NATIONAL ENTRANCE EXAMINATION 2021

Examination Date: Wednesday 25 August 2021

Total Time allowed: 2 hours.

This examination consists of 60 multi-choice questions. Students are advised to allocate equal time to each question (**2 minutes per question**). Marks will not be deducted for incorrect answers.

Equipment: BLACK Ballpoint pen **ONLY**, ruler, and non-programmable calculator.

Please make sure your teacher **photocopies** the completed InspiroScan bubble form and **keeps a copy** for their records. Your teacher needs to place the **ORIGINAL** InspiroScan bubble form in the courier bag provided and **courier to Massey University <u>IMMEDIATELY</u>.**

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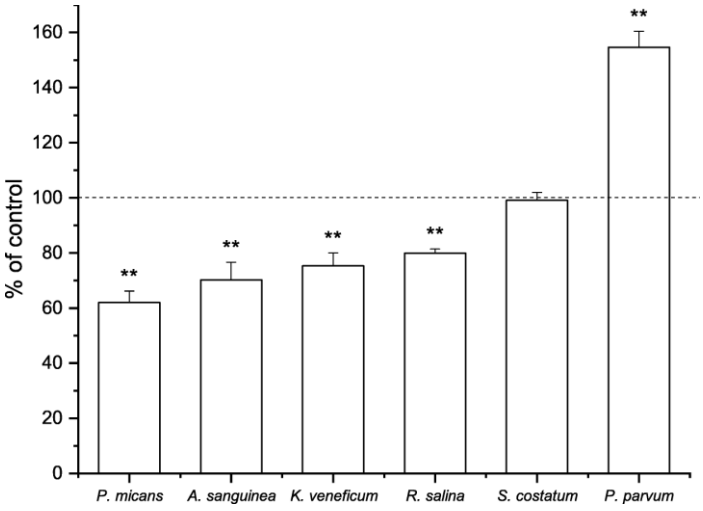
Section A

Questions 1 & 2

The dinoflagellate *Cochlodinium geminatum* forms near-monospecific blooms in the South China Sea, causing massive fish mortalities and negatively affecting the regional economy. Many studies have shown that dinoflagellate species often have low growth rates compared with other phytoplankton, so how is this species able to out-compete other phytoplankton species and form blooms? Researchers cultured *C. geminatum* with six species of microalgae found in the South China Sea and counted the number of algal cells at the end of incubation. Their results are shown in the graph at right. Resources were not limited and monocultures of *C. geminatum* and target species under the same conditions were used as controls. ** indicates a significant difference from the control.



Source: https://link.springer.com/article/10.1007/s10811-019-01784-y

Question 1

What conclusion can be drawn from the results in the graph above?

- **A.** *Cochlodinium geminatum* decreases the growth of other algae species in the water.
- **B.** The growth of *S. costatum* and *P.parvum* is unaffected by the presence of *C. germinatum*.
- **C.** *C. germinatum* inhibits the growth of *P. micans* but does not affect the growth of other species.
- **D.** *C. germinatum* inhibits the growth of some species and increases the growth of other species.
- **E.** The growth of algal species is inhibited, increased, or unaffected by the presence of *C. germinatum.*

Question 2

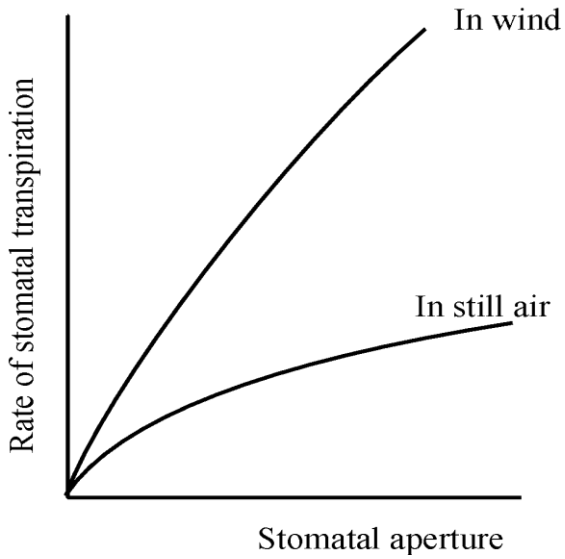
Algae and dinoflagellates compete for resources in their marine environment. Competition among members of the same species is known as intraspecific competition, while competition between individuals of different species is known as interspecific competition. Competition is divided into two types: interference competition, where organisms interact directly, fighting for scarce resources; and exploitative competition, where organisms compete indirectly by consuming scarce resources, making them unavailable for the other species. Competition can cause species to evolve differences in traits. Allelopathy is a common trait by which one organism produces biochemicals that influence the growth, survival, development, and reproduction of other organisms.

Considering the data above, what is the most likely explanation of the ability of the dinoflagellate *Cochlodinium geminatum* to form near-monospecific blooms?

- **A.** Interference competition between *C. geminatum* and algal species.
- **B.** Allelopathy and interspecific competition.
- **C.** Intraspecific competition.
- **D.** Exploitative competition between *C. geminatum* and other algal species.
- **E.** The production of alleleopathic chemicals by *C. geminatum* that negatively affects algal growth.

Question 3

The graph at right shows how the rate of transpiration varies with stomatal aperture in *Zebrina*, a common house plant.

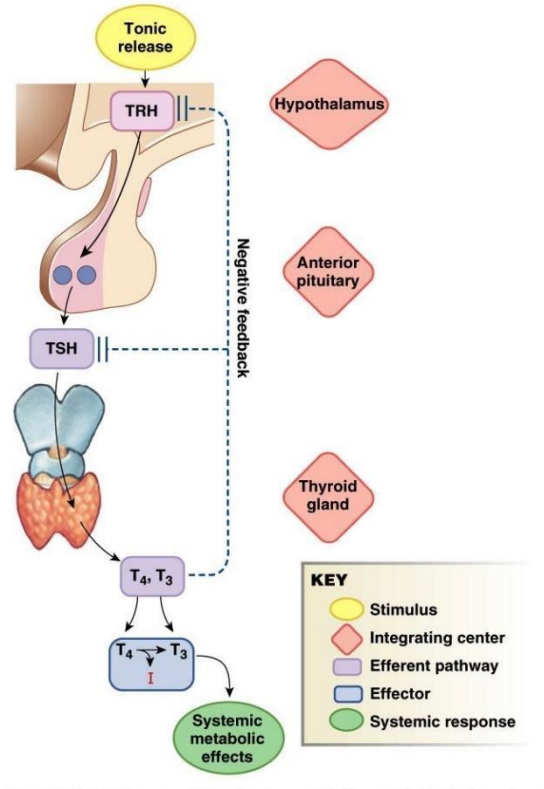


The difference between the two curves is best explained by;

A. The effect of wind on the thickness of the still layer surrounding the leaf.
B. A reduction of stomatal aperture in still air.
C. A lowering of temperature in the wind.
D. An increase in photosynthesis in moving air.
E. A greater rate of diffusion in moving air.

Question 4

Thyroid hormones (T3, T4) are produced by and secreted from the thyroid gland, which sits just below the larynx and has two lobes, one on each side of the trachea. Their secretion is controlled via the hypothalamus-pituitary pathway. Iodine is an essential for thyroid hormone production. The thyroid hormones control metabolism and exerts a negative feedback on both TRH release in the hypothalamus and TSH release in the anterior pituitary.



Copyright © 2007 Pearson Education, Inc., publishing as Benjamin Cummings.

Given the diagram above, if iodine is unavailable, which of the following is most likely:

A. Increase in TRH, increase in TSH, increase in thyroid hormones.
B. Decrease of TRH, increase in TSH, increase in thyroid hormones.
C. Increase of TRH, decrease in TSH, decrease in thyroid hormones.
D. Increase of TRH, increase in TSH, decrease in thyroid hormones.
E. None of the above.

Question 5

You decide to study feeding relationships among sea otters, sea urchins, and kelp. You know that sea otters' prey on sea urchins and that urchins eat kelp. You measure kelp abundance at four coastal sites and then spend one day at each site and record whether otters are present or absent every 5 minutes during the day.

Unfortunately, at the very end of the observation you accidentally splash seawater onto your data table (shown below) and three of your recorded values are lost. You remember that all results were consistent with your hypothesis (prediction), which reflected what you knew about the feeding relationship among sea otters, sea urchins, and kelp.

Site	Kelp Abundance (% cover)	Otter Density (# sightings per day)
1	75	98
2	X	18
3	60	Y
4	25	Z

Source: Campbell Biology 10th edition

Which set of values would best mimic your missing results?

- **A.** X = 10, Y = 35, Z = 47
- **B.** X = 15, Y = 85, Z = 36
- **C.** X = 45, Y = 22, Z = 25
- **D.** X = 20, Y = 44, Z = 13
- **E.** X = 70, Y = 32, Z = 14

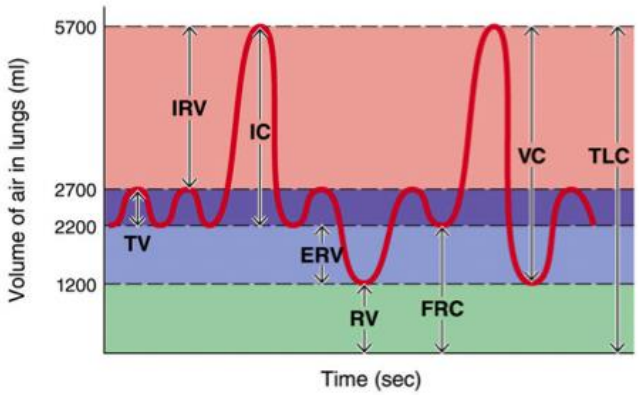
Question 6

A spirogram shows the volume of air in the lungs during ventilation. Using the diagram and information below, calculate the approximate pulmonary ventilation of this patient where:

Pulmonary ventilation = Tidal volume (TV) x Respiratory rate

Name: Hone Apple
DOB: 12/1/93
Heart rate: 72 bpm
Respiratory rate: 12
Vital capacity (VC): 4489 mL
Expiratory reserve volume (ERV): 990 mL
Inspiratory reserve volume (IRV): 3023 mL
Inspiratory capacity (IC): 3498 mL

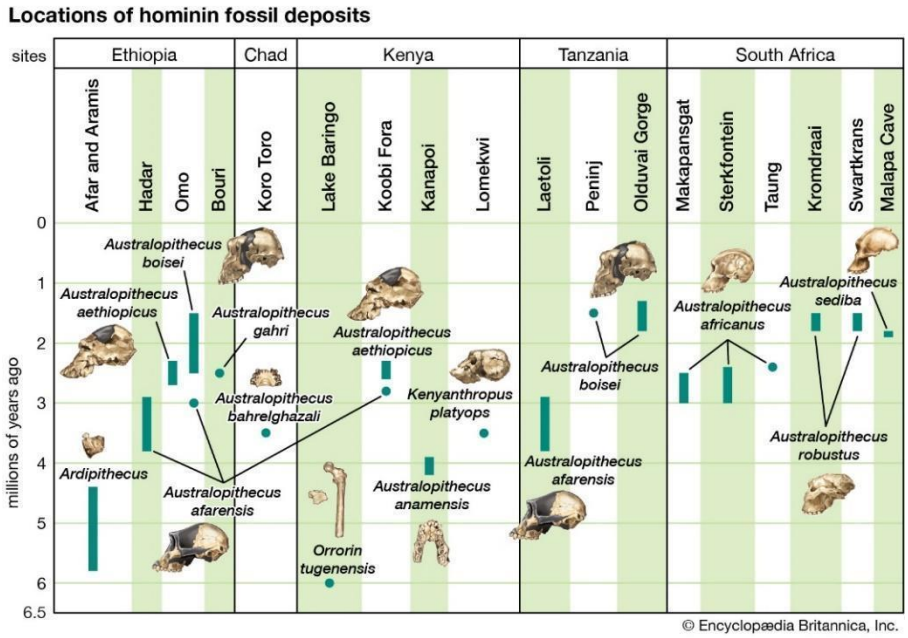
- **A.** 5700 mL/min
- **B.** 11880 mL/min
- **C.** 11892 mL/min
- **D.** 24396 mL/min
- **E.** None of the above.



(b) Normal spirogram of a healthy young adult male

Question 7

Our species, *Homo sapiens*, is part of a taxonomic subfamily called Homininae. Members of this subfamily are known as hominins. The diagram below shows the approximate time ranges and sites that have yielded fossils for some of the earliest putative hominins. Each dark green line or dot indicates the approximate time period when the correspondingly labelled species could have lived on Earth.



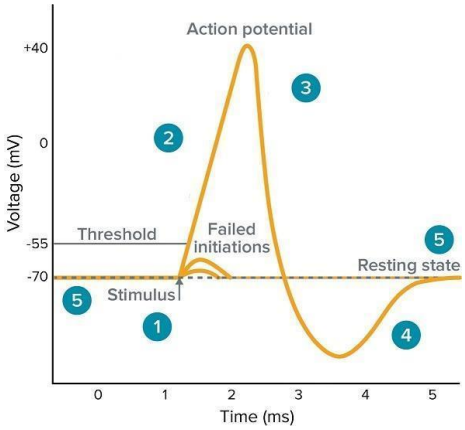
Source: https://www.britannica.com/topic/Homo-habilis/Evolutionary-implications#/media/1/270419/1495

Based on the above diagram, which of the following statements **CANNOT** be assumed correct?

- **A.** The hominin species with the oldest fossil deposit did not exist on Earth at the same time as any of the other species shown.
- **B.** The third oldest fossil deposit was not excavated in Tanzania or Ethiopia.
- ***C.*** *Australopithecus afarensis* fossil deposits have been found at more sites than that of *Australopithecus robustus* and *Australopithecus garhi* combined.
- **D.** On average, fossils excavated in Tanzania are approximately the second youngest in age.
- **E.** The 1-million-year period that yielded the most fossil deposit sites took place 2-3 million years ago.

Question 8

Action potentials are electrical signals that travel down the axons of neurons. Neurons have a negative resting membrane potential because the cytoplasm is more negative than the extracellular fluid. During repolarisation, K+ channels open, and potassium ions flow rapidly out of the cell. Which point on the graph represents this?



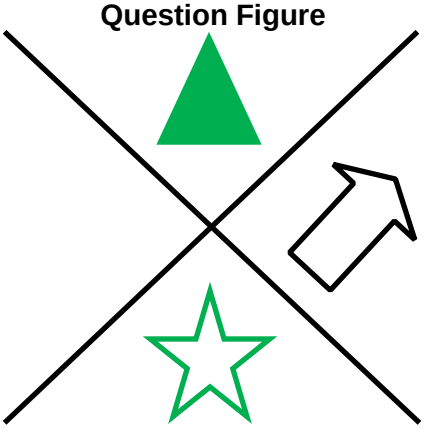
- **A.** 1
- **B.** 2
- **C.** 3
- **D.** 4
- **E.** 5

Source: https://www.moleculardevices.com/applications/patch-clamp-electrophysiology/what-action-potential#gref

Question 9

Which of the answer figures is a rotation of the question figure?

Question Figure



Answer Figures

A.

B.

C.

D.

