain these data is that in a transpiring plant

- A. phloem tissue is not involved in transpiration
  - B. root pressure reaches a maximum value just after noon
  - C. xylem vessels are sometimes under tension
  - D. water is transported in the xylem vessels
  - E. the rise of sap shows an endogenous rhythm
- Q34.** A homozygous tall maize plant is fertilised by a dwarf maize plant. From which one of the following tissues of the resultant grain will the allele for dwarfness be **absent**?
- A. cotyledon
  - B. endosperm
  - C. fruit wall
  - D. coleoptile

**Q35.** Two species of plant, X and Y, were grown in each of two regimes of day length, and their flowering response recorded.

Regime 1: 8 hours daylight, 16 hours darkness;  
Result: X flowered, Y did not flower.

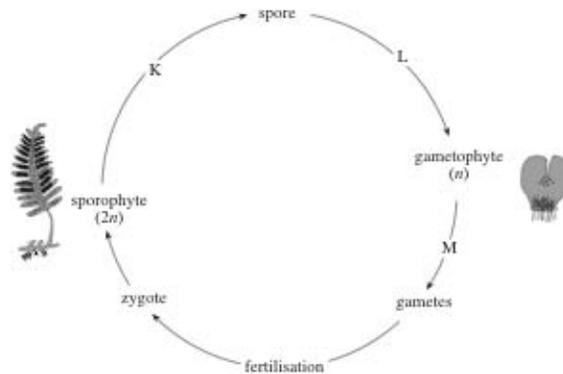
Regime 2: 8 hours of daylight, 16 hours of darkness, interrupted after 8 hours by 10 minutes of bright light from an incandescent lamp;  
Result: X and Y both flowered.

The probable explanation of these results is that

- A. X is a long-day plant, Y is a short-day plant
  - B. X is a long-day plant, Y is a day-neutral plant
  - C. X is a day-neutral plant, Y is a long-day plant
  - D. X is a day-neutral plant, Y is a short-day plant
  - E. X is a short-day plant, Y is a long-day plant
- Q36.** A vacuolated plant cell is equilibrated in pure water, and then transferred to a sucrose solution with a water potential of  $-800$  kPa. Which one of the rows **A - D** shows what would happen next?

	Direction of net water movement	Pressure potential ( $\psi_p$ )
<b>A.</b>	into cell	increases
<b>B.</b>	out of cell	decreases
<b>C.</b>	into cell	decreases
<b>D.</b>	out of cell	increases

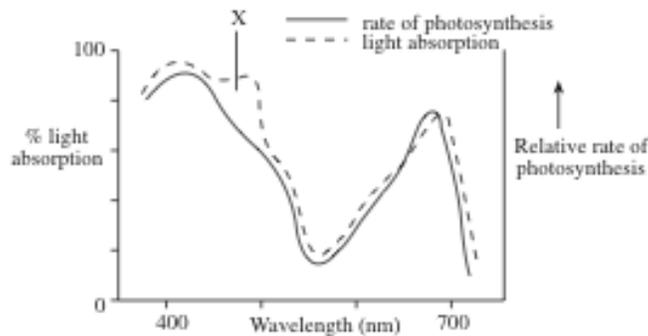
**Q37.** The diagram represents the life cycle of a fern, with the stages drawn to different scales.



Which one of the rows A to E correctly represents the nuclear events occurring at stages K, L and M?

	K	L	M
<b>A.</b>	mitosis	meiosis	mitosis
<b>B.</b>	mitosis	mitosis	meiosis
<b>C.</b>	mitosis	meiosis	meiosis
<b>D.</b>	meiosis	meiosis	mitosis
<b>E.</b>	meiosis	mitosis	mitosis

**Q38.** The graph shows the effect of wavelength of light on the rate of photosynthesis and on the amount of light absorbed by the pigments in a green seaweed.