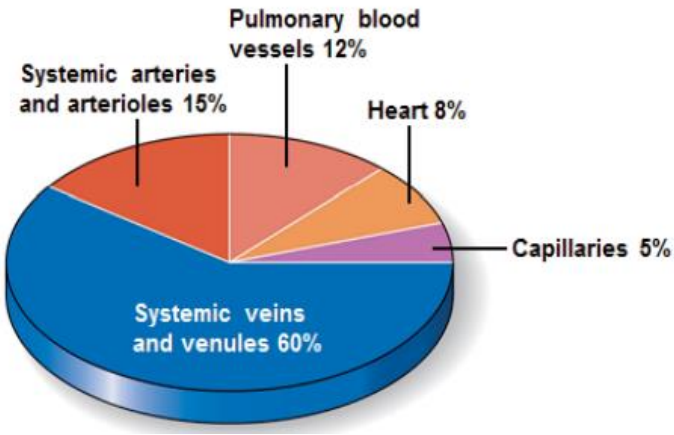
None of these

E.

Question 10

For a total blood volume of 35mL, what is the expected volume contained in the systemic arteries and arterioles and the pulmonary blood vessels?

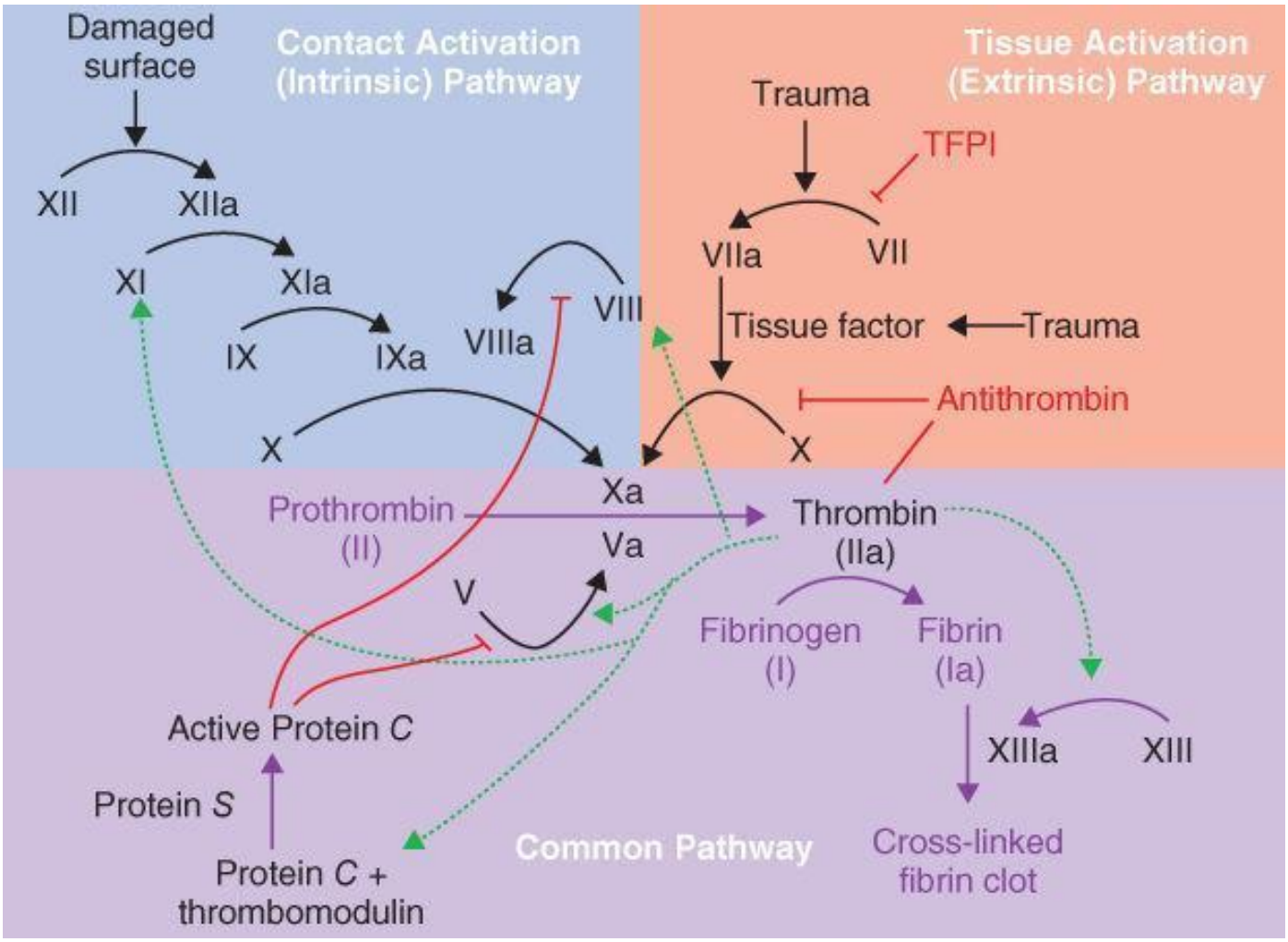
A. 5.25 mL
B. 945 µL
C. 0.525 µL
D. 9.45 mL
E. 52.5 mL



Source: The distribution of blood volume. [From Fig 18.5 Marieb & Hoehm Anatomy and Physiology. Pearson.4th Ed 2011]

Question 11

The diagram below shows the key pathways for hormone activation in the human blood clotting process. Black arrows indicate the activation of an event. Green dotted arrows from hormones specify the stimulation of another hormone, and red solid lines specify inhibition e.g. TFPI is a tissue factor pathway inhibitor.



Source: https://pocketdentistry.com/coagulation/

Which process **alone** would result in a **decreased** formation of cross-linked fibrin clots?

- **A.** Increased activation of Factors V, VIII, XI and XIII by Thrombin (IIa).
- **B.** Heightened inhibition of Protein S.
- **C.** The actions of inhibitory hormones being reduced in the tissue factor (extrinsic) pathway.
- **D.** Increased activation of the binding of thrombomodulin with Protein C by Thrombin (IIa).
- **E.** Greater exposure of the human body to damaged surfaces and trauma.

Question 12

The photo at right compares the tooth of a modern great white shark (left) with a significantly larger megalodon tooth (right).

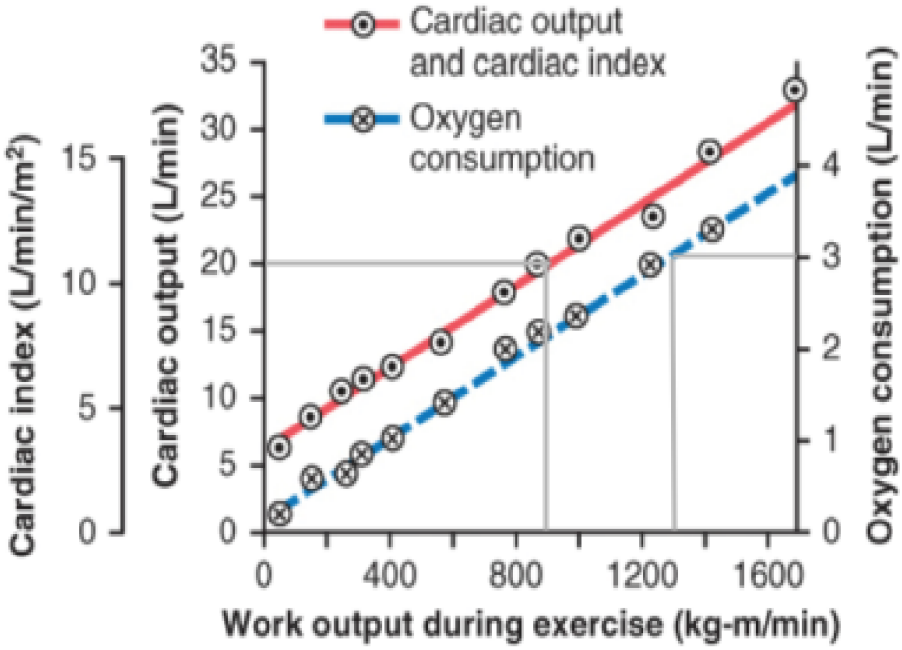
Source: https://www.britannica.com/animal/megalodon

The extinct megalodon had a huge mouth: its bite diameter was 3 metres across. Assuming that the great white shark tooth in the image is approximately 5cm in length from root to tip, approximately **how many** megalodon teeth could fit side-by-side in a single row across the bite diameter of a megalodon?

A. 10
B. 15
C. 24
D. 30
E. 40

Question 13

Cardiac output and oxygen consumption during exercise have been determined and averaged across a range of participants. It has been found that cardiac output is directly related to oxygen consumption, as illustrated in the figure below.



Source: Fig 20-3. Hall: Guyton and Hall Textbook of Medical Physiology, 13th Edition. Elsevier, 2016

Approximate the cardiac output for a work output during exercise of 1800 kg-m/min.

A. 40 L/min
B. 44 L/min
C. 27 L/min
D. 4.4 L/min
E. 33 L/min

Questions 14 & 15

Researchers interested in the memory processes of Alzheimer patients conducted a study comparing Alzheimer patients to adults with normal memory. The participants were administered a list of 21 unrelated words, at the rate of one word every three seconds. Immediately after the presentation of the last word, the participants were asked to recall as many words as they could from the list. The Alzheimer patients were 60 to 80 years of age. Participants without memory impairments were divided into three age groups: 20–39, 40–59, and 60–80. After the recall task, the participants were given a recognition task. The results of the study are presented in Figure 1. The list of words was presented in the same order to all groups.

The researchers were also interested in the percentage of total recall for words from different parts of the list. More specifically, they analysed the percentage of each group's recall from the beginning, middle, and end of the list. The results are presented in Figure 2. The performances of 20–39 and 40–59 year-old groups did not differ significantly and are combined into one group.

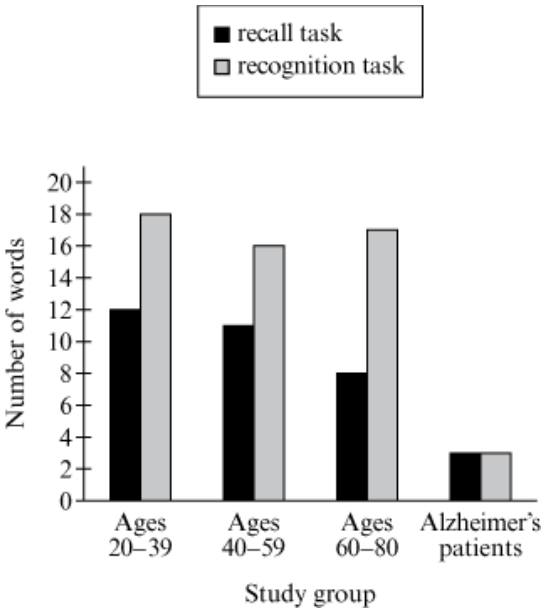


Figure 1 Number of words recalled and recognized.

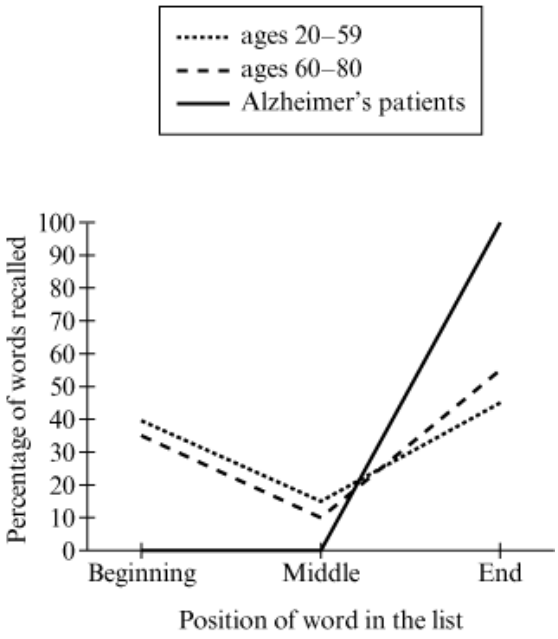


Figure 2 Percentage of words recalled as a function of position in the list.

Question 14

Which statement is **NOT** supported by the data in Figure 1?

- **A.** As people grow older, their ability to recall declines.
- **B.** Recognition is relatively stable in adults without memory impairments.
- **C.** The memory problems in Alzheimer disease are an acceleration of the aging process.
- **D.** Participants without memory impairments perform better in the recognition task compared to the recall task.
- **E.** Alzheimer's patients struggle to perform both recall and recognition tasks.

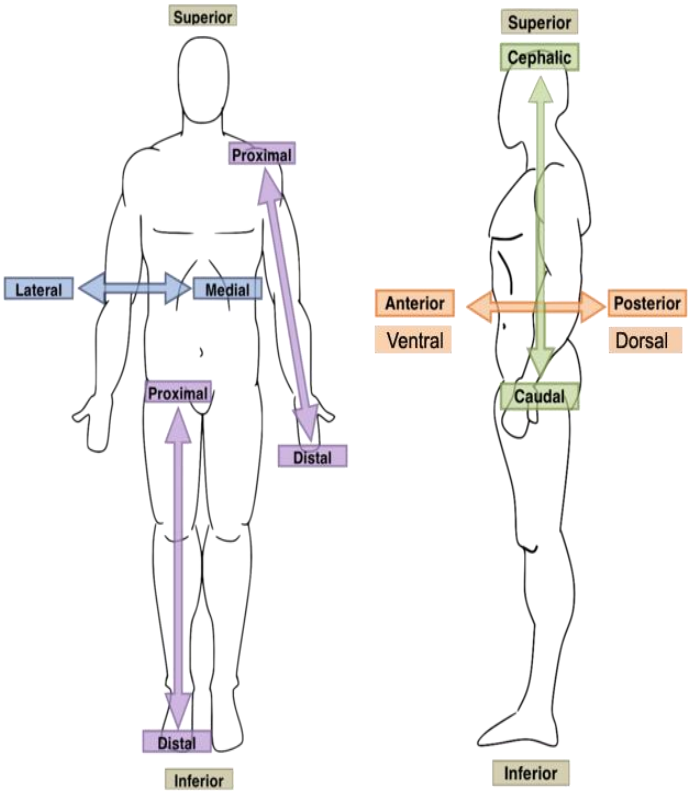
Question 15

Which of the following statement is **TRUE**?