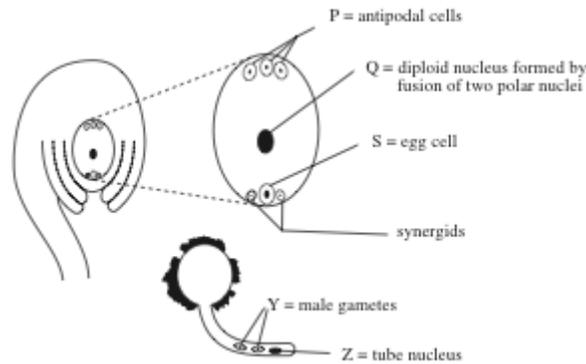
The difference between the two curves at X is due to

- A. inefficient trapping of light energy by the chlorophyll
- B. no production of ATP at that wavelength
- C. photorespiration occurring at that wavelength
- D. carotenoids absorbing light that is not then used in photosynthesis
- E. fluorescence of carotenoids

**Q39.** During the light-dependent reactions of photosynthesis,  $\text{NADP}^+$  is converted into  $\text{NADPH}$ . This requires the addition of

- A. one hydrogen atom
- B. one electron and a  $\text{H}^+$  ion
- C. two electrons and a  $\text{H}^+$  ion
- D. two  $\text{H}^+$  ions and an electron
- E. two electrons and two  $\text{H}^+$  ions

- Q40.** If light were a limiting factor, the rate at which bubbles of gas would be given off by *Elodea* (a pondweed), when exposed to a small but bright light source, would be increased four-fold if
- the light were placed at half of the original distance from the plant
  - the light were placed at a quarter of the original distance from the plant
  - the temperature were raised 10 °C
  - the carbon dioxide supply were increased four-fold
  - the carbon dioxide supply were doubled
- Q41.** Which one of the following would *not* increase the rate of water uptake from soil to root?
- an increase in the concentration of soluble metabolites in root cells
  - a decrease in the concentration of mineral ions in the soil
  - an increase in root surface area
  - a decrease in pressure potential of the root xylem sap
  - a decrease in the concentration gradient of soluble metabolites across the root cortex
- Q42.** The diagrams show vertical sections of an ovule and of a pollen grain from the same species of flowering plant.



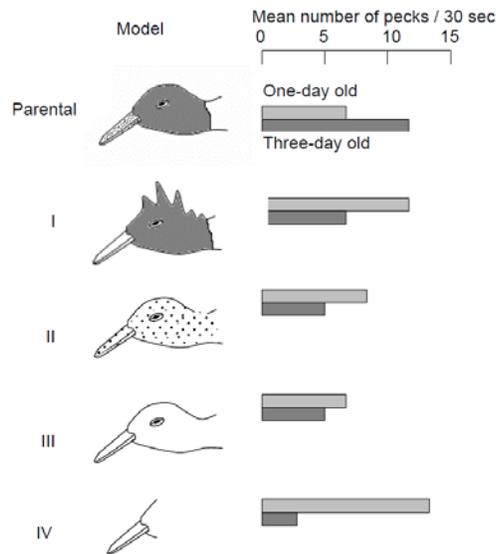
Which one of the following combinations, **A – E**, represents the structure which, after fertilisation, becomes the endosperm?

- Z + Q
- Z + S
- Y + S
- P + Y
- Y + Q

**QUESTIONS CONTINUED ON THE NEXT PAGE**

**Tutorial 4 – Animal Behaviour (7 marks)**

- Q43.** A male Siamese fighting fish will respond to a model fish by producing a threat display. With continued presentation of the model fish the response is reduced. This is an example of
- classical conditioning
  - imprinting
  - operant conditioning
  - habituation
  - a simple reflex
- Q44.** A series of experiments were conducted with one-day and three-day old chicks. The one-day old chicks were removed from the parents at hatching whereas the three-day old chicks had been reared with their parents until the time of the experiment. Both sets of chicks were presented with models of the parent head and the following responses obtained:



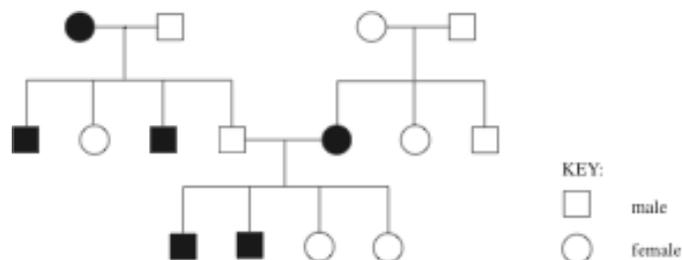
Which is the best interpretation of these results?

- Pecking behaviour is a fixed action pattern where any long pointed object acts as an equally effective stimulus.
  - The pecking rate of laughing gull chicks increases with age
  - The response of one-day old chicks is more pronounced when the model is closer to that of the parent
  - The act of pecking is an innate behaviour whilst the discriminatory capacity of the chick is a result of learning
  - Pecking behaviour is triggered by a sign stimulus, the head colour of the adult gull
- Q45.** The flatworm (*Dendrocoelum lacteum*) increases its rate of turning as light intensity increases and, as a consequence, is found aggregated in dark places. This is an example of:
- Negative klinokinesis
  - Klinokinesis
  - Negative phototaxis
  - Orthokinesis
  - Negative orthokinesis

- Q46.** The tamarin, a New World monkey, lives in groups containing a dominant female who suppresses ovulation in subordinates, causing her to be the only one capable of reproduction. The dominant female births multiple offspring fertilized by more than one male. The males have a high investment in the care of the offspring with males often carrying infants on their backs, even when they are not the father. Both related and unrelated males cooperate to care for the young. Which of the following terms best describes the behavior of the female tamarins?
- Monogamy
  - Polygamy
  - Polygyny
  - Polyandry
  - Promiscuity
- Q47.** Blue jays are omnivorous birds who supplement their vegetarian diet with insects. When a blue jay eats a monarch butterfly the foul taste of the butterfly causes the blue jay to vomit up the food. Blue jays who have previously consumed a monarch butterfly will avoid them in future with the result that wild monarch butterflies are less susceptible to natural predation by blue jays than other species of butterfly. The blue jays avoidance of monarch butterflies as a food is a result of:
- Habituation
  - Classical conditioning
  - Operant conditioning
  - Observational learning
  - Insight learning
- Q48.** Vampire bats feed solely on blood and can only survive about two days without a meal. When a bat fails to find food it will “beg” from other members of the colony. The other bat will then regurgitate a small amount of blood, even if the “begging” bat is unrelated. This reciprocal altruism is
- largely limited to species living in stable social groups
  - adaptive only if the aided individual returns the favour at a later date
  - seen when there are likely to be negative consequences associated with not returning favours
  - B and C only
  - A, B and C
- Q49.** Which of the following is **NOT** true of a typical co-operative breeding system in birds?
- It involves breeding pairs plus helpers
  - the group defends an all-purpose territory
  - helpers are genetically related to the breeding pair
  - helpers are usually only females
  - all of the above are true

**Tutorial 5 – Genetics & Evolution (26 marks)**

- Q50.** The diagram shows the pedigree of a human family in which the individuals marked with shaded symbols are deaf.



- Deafness in this family is inherited as
- an autosomal dominant characteristic
  - an autosomal recessive characteristic
  - an X-linked dominant characteristic
  - an X-linked recessive characteristic
  - a Y-linked characteristic

**Q51.** Day-old chicks are difficult to sex but their down feathers will reveal the effects of a sex-linked dominant allele called 'barred'. In birds the female is the heterogametic sex. Which one of the following crosses allows correct sexing of the resultant chicks?