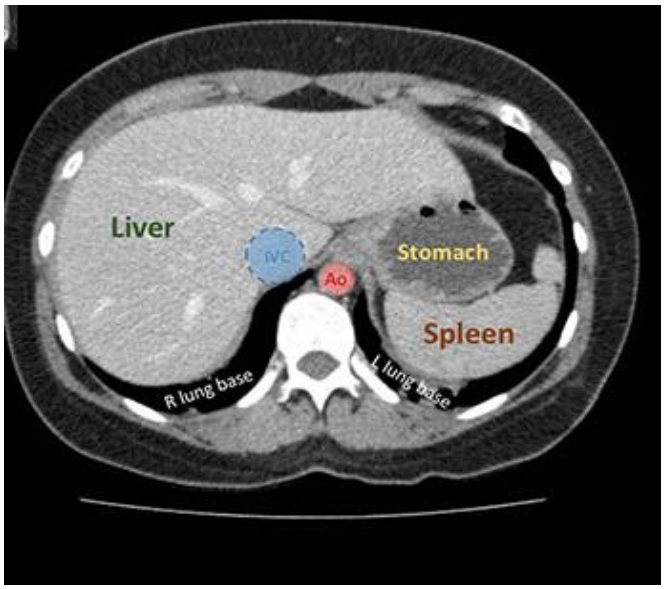
- **A.** Alzheimer's patients were always the worst group at word recall tasks.
- **B.** People aged 60-80 were the worst at recalling the words at the end of a list.
- **C.** People aged 60-80 were the worst at recalling the words in the middle of the list.
- **D.** People aged 40-59 were the worst at recalling the words in the middle of a list.
- **E.** People aged 20-59 were the worst at recalling the words at the end of a list.

Question 16

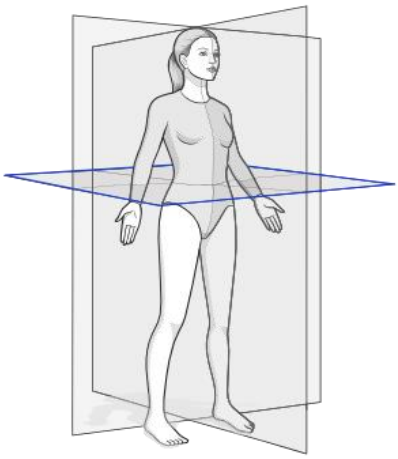
Image 1, on the left below, illustrates some relative anatomical terms. Image 2 (top right) is of a CT scan 'slice' through the abdomen (in the plane outlined in blue in image 3 at bottom right), which is viewed as if you are looking up from the patient's feet.



Source: lumenlearning.com



Source: radiologycafe.com



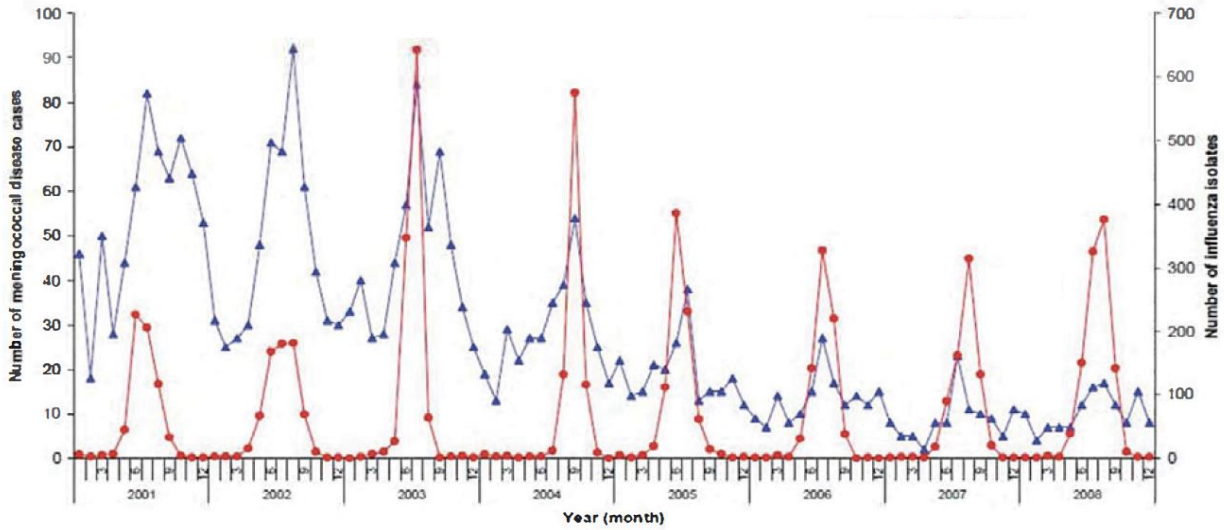
Source: kneeguru.com

Based on this information, which of the following statements is the most accurate?

A. The stomach is superior to the spleen.
B. The stomach is anterior to the liver.
C. The liver is on the left side of the body.
D. The spleen is medial to the aorta (Ao).
E. The spleen is mostly dorsal to the stomach.

Question 17

This graph shows the number of cases of meningococcal disease and influenza over a number of years.



Source: https://surv.esr.cri.nz/index.php?SubsiteID=11

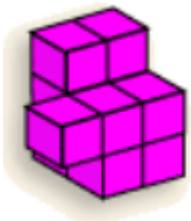
Which of these statements would be the most reasonable to make?

A. During the early 2000s, meningococcal disease was more prevalent than influenza.
B. The number of influenza infections is consistently seasonal.
C. In the middle of 2002, there were approximately three times as many meningococcal cases than there were influenza cases.
D. No influenza is seen in the summer months.
E. Influenza is a more serious condition than meningococcal disease.

Question 18

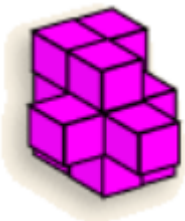
The block on the left below is disassembled and one piece is removed, leaving just the two pieces on the right.

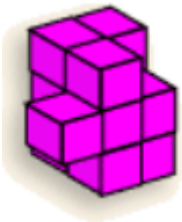
Which piece A – E is the missing piece?

A.


B.


C.

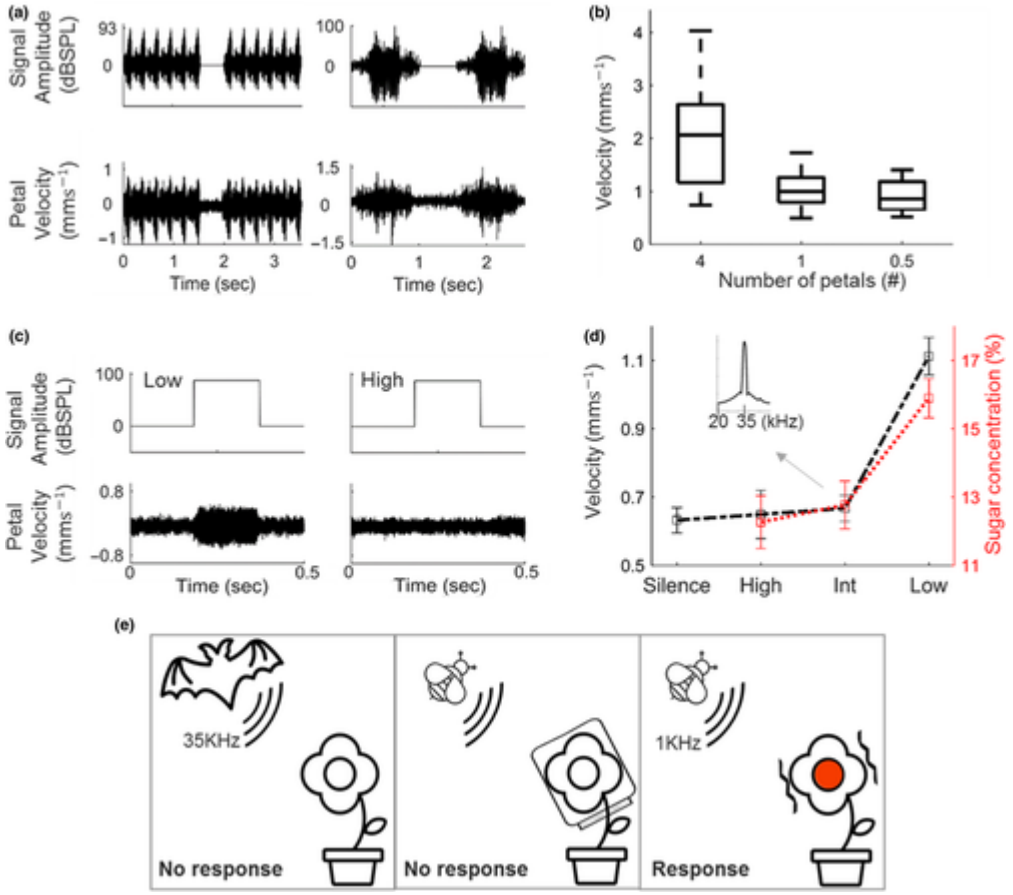

D.


E.


Modified from: https://psychologytoday.tests.psychtests.com/bin/transfer

Question 19

Can plants sense natural airborne sounds and respond to them rapidly? Investigators exposed flowers of the evening primrose (*Oenothera drummondii*), which is insect-pollinated, to either the playback sound of a flying bat, bee or to synthetic sound signals at similar frequencies and recorded the vibration of the flowers and the amount of nectar produced.



Source: https://doi.org/10.1111/ele.13331

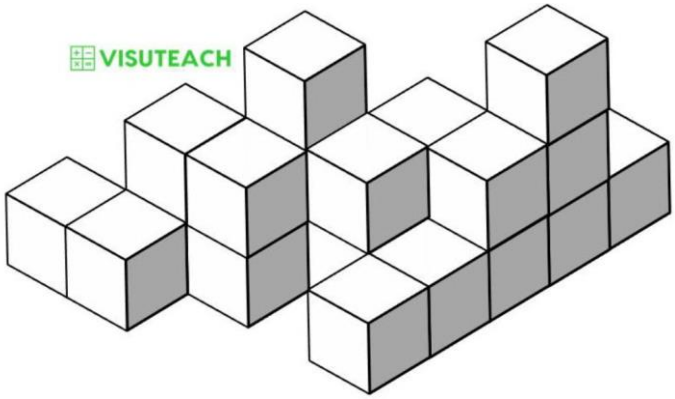
What conclusion/s can be drawn from these results?

A. The flower increases the sugar concentration of the nectar in response to pollinator sounds.
B. Flowers vibrate in response to airborne sound in the pollinator's frequency range.
C. The flower serves as the sound receptor.
D. Only A and B can be concluded from these results.
E. A, B and C can all be concluded from these results.

Question 20

How many blocks in total are in the pile in the diagram at right? Some blocks are hidden from view.

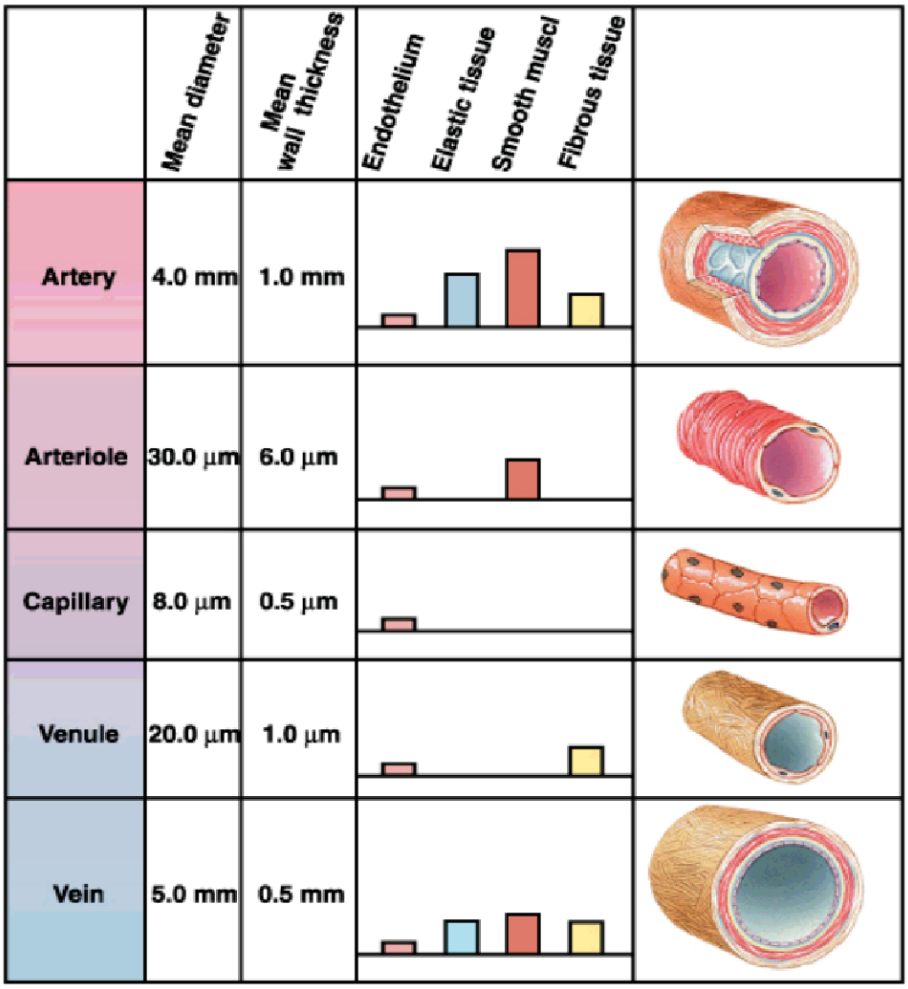
A. 19
B. 20
C. 21
D. 22
E. 23



Source: https://www.visuteach.com/wp-content/uploads/membership/demos/spatial-reasoning/block-counting/demo-E/index.h

Question 21

The following figure summarises the key structural features of human blood vessels.



Source: From Fig 15-2 Human Physiology: An integrated approach. D Silverthorn Pearson Ed 2007

Which of the following blood vessel types is most likely to have a wall thickness of $55 \times 10\ m^{-7}$?

A. Artery
B. Arteriole
C. Capillary
D. Venule
E. Vein

Question 22

Poiseuille's law (at right) is a formula for the movement of fluid in a system, such as blood in a blood vessel. It relates the flow rate (Q) to the difference in pressure (ΔP) to the radius, the viscosity of the liquid (η) and the length of the tube (L).