	Hen	Cock
<b>A.</b>	barred	heterozygous barred
<b>B.</b>	unbarred	homozygous barred
<b>C.</b>	barred	unbarred
<b>D.</b>	unbarred	heterozygous barred

**Q52.** A population in Hardy-Weinberg equilibrium has a frequency of a particular recessive allele of 0.2. The percentage of heterozygotes in the population would be

- A. 0.16
- B. 0.8
- C. 16
- D. 32
- E. 64

**Q53.** The light and dark forms of the peppered moth *Biston betularia* illustrate discontinuous variation. This means that

- A. there are no intermediate forms
- B. they are confined to certain areas
- C. selection by predation has eliminated further variation
- D. they are unlikely to vary in nature
- E. the frequency of the rarer form is lower than that which could be accounted for by recurrent mutation

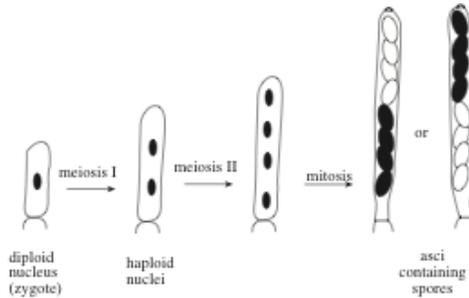
**Q54.** Which one of the following pieces of information provides the **MOST** direct evidence that individuals who are heterozygous for the sickle cell condition have a selective advantage in areas where malaria is endemic?

- A. The geographical distribution of malaria and high sickle cell allele frequency are closely correlated
- B. Mortality from malaria is lower in heterozygous individuals than in those with normal blood
- C. Heterozygous individuals are less susceptible to experimentally induced malaria than are homozygous individuals
- D. Counts of malarial parasites in the blood of heterozygous individuals are lower than in those with normal blood
- E. Malarial parasites grow more slowly in heterozygous individuals than in those with normal blood

**Q55.** In mice the allele *C* must be present before colour pigments are produced in the fur. Individuals lacking this allele are albino. Another pair of alleles determines whether the fur will be agouti (*A*) or black (*a*). Which one of the rows **A to E** shows, as far as these two pairs of alleles are concerned, the number of different genotypes which could result in albino, agouti and black mice?

	albino	agouti	black
<b>A.</b>	3	4	2
<b>B.</b>	4	2	3
<b>C.</b>	2	3	4
<b>D.</b>	3	1	2
<b>E.</b>	4	4	2

**Q56.** In the fungus *Sordaria fimicola*, a diploid nucleus containing alleles for both black and for white spore colours can give rise to an ascus containing one of several spore patterns. The spores are arranged linearly in the ascus according to the order in which they are formed. Two possible asci, and their method of formation, are shown in the following diagram.



The arrangement of spores in the two asci is explained by the alleles for spore colour undergoing

- A. crossing over
  - B. independent assortment
  - C. segregation during meiosis I
  - D. segregation during meiosis II
  - E. mutation
- Q57.** In a series of breeding experiments using *Drosophila*, a linkage group composed of five genes was found to show the following recombination frequencies per 100 fertilised eggs.

	Singed Bristles ( <i>sn</i> )	Vermilion eye ( <i>v</i> )	White Eye ( <i>w</i> )	Ruby Eye ( <i>rb</i> )	Tan Body ( <i>t</i> )
Singed Bristles ( <i>sn</i> )	0.0	12.0	19.5	13.5	6.5
Vermilion eye ( <i>v</i> )	12.0	0.0	31.5	25.5	5.5
White eye ( <i>w</i> )	19.5	31.5	0.0	6.0	26.0
Ruby eye ( <i>rb</i> )	13.5	25.5	6.0	0.0	20.0
Tan body ( <i>t</i> )	6.5	5.5	26.0	20.0	0.0

From this table of results it can be deduced that the correct sequence of the genes on the chromosomes is

- A. *sn—t—v—rb—w*
  - B. *sn—v—w—rb—t*
  - C. *w—t—sn—rb—v*
  - D. *w—rb—sn—t—v*
  - E. *w—rb—t—sn—v*
- Q58.** Which one of the following is an example of divergent evolution?
- A. eye of locust and blackbird
  - B. forelimb of pigeon and dolphin
  - C. wings of cockroach and bat
  - D. skeleton of tortoise and lobster
  - E. scales of shark and trout

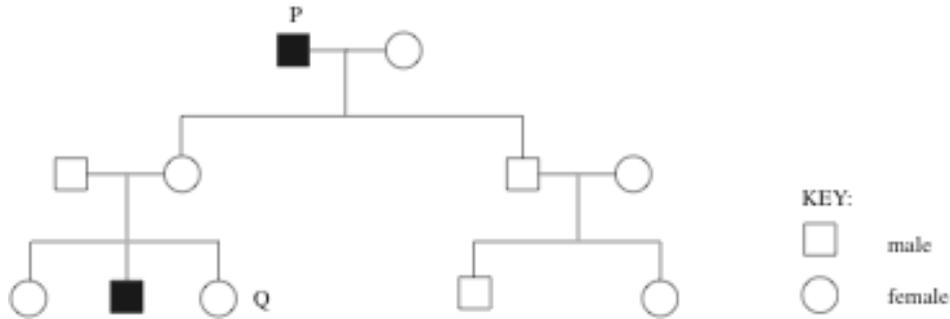
- Q59.** Colour blindness results from the presence of a sex-linked allele which is recessive in females. A colour blind woman and a man with normal vision produced a child with normal vision and a sex chromosome complement XXY. This suggests that chromosomes failed to separate during the formation of the
- sperm
  - egg
  - sperm and egg
  - sperm or egg
- Q60.** Which one of the following pieces of information provides the most direct evidence that the puffs, seen on the giant (polytene) chromosomes of fly larvae, are regions of active gene transcription?
- Substances such as chloramphenicol, which inhibit protein synthesis in the cytoplasm, do not reduce the formation of chromosome puffs
  - During metamorphosis, puffs appear in new regions of the chromosomes. Injecting ecdysone (insect moulting hormone) induces similar changes
  - In cells supplied with radioactive uridine (a uracil-containing nucleotide), the giant chromosomes become most densely labelled in the region of the puffs
  - Substances such as actinomycin D, which inhibit RNA synthesis, do not prevent puffing of giant chromosomes
- Q61.** The table shows the results of an investigation into survival in relation to clutch size in Swiss starlings.

Number of young in clutch	1	2	3	4	5	6	7	8
Number of young marked	65	328	127 8	395 6	617 5	315 6	651	120
Number of marked birds recaptured after 3 months	0.0	1.8	2.0	2.1	2.1	1.7	1.5	0.8

The information suggests that clutch size in Swiss starlings is a result of

- disruptive selection
  - stabilising selection
  - directional selection
  - artificial selection
  - recurrent mutation
- Q62.** E and T represent alleles of two linked genes in maize. Plants of the genotype *EETT* were crossed with plants of the genotype *eett*. The resulting F1 plants were backcrossed with *eett* plants to produce a generation of which 36 391 plants showed either both dominant or both recessive characters, while 9141 plants showed only one of the dominant characters. Which one of the following most closely represents the cross-over value between the two genes?
- 0.25%
  - 5%
  - 30%
  - 25%
  - 20%

**Q63.** The diagram shows the pedigree of a human family in which the individuals marked with shaded symbols have no sweat glands. This is a rare condition.

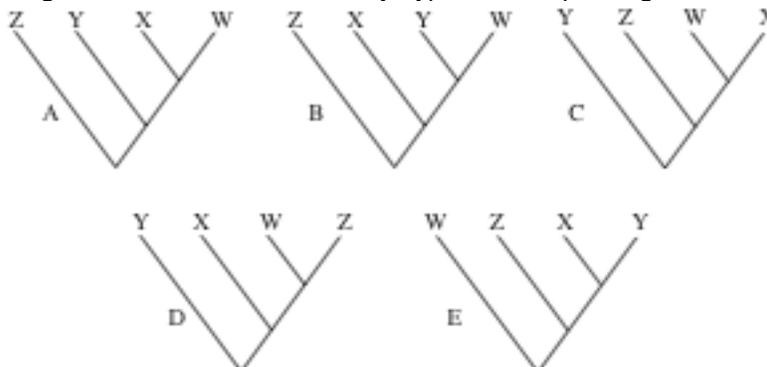


Which of the following would be the best inference from the data?