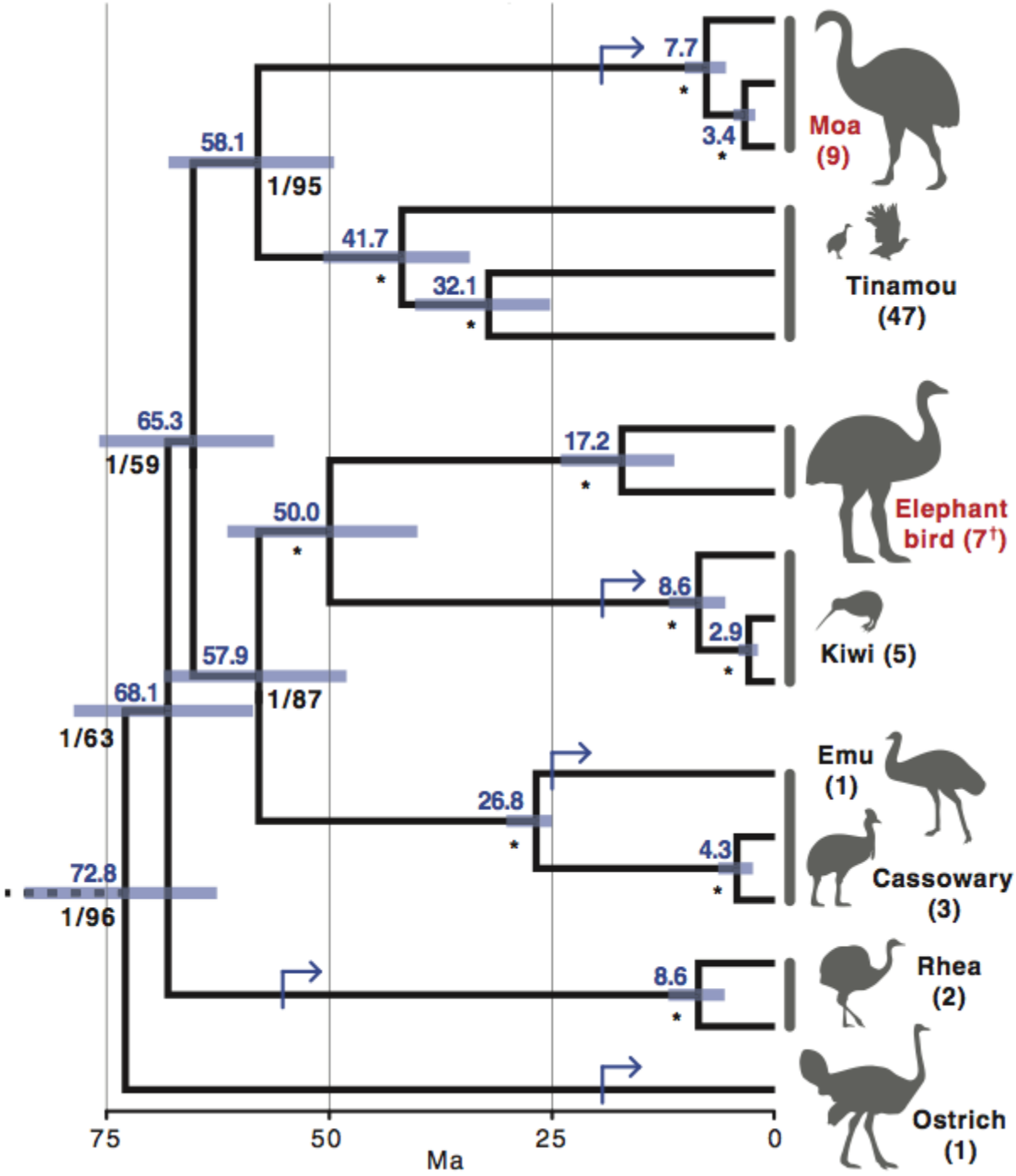
$$Q = \frac{\pi \mathrm{Pr}^4}{8\eta l}$$

If a person has a partially blocked artery from an atherosclerotic plaque which halves the vessel radius, the new flow rate will be ….

A. 1/2 of the original
B. 1/4 of the original
C. 1/8 of the original
D. 1/16 of the original
E. 1/32 of the original

Question 23

A phylogenetic tree is a diagram used to represent a relationship (a phylogeny) between groups of organisms, showing how they are related, and their most recent common ancestors. The tree below shows the phylogeny of the ratites, mostly flightless birds that lack a keel on their sternum. The phylogeny is based on mitochondrial DNA sequences. Extinct species are in red.



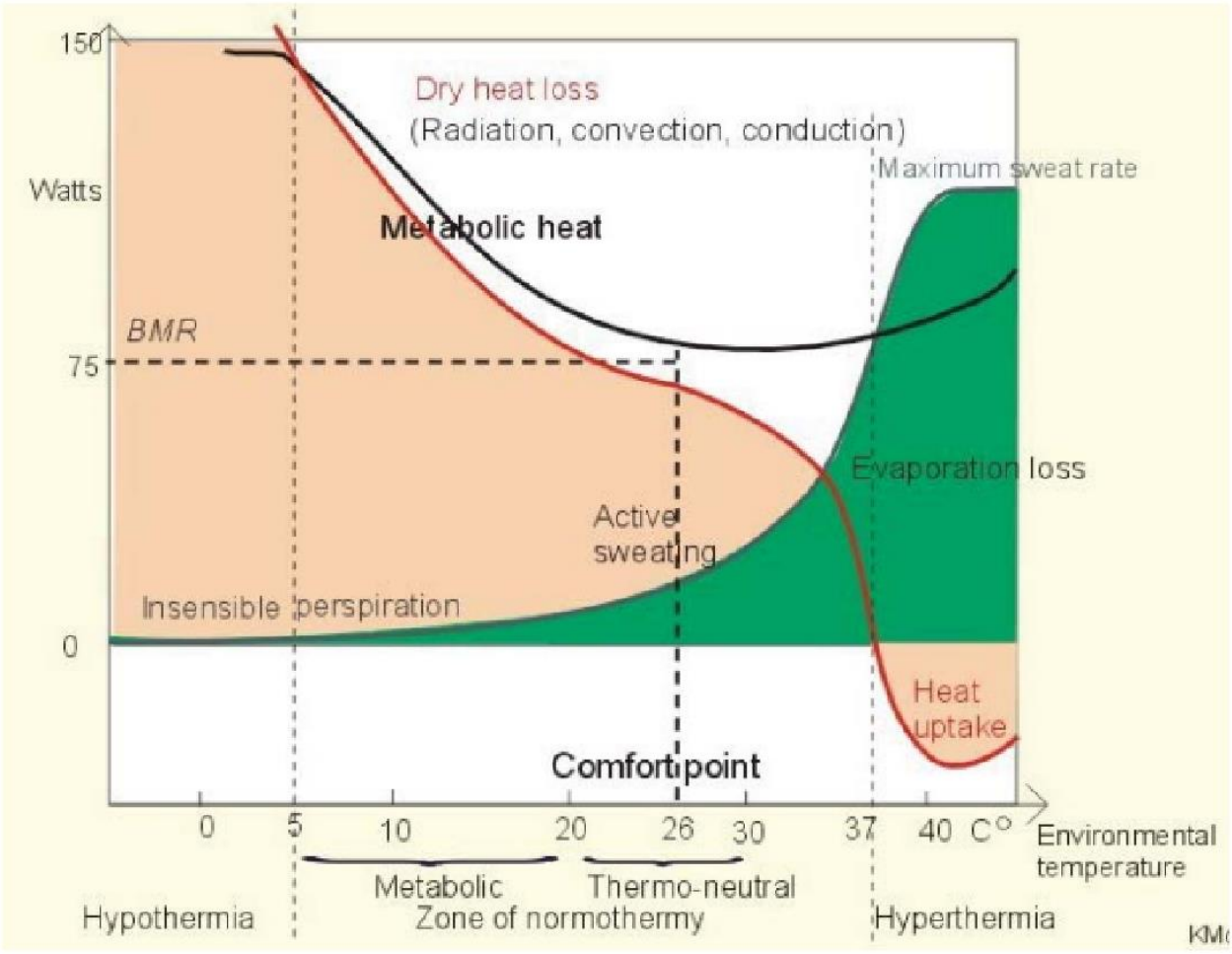
Source: https://evobites.com/2014/10/25/grayson_birdphylogeny/

Based on the tree above, which statement is **NOT** correct?

- **A.** The extinct Madagascan elephant bird is more closely related to the kiwi than the moa.
- **B.** The tinamou, which can fly, are most closely related to the flightless moa.
- **C.** The American rhea diverged from the other ratites approximately 68 million years ago.
- **D.** Kiwi and moa diverged from each other around 8 million years ago.
- **E.** The cassowary and emu are both found in Australia and share a relatively recent ancestor, diverging 26.8 million years ago.

Question 24

An experiment investigating the effect of environmental temperature on modes of heat transfer for humans obtained the following results.



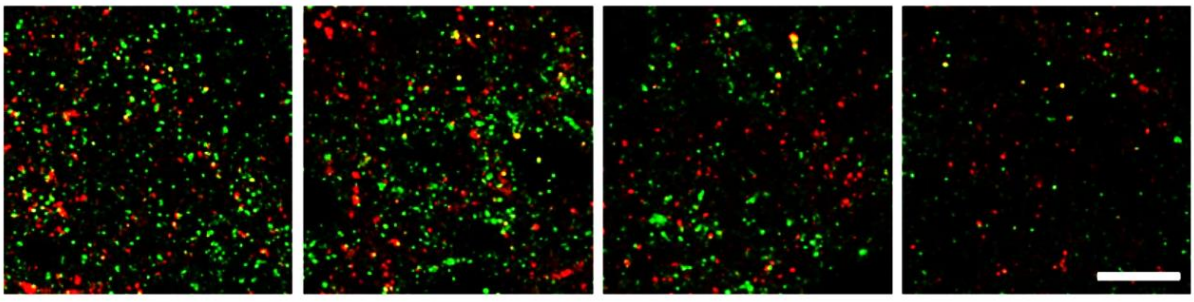
Source: Paulev-Zubieta New Human Physiology 2nd edn, Chpt. 21.

Which of the following statements are correct?

- **A.** Evaporation heat loss is predominant at high environmental temperatures.
- **B.** Dry heat loss processes become more effective at high environmental temperatures.
- **C.** Evaporation heat loss is less effective than dry heat loss.
- **D.** Dry heat loss decreases linearly with environmental temperature.
- **E.** At an environmental temperature of 26°C there is no heat loss due to evaporation.

Question 25

Neurons are often thought of as the main cell type of the brain. However, they rely on a range of other cell types, collectively termed glia, to maintain proper function. Microglia are a type of glial cell that have an important function as 'gardeners', pruning neuronal connections to maintain homeostasis. However, in neurodegenerative diseases such as Alzheimer's disease (AD), microglia may excessively prune neuronal connections, contributing to disease. Researchers investigated a proposed regulator of pruning (SIRPα), by analysing the number of neuronal connections (bright red & yellow-green dots) in control and AD tissue and with either wild-type microglia or microglia lacking SIRPα (SIRPα cKO), as shown in the figure below.



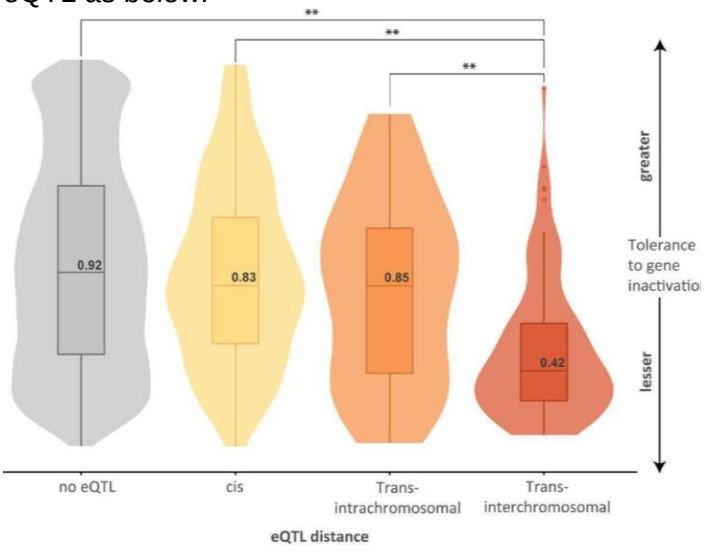
Source: https://doi.org/10.1038/s41467-021-22301-1

Which of these statements is the best interpretation of these results?

A. Alzheimer's disease reduces neuronal connections, and a lack of microglial SIRPα increases this effect.
B. The red dots are usually bigger than green dots.
C. A lack of microglial SIRPα reduces the number of neuronal connections.
D. Loss of neuronal connections causes the memory loss experienced by patients with Alzheimer's.
E. None of these interpretations are correct.

Question 26

eQTLs are regulatory genetic variants which alter the expression of another gene. An eQTL may regulate a gene or genes located nearby on the same chromosome (cis), or distant genes (Trans) on the same (intrachromosomal) or a different (interchromosomal) chromosome. The distribution of a regulated gene's tolerance to inactivation (how essential it is for survival) can be plotted against its distance from a regulating eQTL as below.



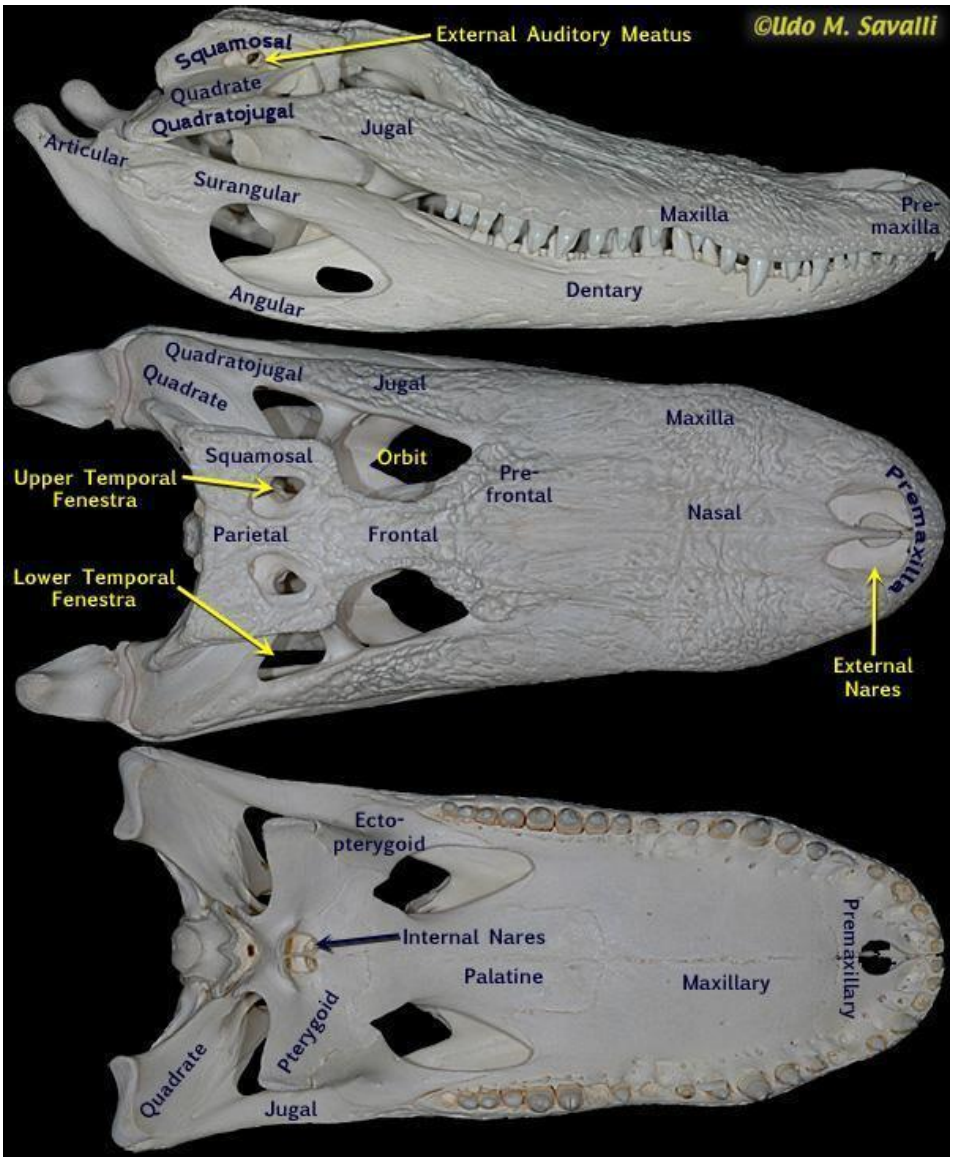
Source: https://doi.org/10.1101/2021.04.08.439080

From this graph it can be concluded:

A. Most genes are regulated by cis eQTLs.
B. eQTLs on different chromosomes tend to regulate genes intolerant to inactivation.
C. Tolerance to gene inactivation is a discrete variable.
D. Cis eQTLs regulate genes with a significantly different tolerance to inactivation than trans-intrachromosomal eQTLs.
E. Trans eQTLs do not regulate genes that are essential for survival.

Questions 27 & 28

Vertebrate skulls are made of many bones. The joins between the bones form lines called sutures. The photographs below are of the skull of a crocodile and the bones have been labelled with their scientific names.



Source: http://www.savalli.us/BIO370/Anatomy/5.AlligatorSkeletonLabel.html

Question 27

The labelled crocodile skulls in the photographs above show us that ….

- **A.** The upper teeth of the crocodile are supported by the jugal, nasal and dentary bones.
- **B.** Crocodile nostrils (nares) are in the nasal bones.
- **C.** The dentary bone has a notch for the lower tooth.
- **D.** The jugal bone is lateral and below the eye.
- **E.** The palatine bone is flanked by squamosal bones.

Question 28

From the names of bones, we can reasonably conclude that ….

- **A.** The prefrontal is found closer to the animal's front than the frontal bone.
- **B.** The term fossa refers to a hole in a bone.
- **C.** The quadratojugal likely links the jugal and quadrate bones.
- **D.** Post orbital refers to 'behind' the eye.
- **E.** All of the above are correct.

Question 29

Restriction enzymes are endonucleases that produce cuts in double-stranded DNA. They can produce either blunt ends without overhangs, or 'sticky' ends with short single-stranded overhangs, as shown below. Remember that DNA has complementary base pairing where guanine (G) always bonds to cytosine (C) and adenine (A) always binds to thymine (T).

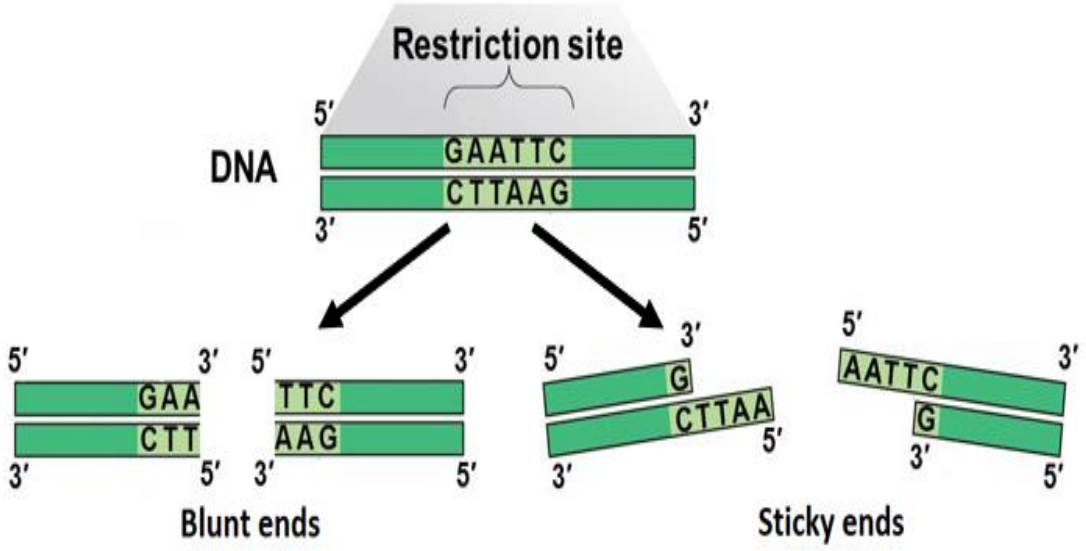


Image adapted from Campbell Biology

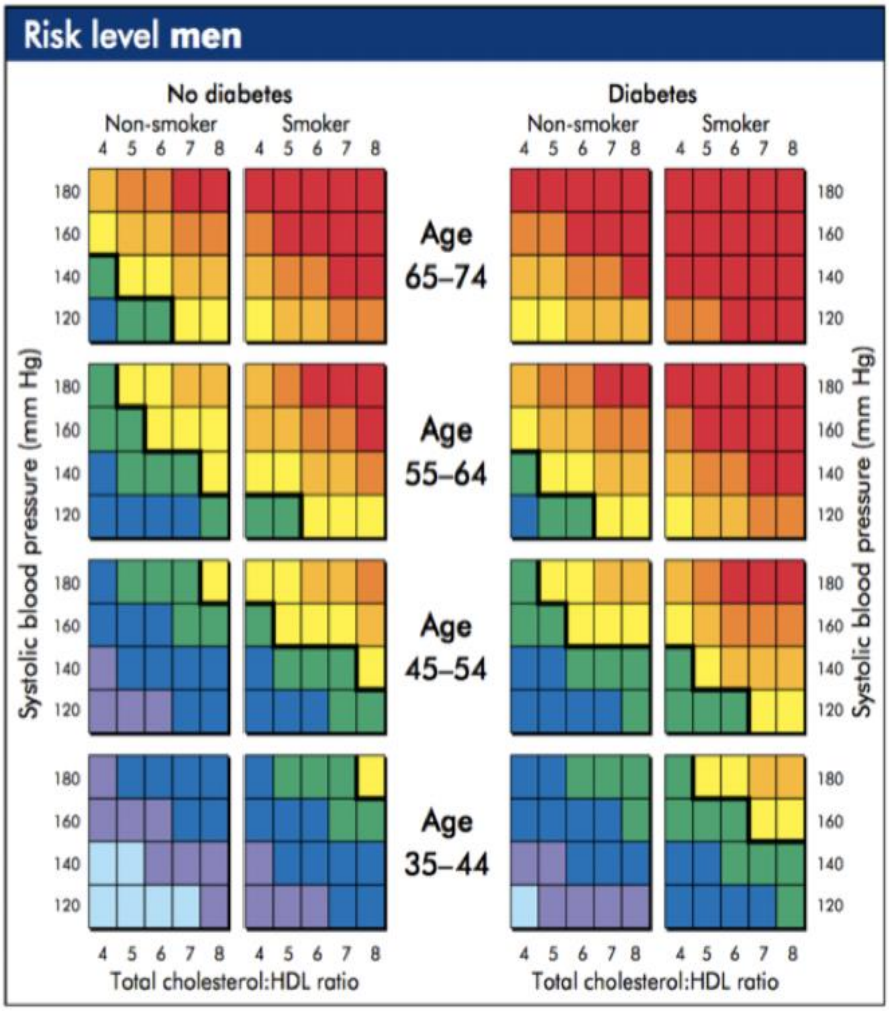
XbaI
T C T A G A A G A T C T
NheI
G C T A G C C G A T C G
FseI
G G C C G G C C C C G G C C G G
EcoRV
G A T A T C C T A T A G
BfaI
C T A G G A T C

Using the restriction sites shown at left, in which bold red lines show where each enzyme cuts, determine which of the following statements are **INCORRECT**.

A. The sticky ends generated by XbaI and NheI have complementary overhangs.
B. EcoRV generates blunt ends.
C. Restriction sites contain equal proportions of thymine (T) and guanine (G) bases.
D. A BfaI site is more likely to occur by chance in a sequence of DNA than a FseI site.
E. None of the above are incorrect.

Question 30

This diagram shows the atherosclerosis risk for men based on their age, diabetes status, whether they smoke, systolic blood pressure, and total cholesterol:HDL ratio. Colour corresponds to risk for atherosclerosis, where people with the same colour box have the same risk; the red end of the spectrum is higher risk, and purple is lower risk.



Source: Rod Jackson, University of Auckland

Consider four patients, as follows:

Patient A: a woman aged 66 who does not have diabetes, is a smoker, has a systolic blood pressure of 160 mmHg and a total cholesterol:HDL ratio of 6.
Patient B: a man aged 58 who has diabetes, smokes, has a systolic blood pressure of 180 mmHg and a total cholesterol:HDL ratio of 8.
Patient C: a man aged 36 who has diabetes, does not smoke, has a systolic blood pressure of 160 mmHg and a total cholesterol:HDL ratio of 8.
Patient D: a man aged 46 who does not have diabetes, is a smoker, has a systolic blood pressure of 140 mmHg and a total cholesterol:HDL ratio of 6.

Which of the following statements is true?

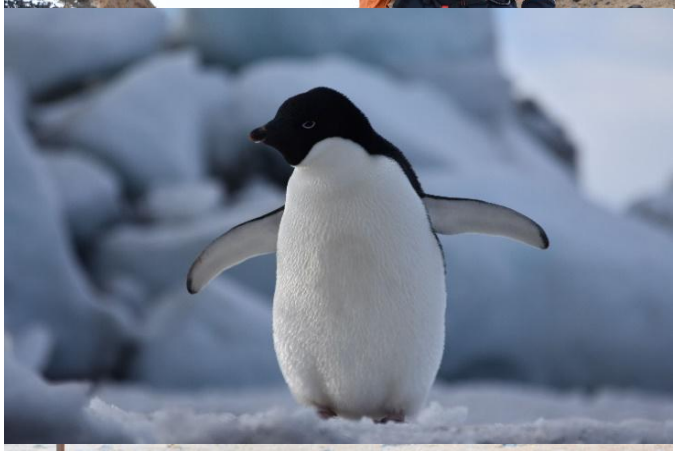
A. Patient A and patient B have the same risk level for atherosclerosis.
B. Patient B could notably decrease his atherosclerosis risk if he halved his total cholesterol:HDL ratio.
C. Patient C has little risk of atherosclerosis.
D. Patient D has the highest atherosclerosis risk of the four patients.
E. Patient C and patient D have the same risk level for atherosclerosis.

Section B

The questions in Section B are designed to get you thinking about current biological research. Hopefully, you will be inspired, amused, and, most importantly, learn something new as you sit this exam. Research biologists get to go to some incredibly beautiful places, including Antarctica, and have the best work stories. This year's exam highlights some of the great research being done on 'poo' – yes poo, faeces, guano, or scat! It's an important topic for biologists as it can tell us so much about the diet of organisms, the relationships between organisms in a food web, and provide us with samples for genetic analysis. Enjoy!

FORAGING AND REPRODUCTIVE BEHAVIOURS IN ADELIE PENGUINS

Taylor Hamlin (at right) is a PhD student at Otago University. His research involves investigating the links between the foraging and reproductive behaviours of Adélie penguins (*Pygoscelis adeliae*). More specifically, his team wants to get a better understanding of what the penguins are doing while foraging at sea, and how their decision-making at sea affects their reproductive success. It seems logical that a parent who can bring back more food, more frequently, will have larger chicks that will have a higher chance of survival. However, scientists do not know the characteristics of a good forager, where they go, what prey they utilise, and how efficiently they forage.



To study this, Taylor's group spent two summers at Cape Bird, at the northern tip of Ross Island, just off the mainland coast of Antarctica. At Cape Bird there is a moderately-sized Adélie penguin colony of around 75,000 breeding pairs. Over the summer, which is when these penguins breed, they monitored a small sub-population of nesting Adélies. They built a small enclosure around them with a gate at the seaward side, so they could monitor all movements in and out of the nesting area. They used GPS trackers to record at-sea locations, automated weighing for foraging success (i.e., how much food they were bringing back to feed chicks), and daily nest observations for egg and then chick health and survival.

As the penguins walk across the entrance to their nest, their weight force is automatically recorded on the weigh station pictured (at right), with the scales located on a plate in the centre of the gate.

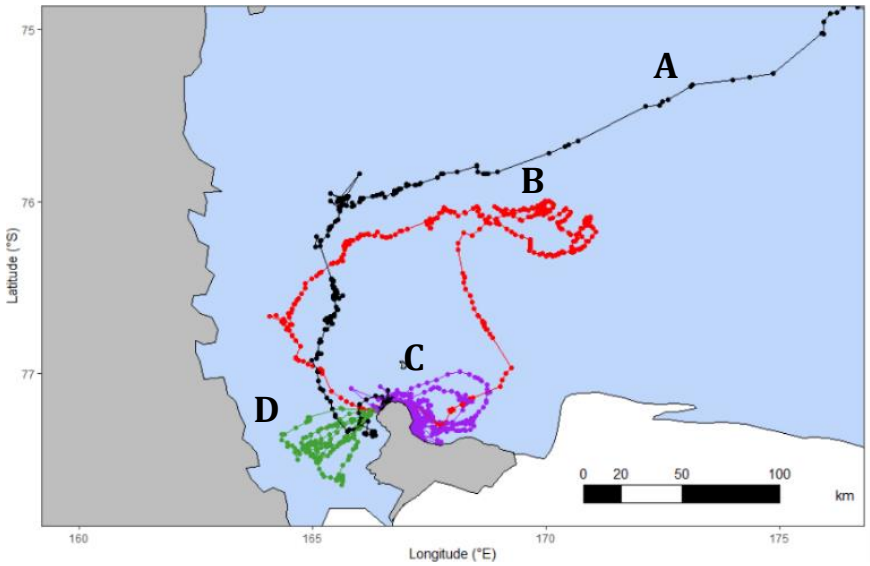
Because Adélie penguins come onto land at regular locations and times, they provide an easy model for scientists to study the wider Antarctic food web. This is particularly applicable to the Ross Sea, as a Marine Protected Area (MPA) was established there recently. The Ross Sea MPA is overseen by several countries and is set to be reviewed in 2052, so this work could go towards a long-term study on the impacts of the MPA on the Ross Sea ecosystem, which could in turn justify any future management decisions.

Question 31

The figure on the right shows tracking of 4 individual penguins, labelled A – D.

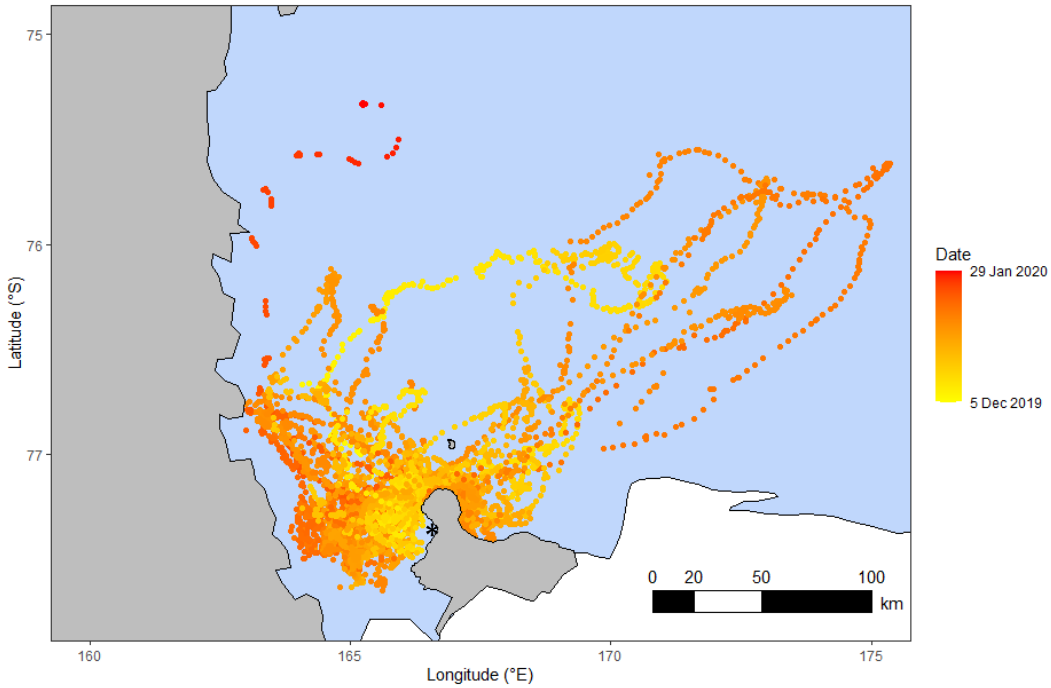
Predict which of the penguins would have had the best foraging efficiency.