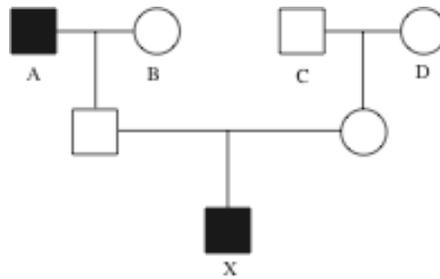
- A. A mutation occurred in individual P
  - B. The mutant allele is on the X chromosome
  - C. The normal allele is incompletely dominant
  - D. Individual Q is carrying the mutant allele
- Q64.** Genetic adaptation is best described as
- A. a process by which an individual organism gradually changes itself to suit its environment
  - B. a change in allele frequencies in a population as a result of changing environmental circumstances
  - C. the emergence of new forms as a result of mutations in the genetic material
  - D. a change in the genotype of an individual organism as a result of selection pressure
  - E. the occurrence of advantageous mutations
- Q65.** A cladogram is a branching diagram in which groups of closely related species (i.e. those sharing many characteristics) are shown to have branched away from the common line of descent via the same ancestor. The table gives a number of characteristics which are found in a group of four species, W, X, Y and Z.

Characteristic	Species			
	W	X	Y	Z
Fingers and toes	shaded	shaded	shaded	shaded
Endothermy	shaded	shaded	shaded	shaded
3 ear ossicles	shaded	shaded	shaded	shaded
Amnion	shaded	shaded	shaded	shaded
Placenta	shaded	shaded	shaded	shaded
Internal fertilisation	shaded	shaded	shaded	shaded
Mammary glands	shaded	shaded	shaded	shaded
Oviparity (lays eggs)	shaded	shaded	shaded	shaded
Webbed feet	shaded	shaded	shaded	shaded
Hair	shaded	shaded	shaded	shaded
Feathers	shaded	shaded	shaded	shaded

Which one of the cladograms below is the most likely hypothesis explaining the distribution of characters?



**Q66.** In the following pedigree of a human family carrying the sex-linked allele for red-green colour-blindness, colour-blind individuals are shown by shaded symbols.

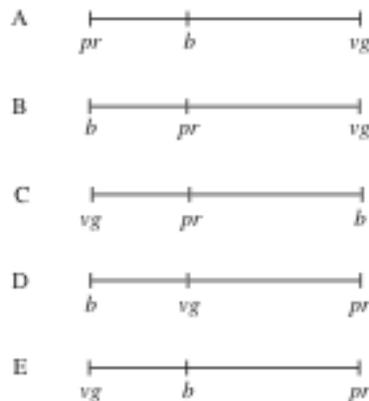


Assuming no mutations, from which grandparent, A, B, C or D did X inherit his colour blindness?

**Q67.** The table shows the recombination (crossover) values found in an investigation of three linked alleles.

Between alleles	% recombination
<i>Pr</i> and <i>b</i>	6.1
<i>Pr</i> and <i>vg</i>	10.2
<i>B</i> and <i>vg</i>	16.3

Which one of the following is the correct linkage map?



**Q68.** The diagram shows the sequence of bases in a strand of DNA that codes for a polypeptide composed of ten amino acids. An additional base sequence coding for the start signal is on the left.

**T A C G G T C A A T C T G G T T C T G G T T C T T C T C A G C A A**

When the polypeptide for which this gene codes was hydrolysed, it yielded the amino acids shown in the table.