- **A.** Penguin A
- **B.** Penguin B
- **C.** Penguin C
- **D.** Penguin D
- **E.** There is not enough information available to draw a conclusion.



Question 32

The figure below shows all the GPS location data for tracked Adélies in the 2019-2020 summer. The observations are coloured by date, with the start of December in yellow and end of January in red. The location of the penguin colony is marked with *****.



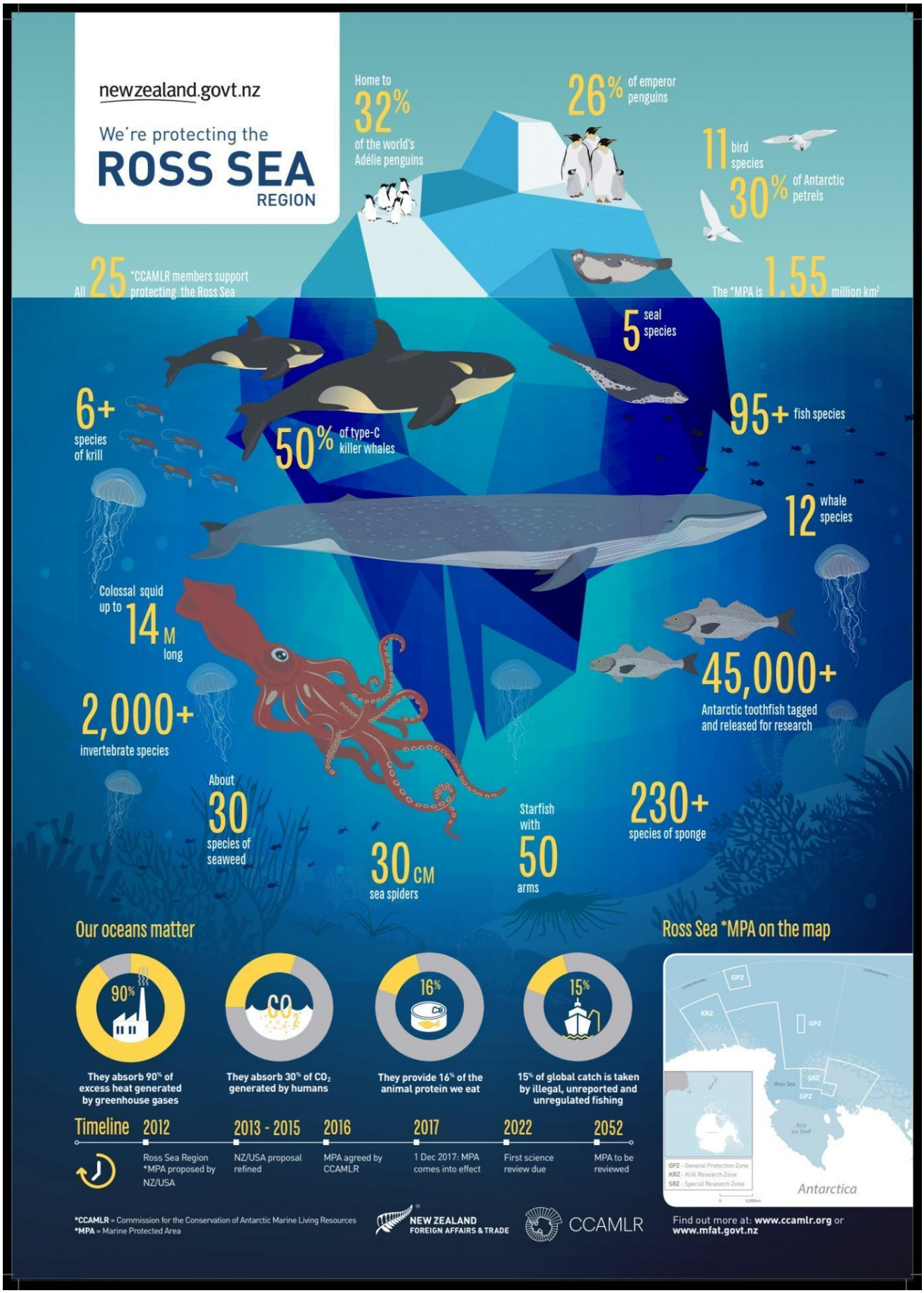
There are six statements about this figure, each of which may be true or false.

1. There is more food for penguins closer to a landmass throughout summer.
2. Bigger prey can be found further out to sea.
3. Penguins hunt in groups.
4. On average, penguins dive deeper further out at sea.
5. Penguins have a maximum range of 100km for foraging.
6. On average, penguins forage further from the colony (*) later in summer.

Which of the statements above can be inferred to be **TRUE?**

- **A.** Statements 1 and 2.
- **B.** Statements 3 and 4.
- **C.** Statements, 1, 5 and 6.
- **D.** Statement 6.
- **E.** All of the statements above are true.

Questions 33 & 34



Source: https://www.mfat.govt.nz/en/environment/antarctica-and-the-southern-ocean/ross-sea-region-marine-protected-area/

Question 33

Which of the statements below is **NOT** supported by the infographic on the previous page?

- **A.** There is international consensus on protecting the Ross Sea.
- **B.** There is biodiversity worth protecting in the Ross Sea.
- **C.** The Ross Sea Marine Protected Area should be expanded.
- **D.** The ocean affects our climate.
- **E.** There is scientific research happening in the Ross Sea region.

Question 34

Which of the groups listed below would be likely to have the greatest total genetic diversity?

- **A.** Whales
- **B.** Invertebrates
- **C.** Starfish
- **D.** Krill
- **E.** Fish (including toothfish)

Question 35

The map (below right) shows the Ross Sea region Marine Protected Area, which covers 1.55 million square kilometres. It consists of three zones:

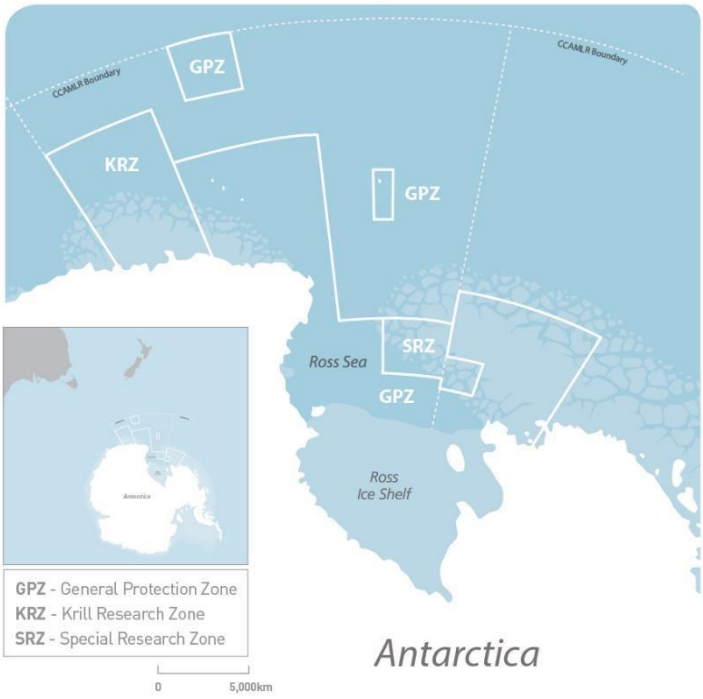
GPZ - A 'no take' General Protection Zone (a fully protected area where no commercial fishing is permitted) split into three separate areas.

SRZ - A Special Research Zone which allows for limited research fishing for krill and toothfish.

KRZ - A Krill Research Zone which allows for controlled research fishing for krill, in accordance with the objectives of the MPA.

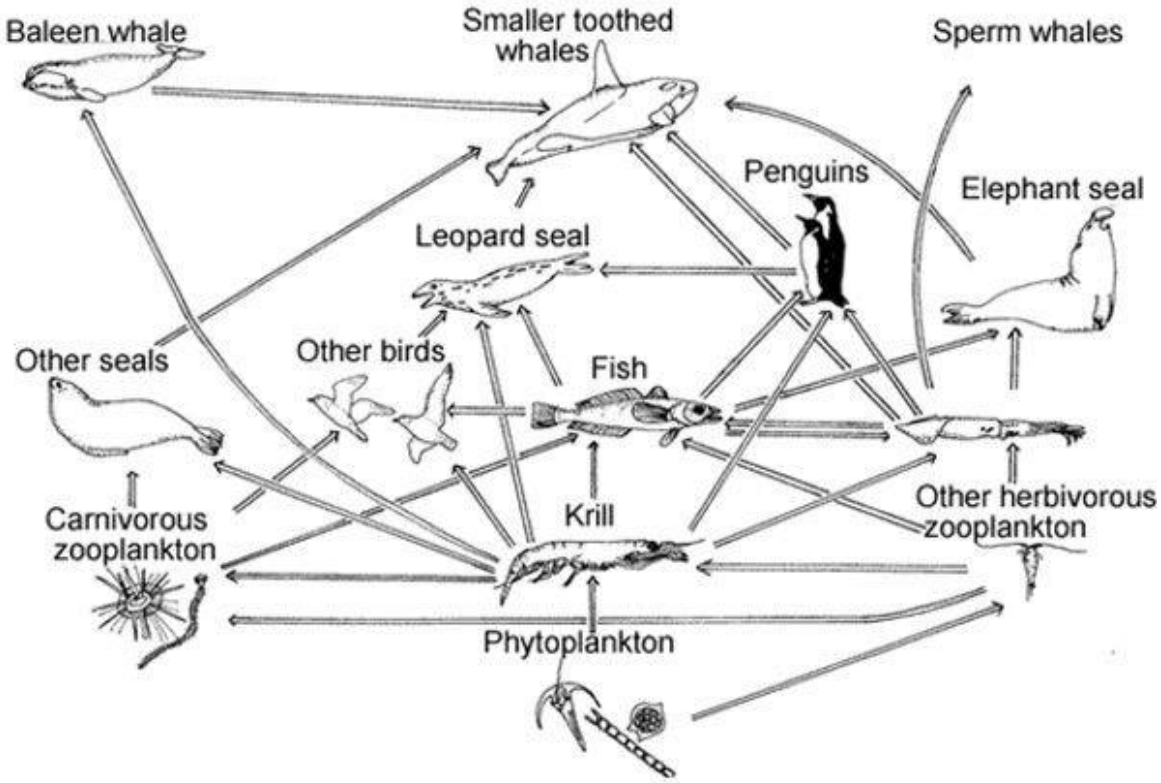
Use the map to estimate the most likely percentage of the Marine Protected Area which is **completely** protected (i.e., no fishing for any reason).

- **A.** 22%
- **B.** 32%
- **C.** 52%
- **D.** 72%
- **E.** 92%



Questions 36 – 39

The figure below is a food web of the Antarctic marine ecosystem. Food webs show the trophic (feeding) relationships between organisms with the arrows representing the transfer of energy from one organism eating another.



Question 36

Predict the most likely impact of significantly increasing the number of krill harvested.

- **A.** An increase in penguin population size.
- **B.** An increase in the size of individual phytoplankton.
- **C.** An increase in the population size of herbivorous zooplankton.
- **D.** A decrease in the population size of carnivorous zooplankton.
- **E.** No change to Antarctic ecology.

Question 37

The '10% rule" predicts that 10% of the energy available at one trophic level will be available for the next trophic level. Use this information and consider the 2 food chains below.

i) Phytoplankton → herbivorous zooplankton → carnivorous zooplankton → other birds → leopard seal → smaller toothed whales

ii) Phytoplankton → krill → leopard seal → smaller toothed whales

How much more phytoplankton would be needed to support the energy needs of smaller toothed whales via food chain i) compared to food chain ii)?

- **A.** 100 x
- **B.** 50 x
- **C.** 20 x
- **D.** 10 x
- **E.** The same amount.

Question 38

Where is most of the other 90% of energy likely to go?

A. Transformed to heat via cellular respiration.
B. Used as a source of energy for movement in the ocean.
C. Stored as fat in the organism.
D. Used as a source of energy for bioluminescence.
E. Consumed by decomposers.

Question 39

A keystone species can be defined as a species that has an extremely high relative impact on their ecosystem. This can be through habitat modification, nutrient cycling and/or the effect that they have on most other species in their food web.

Based on the information provided, what is the most likely candidate to be classified as 'keystone' species in the Antarctic ecosystem?

A. Penguins
B. Krill
C. Carnivorous Zooplankton
D. Leopard Seal
E. Sperm Whale

Penguins live in some of the most remote and hostile places on Earth and their numbers can be very difficult to monitor. Traditionally, direct counts have been used to estimate penguin distribution and abundance but recently scientists have been monitoring penguin colonies from space using satellite cameras.