Amino acid	Number of amino acid residues per polypeptide
w	1
x	2
y	3
z	4

The correct sequence of amino acids in the polypeptide is

- A. x y z x z y z z w y
- B. y z x y z z y z w x
- C. z x y z y z y y w z
- D. y x z y z y z z x w
- E. y x z y z y z z w x

- Q69.** Chickens of the variety 'Wyandotte' are white because they possess the dominant allele (*I*) of a colour inhibitor gene in addition to the dominant allele (*F*) of a colour factor gene. Hens of the variety 'leghorn' are white because they are homozygous recessive for the colour factor gene.

The ratio of white to coloured offspring in the second generation of a cross between white Wyandotte (*IIF*) and white leghorn (*iff*), if the genes assort independently, would be

- A. 15 white : 1 coloured
  - B. 13 white : 3 coloured
  - C. 12 white : 4 coloured
  - D. 10 white : 6 coloured
  - E. 9 white : 7 coloured
- Q70.** Dandelions are triploid and their pollen is sterile. This is most likely to be because
- A. the germinating pollen contains three gametic nuclei
  - B. the stigmas lack a specific chemical necessary for pollen tube formation
  - C. polyploids are infertile
  - D. the meiotic mechanism breaks down
- Q71.** During the 19<sup>th</sup> century an accidental hybridisation occurred between *Spartina anglica* ( $2n = 56$ ) and *S. alterniflora* ( $2n = 70$ ). The result was *S. townsendii*, a fertile hybrid. How many chromosomes would be expected in cells of the hybrid?
- A. 56
  - B. 63
  - C. 70
  - D. 126
  - E. 252
- Q72.** In Guinea pigs, black hair (B) is dominant over white (b), rough coat texture (R) is dominant over smooth (r), and short hair (S) is dominant over long hair (s). These genes are found on separate chromosomes. A homozygous black, rough, short-haired Guinea pig was crossed with a white, smooth, long-haired one. The offspring of this cross were mated and 200 offspring were produced. How many of these F<sub>2</sub> offspring would you expect to be black with a rough long haired coat?
- A. 9
  - B. 14
  - C. 28
  - D. 42
  - E. 84
- Q73.** In humans, identical twins occur in about one in 300 births. Assuming that red hair is recessive to dark hair, what are the chances of a dark-haired couple, each of whom had a red-haired parent, having red-haired identical twin boys?
- A. 1/600
  - B. 1/1200
  - C. 1/2400
  - D. 1/4800
  - E. 1/9600
- Q74.** In a breeding experiment, two white-flowered sweet peas were crossed and all the offspring had purple flowers. This result could be explained if the parent plants
- A. both carried the genes for the synthesis of purple pigment.
  - B. had different genotypes, one carrying the genes for purple pigment and the other carrying the genes for the enzyme activating them.
  - C. were both lacking one of the genes controlling the enzymes on the pathway synthesising purple pigment.
  - D. had the same genotype and were both heterozygous for the genes responsible for synthesising purple pigment.

- Q75.** Some clover plants are *cyanogenic* because they produce hydrogen cyanide when the leaves are mechanically damaged. *Acyanogenic* plants do not produce cyanide. When two acyanogenic plants were crossed, the following results were obtained.

Offspring	Cyanogenic	Acyanogenic
F <sub>1</sub>	All	None
F <sub>2</sub>	151	41

These results could be explained if the parent plants

- A.** both lacked the allele for an enzyme to convert the substrate to hydrogen cyanide
- B.** both lacked the allele for the synthesis of the substrate from a precursor
- C.** had different genotypes, one carrying the allele for the enzyme and the other for the synthesis of the substrate
- D.** had the same genotype, being heterozygous for both substrate and enzyme genes
- E.** had different genotypes, one being heterozygous for two loci, the other homozygous recessive for both

**END OF EXAM**

NAME: **MODEL ANSWERS**

# NZ INTERNATIONAL BIOLOGY OLYMPIAD



## 2011 Selection Examination

**Instructions:**

Write your name in the space provided at the top of this sheet.

Answer all 75 questions.

Use a pencil to shade in the answers you consider correct as shown opposite →

If you make a mistake, carefully rub it out and enter your new choice.

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