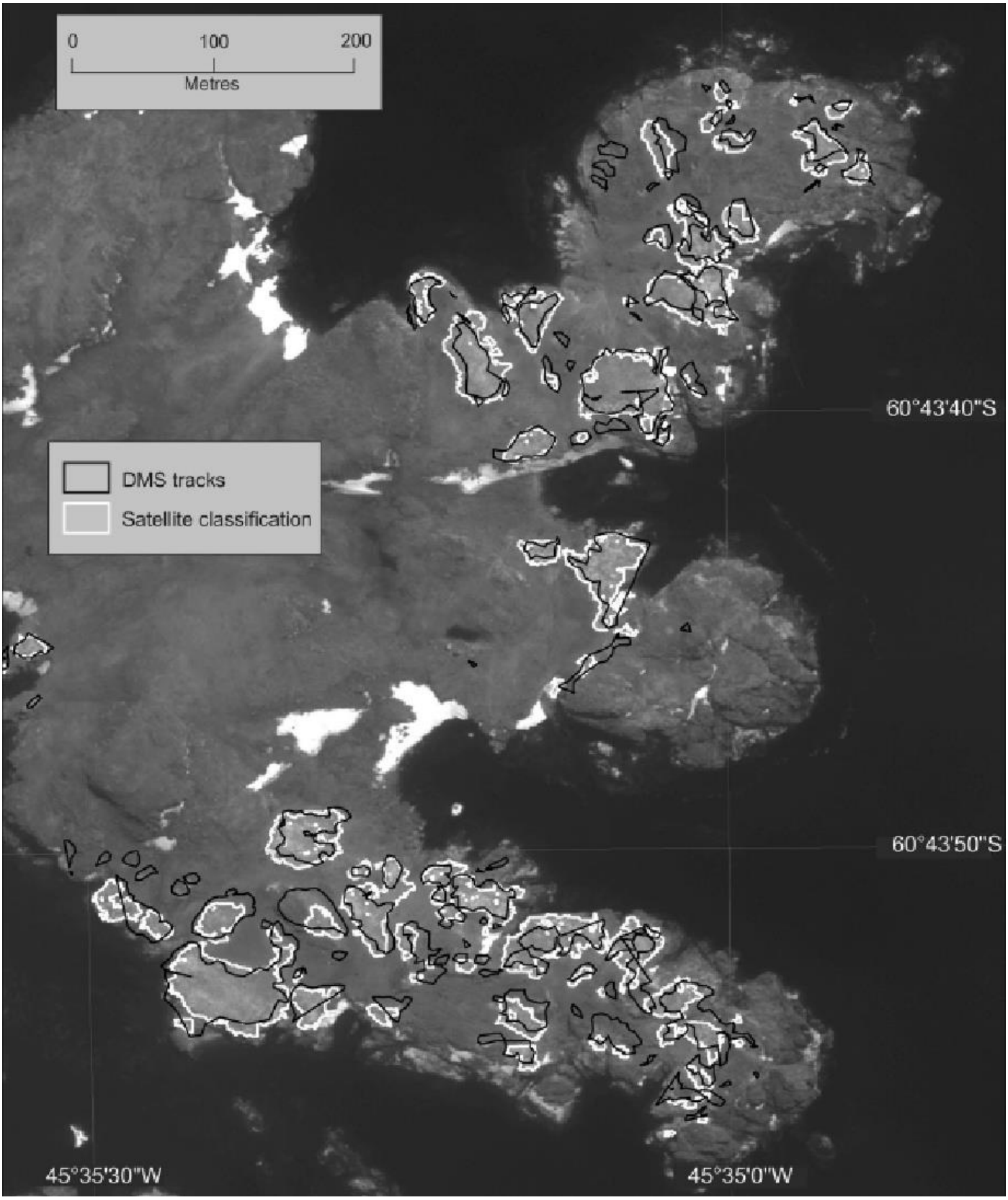
Source: http://www.bbc.com/earth/story/20141210-surprising-use-of-penguin-poo

Credit: Norman Ratcliffe

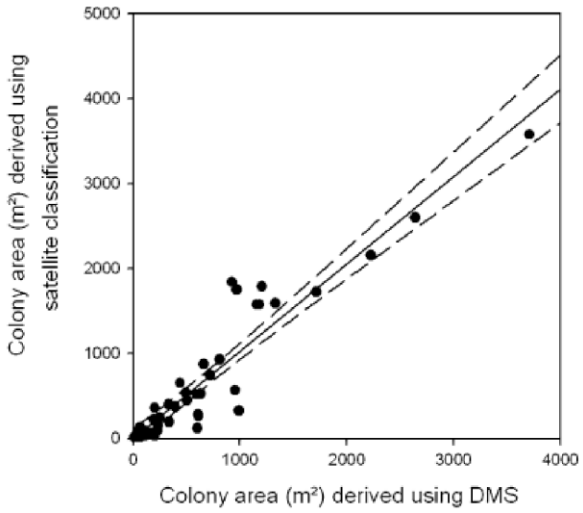
Penguin poo on the ice. **Credit:** DigitalGlobe / BAS)

Using satellite imagery, the colour of penguin 'poo' or guano can be used to estimate the size of populations and tell the different species of penguins apart. Adélie penguins breed earlier than chinstrap penguins at Signy Island, and in mid-January Adélie chicks were in crèche and chinstrap penguins still on eggs or young chicks. Direct field observations have shown that guano from chicks is darker and redder than that of adult birds.

The photo below shows the locations of Adélie and chinstrap penguin colonies on the Gourlay Peninsula on Signy Island. Black lines outline the colony boundaries obtained from handheld digital mapping (December 2006), white lines outline colony boundaries from satellite imagery (January 2010). Solid white areas are snow covered.



Source: Waluda, C.M., Dunn, M.J., Curtis, M.L. *et al.* Assessing penguin colony size and distribution using digital mapping and satellite remote sensing. *Polar Biol* **37,** 1849–1855 (2014).



The figure above compares the area occupied by penguin colonies at Signy Island as derived by satellite classification and handheld digital mapping ($n = 45$; $R^2 = 0.88$; $P < 0.001$). Dashed lines indicate 95 % confidence intervals.

Question 40

Which of the following statements about the use of penguin 'poo' to estimate penguin distribution and abundance represents a **CORRECT** conclusion.

A. Adélie penguin colonies will have lighter red guano than the chinstrap penguin colonies in January.
B. The largest penguin colony area measured at Signy Island was less than 3000 m^2.
C. Differences in the estimates of penguin colony area at Signy Island may reflect real differences between colony sizes in different years.
D. The estimates of penguin colony area at Signy Island are identical whether derived by digital mapping or satellite.
E. Satellite analysis of guano colour can be used to estimate the colony size for different penguin species at any time of the year.

To end our section on Antarctic penguin research here is a fun fact from an article in Ecowatch.
Source: https://www.ecowatch.com/antarctic-penguin-poop-laughing-gas-2646052474.html

Scientists from Denmark were studying the effects of glacier retreat and penguin activity on greenhouse gas emissions in South Georgia, an island with over 150,000 breeding pairs of king penguins.

The scientists found themselves going a little "cuckoo", feeling lightheaded and giggly while working in the penguin colony. The cause? Penguin guano produces large amounts of nitrous oxide which is used as a sedative and produces feelings of euphoria, calmness, and sometimes fits of giggles and laughter – hence the nickname 'laughing gas'.

Penguin guano produces nitrous oxide because the penguins' diet is mainly fish and krill, rich sources of nitrogen fixed from the atmosphere by the phytoplankton these species eat. When the guano is deposited on the soil and interacts with the air it is converted to nitrous oxide. Perhaps not so funny as nitrous oxide is a potent greenhouse gas, with a warming effect that is 300 times that of carbon dioxide.

The nitrous oxide produced by the penguin guano is not nearly strong enough to affect the earth's atmosphere, but clearly exerts a local effect - as the scientists discovered.

DNA METABARCODING OF ZOOPLANKTON COMMUNITIES AND BRYDE'S WHALE SCAT

Dr Rochelle Constantine is an Associate Professor in biological sciences and marine science at the University of Auckland. She leads the marine mammal ecology group and is a well-respected champion for the marine environment. One of her most recent projects is focused on the Hauraki Gulf - Tīkapa Moana / Te Moananui-ā-Toi and utilises DNA-barcoding to analyse the zooplankton community in the Gulf and the faeces (scat) of the Bryde's whale, a baleen whale species resident in the Gulf, to determine its diet.

'Scooping poop' from Bryde's whale in the Hauraki Gulf.

Bryde's whales (*Balaenoptera edeni brydei*) eat plankton and like all baleen whales use their baleen plates (hanging bristles made of keratin) to filter out food from the water. Understanding the trophic interactions in the Hauraki Gulf is important to conservation efforts for both the cetaceans (whales) and the ecosystem itself in the face of anthropogenic pressures such as climate change. A key question is whether trophic dynamics are controlled by the availability of resources ('bottom-up') or the impact of predation ('top-down').

Question 41

Productivity of phytoplankton (marine microalgae) in the Southern Ocean was found to be increased in areas rich in whale scat. It is known that the scat is iron-rich and leaches iron particles into the surface waters over a 12-hour period. Phytoplankton need iron for growth and the availability of iron controls primary productivity.

Is this scenario an example of ….

A. 'Bottom-up' control.
B. 'Top-down' control.
C. Both 'bottom-up' and 'top-down' control.
D. Neither 'bottom-up' nor 'top-down' control.
E. Pollution.

Question 42

Considering the information above and the Antarctic food web illustrated in the stem for Questions 36-39, what is the best conclusion about the mechanism by which whale scat increases productivity in the Southern Ocean?

- **A.** It directly increases productivity of phytoplankton which increases the numbers of baleen whales.
- **B.** The iron contained in whale scat drives the iron cycle in the Southern Ocean and increases primary productivity.
- **C.** It increases the number of krill so there is more food for the whales and their numbers increase.
- **D.** By keeping iron in the surface waters, primary productivity and prey abundance is increased and nutrients are transferred from areas of high to low productivity increasing the abundance of krill and baleen whales.
- **E.** None of the above provide an adequate explanation of the mechanism by which whale scat increases productivity in the Southern Ocean.

Bryde's whales are unusual in comparison to other baleen whales, because they do not migrate to Antarctica to feed during the summer months but are resident in the Gulf year-round. They also feed across trophic levels, including both small and large zooplankton (microscopic animals in the water that feed on phytoplankton) and fish in their diet. Bryde's whales in other parts of the world are known to feed on specific prey items despite being able to consume a wide variety of organisms.

Zooplankton in the Gulf show seasonal trends in community composition, but it is not known whether the diet of Bryde's whales follows these seasonal shifts. This study used a multi-locus DNA metabarcoding approach and systematic surveys to determine whale diet and potential prey availability, as this provides a direct approach to assess the diet of these generalist predators foraging across multiple trophic levels.

The zooplankton community was sampled every six weeks for a year using a single vertical hauled plankton net. The researchers classified their samples as either cool-season (Austral winter and spring; 13–17 °C) or warm-season (Austral summer and autumn: 17–21 °C) to align with seasonal temperature regimes: Whale scat was opportunistically sampled using a scoop net when defecation was sighted, with samples collected over several years. Zooplankton DNA and DNA from the whale scat was extracted and used to construct multi-locus DNA barcode libraries using 18S (zooplankton) and COI (whale) gene fragments. This allowed the identification of many operational taxonomic units (OTUs) at a Class or Order level.

The table on the next page summarises the frequency of possible prey taxa occurring across the whale scat samples, identified to Phylum and Class. Data are shown as both presence/absence and relatively high-read abundance taxa (>15% reads per sample). Total sample sizes were 15 for 18S and 16 for COI

Question 43

What taxonomic class does the most abundant organism consumed by Bryde's whales belong to?

- **A.** Branchiopoda
- **B.** Malacostraca
- **C.** Copepods
- **D.** Salps
- **E.** Thaliacea

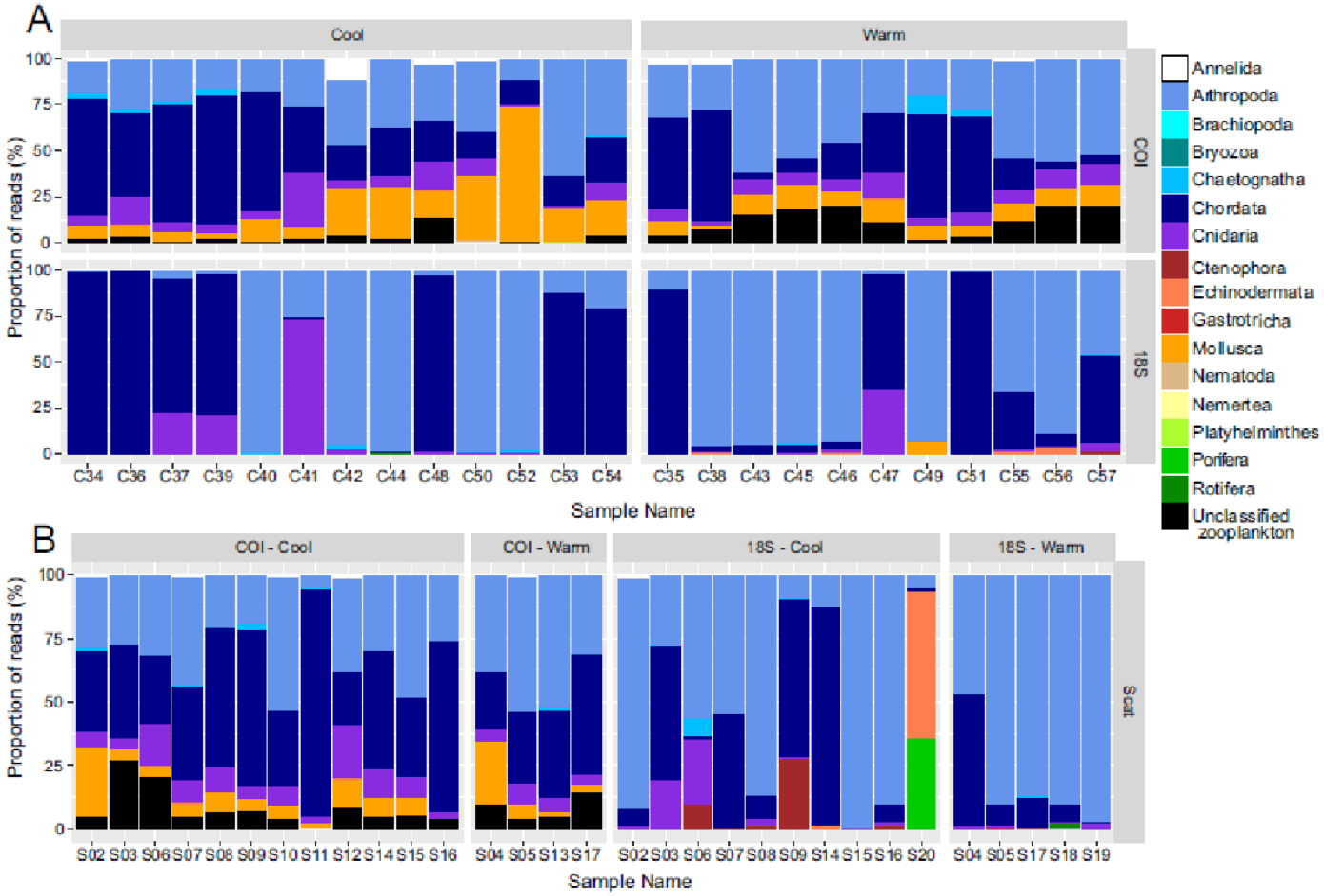
Question 44

What **CANNOT** be concluded from the data in the table overleaf about the possible prey taxa of the Bryde's whale?

- **A.** Few samples of whale scat were found to contain unclassified zooplankton.
- **B.** Krill and copepods were found in all samples of whale scat.
- **C.** Marine worms in the class Clitellata are often found in whale scat samples but are seldom abundant.
- **D.** Sea snails are frequently consumed by the whales but do not form a large part of the whale's diet.
- **E.** Arrow worms form a frequent part of the whale's diet.

Phylum	Class	Common name	Presence/ Absence		High Abundance	
			18S	COI	18S	COI
Annelida	Clitellata	marine worm	3	12	0	0
	Polychaeta	marine warm	7	0	0	0
Arthropoda	Branchiopoda	planktonic crustaceans	1	16	0	5
	Chelicerata	planktonic arthropods	3	13	0	0
	Chilopoda		0	8	0	0
	Malacostraca	krill	15	16	6	1
	Maxillopoda	copepods	15	16	7	3
Chaetognatha	Sagittoidea	arrow worms	11	12	0	0
Chordata	Actinopterygii	ray-finned fish	13	16	2	3
	Appendicularia	tunicates	12	0	0	0
	Elasmobranchii	cartilaginous fish	0	2	0	0
	Holocephali	cartilaginous fish	0	5	0	0
	Sarcopterygii	lobe-finned fishes	0	8	0	0
	Thaliacea	salps	14	16	4	15
Cnidaria	Hydrozoa	jellyfish-like	13	16	2	2
	Scyphozoa	jellyfish-like	0	1	0	0
Ctenophora	Tentaculata	comb jellies	12	0	1	0
Echinodermata	Asteroidea	echinoderms	0	4	0	0
	Echinoidea	echinoderms	4	0	1	0
Gastroricha	Chetonotida	echinoderms	1	0	0	0
Mollusca	Bivalvia	bivalves	2	10	0	0
	Gastropoda	seas snails	3	16	0	2
Nematoda	Chromadorea	marine roundworm	1	0	0	0
Nemertea	Enopla	marine worm	2	0	0	0
Platyhelminthes	Trematoda	flatworm	1	0	0	0
	Turbellaria	flatworm	4	0	1	0
Porifera	Demospongiae	sponge	3	0	0	0
Rotifera	Eurotatoria	zooplankton	2	0	0	0
Zooplankton	unclassified	zooplankton	0	16	0	3

The figure below summarises the taxa stratified by season (cool – winter, spring; warm – summer, autumn) for A. zooplankton community and B. scat samples. The major groups seen in these samples are Arthropoda, including krill and copepods; Chordata, including salps and free-swimming tunicates; Cnidaria (jellyfish); comb jellies, which are in the Phylum Ctenophora; and Mollusca, including the marine snails.



Question 45

Considering the data above, what seasonal changes are evident in the zooplankton community composition?

- **A.** In winter and spring there are more molluscs in the zooplankton.
- **B.** In the cool months unclassified zooplankton are more abundant.
- **C.** Chordata are common species in the zooplankton throughout the year.
- **D.** Arthropoda are only found in the zooplankton in summer and autumn.
- **E.** Cnidaria are more abundant in the zooplankton in winter and spring.

Question 46

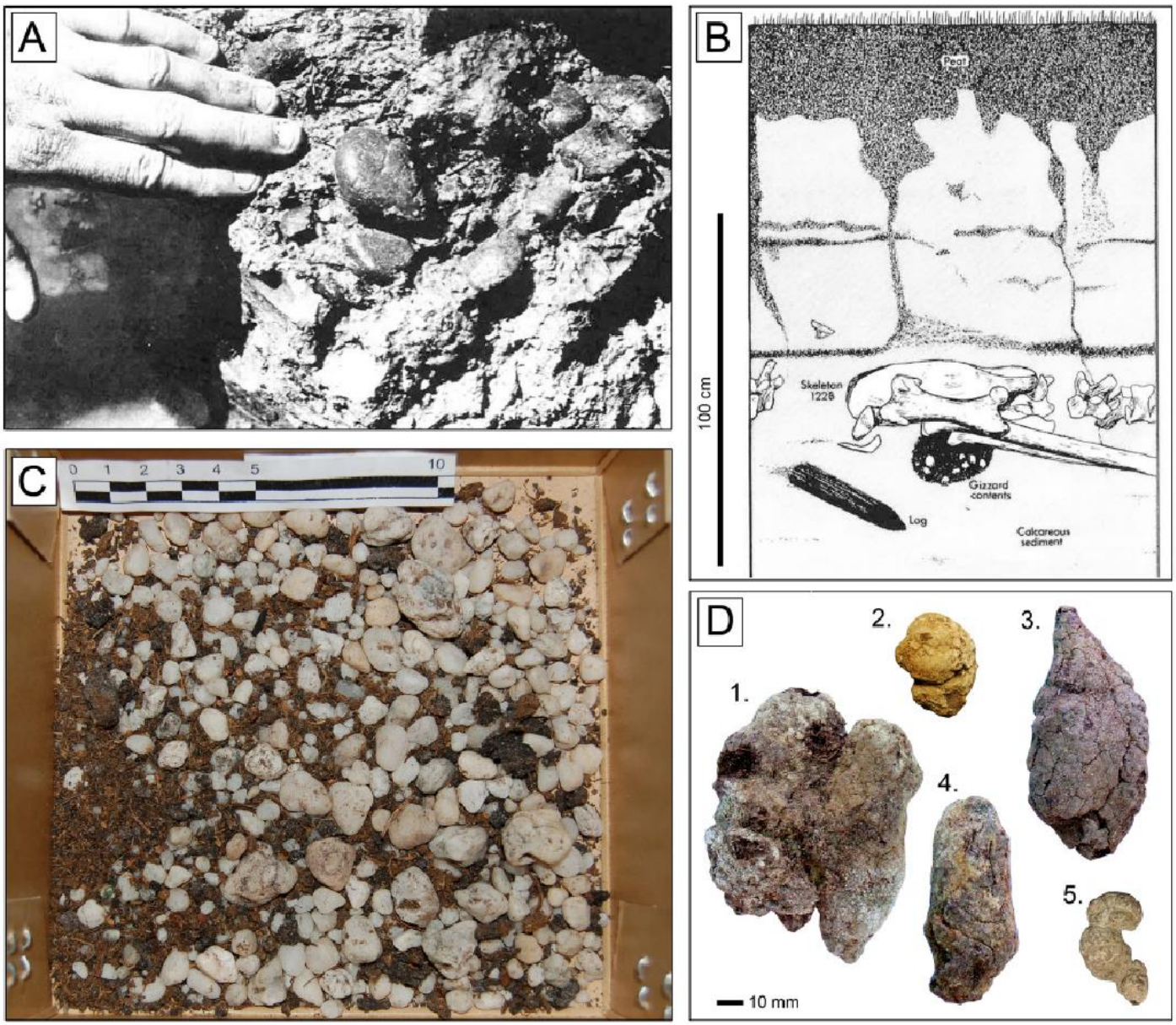
What seasonal changes are evident in the diet of Bryde's whale in the Hauraki Gulf?

- **A.** The whales consume more molluscs in winter and spring.
- **B.** In the cool months unclassified zooplankton are eaten more often.
- **C.** Chordata are commonly consumed throughout the year.
- **D.** Arthropoda are only eaten frequently in summer and autumn.
- **E.** There is little difference in the diet of Bryde's whales between cool and warm seasons.

ANCIENT DUNG – UNDERSTANDING THE DIET AND ECOLOGICAL NICHE OF MOA

Moa were the largest herbivores in pre-human New Zealand and understanding the diet of these birds is important to understand the NZ terrestrial ecosystem and the ecological niches of the various moa species. Researchers From Manaaki Whenua, Landcare Research have been studying moa diets using preserved gizzards (muscular part of a bird's stomach) and coprolites, ancient dung.

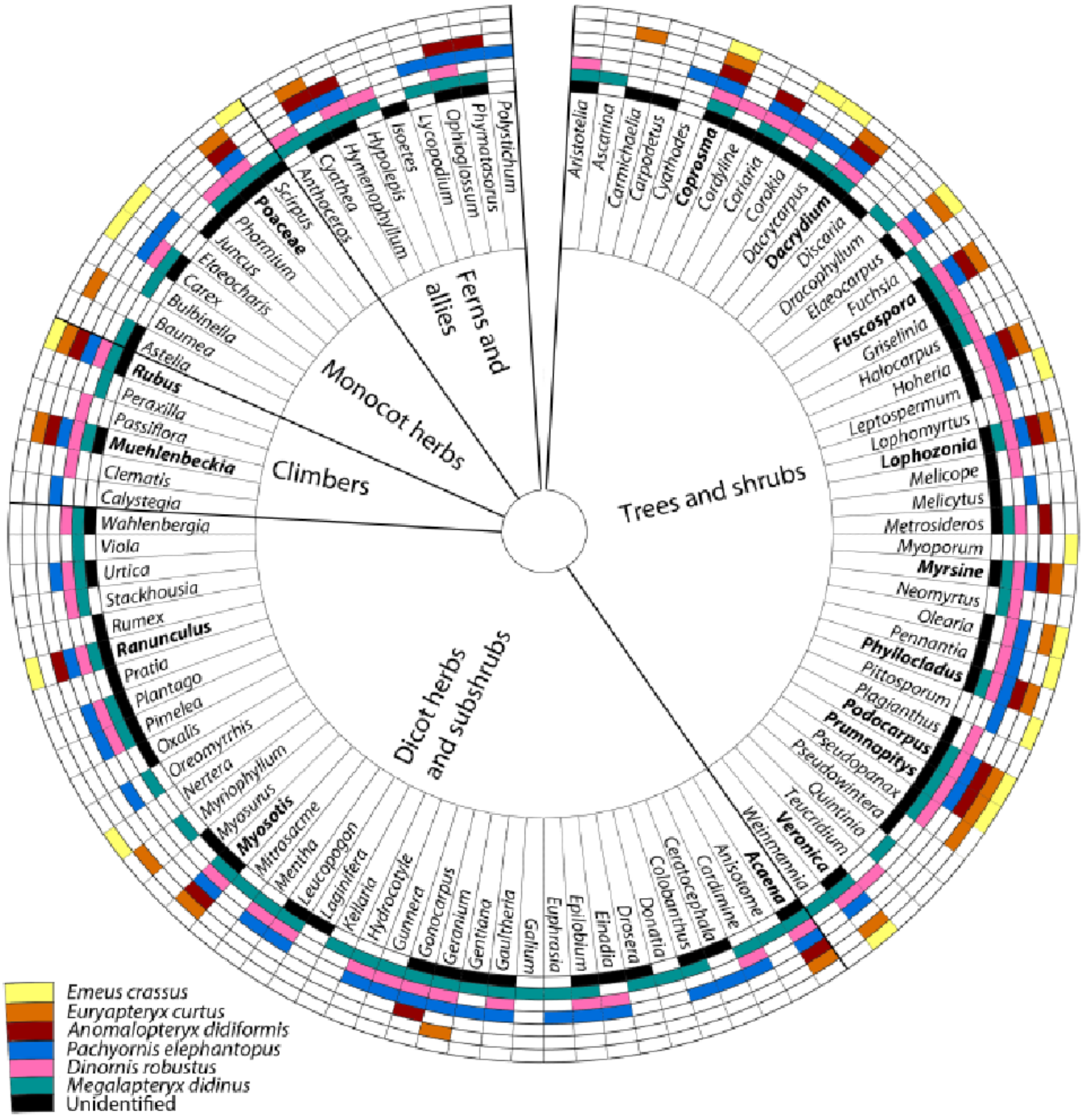
Their study summarises 2755 records of plant remains from 23 moa gizzard contents and 158 moa coprolites. They have been able to identify differences between the diets of different moa species and their habitat preferences which has provided insight into the role of moa herbivory in the evolution of New Zealand's unique plants. It also helps us to understand the ecological functions and roles played by the moa that were lost when these species became extinct, and to determine whether any of these functions and roles have been replaced by introduced animal species.

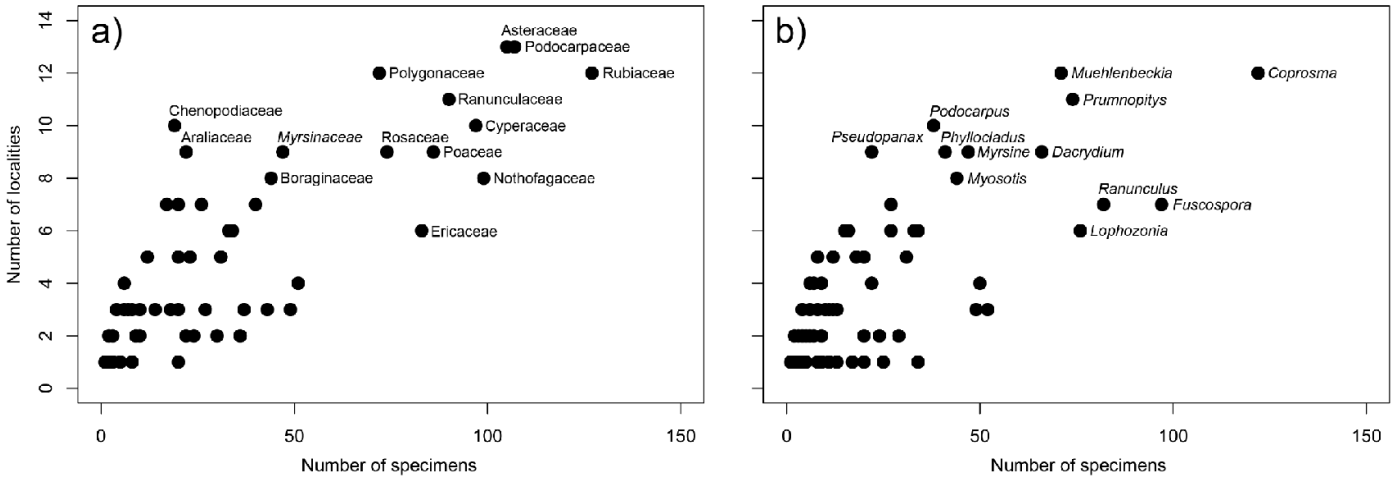


The figure above shows the sources of direct evidence for moa diets. **A** and **B**, in situ gizzard content found adjacent to the skeleton of an immature female South Island giant moa (*Dinornis robustus*); **C**, moa gizzard content from Scaife's Lagoon, west Otago; **D**, Moa coprolites from 5 species of moa; 1. Heavy-footed moa (*Pachyornis elephantopus*) from Dart River Valley, West Otago; 2. Little bush moa (*Anomalopteryx didiformis*) from Mt Nicholas Station, West Otago; 3. South Island giant moa from Dart River Valley, West Otago; 4. Upland moa (*Megalapteryx didinus*) from Dart River Valley, West Otago; 5. Upland moa from Euphrates Cave, Northwest Nelson.

Gizzard content samples typically include numerous seeds, leaves and stem fragments that can be readily identified using comparative reference material. They are also found in situ with moa skeletons, allowing them to be associated with a moa species. The material in moa coprolites is more digested and not as easily identified but can still be analysed for macrofossils such as seeds, leaves, and twigs and microfossils like pollen grains. Coprolites are not found in association with skeletons and so, before the advent of new DNA technologies, it was impossible to identify which moa species they were from. However, ancient DNA (aDNA) analysis of moa coprolites has meant that researchers can attribute moa coprolites to particular species and, together with analysis of pollen and macrofossils, understand moa diets and niche partitioning in greater detail.

The diagram below summarises the occurrence of plant genera (and the grass family Poaceae) in moa gizzard content and coprolites based on all proxies (pollen, macrofossils and aDNA). Bold font indicates plant taxa recorded from gizzard content or coprolites of five or more moa species.





The figure above gives the frequency of occurrence of (a) plant families and (b) genera in moa gizzard and coprolite specimens. Taxon names are shown for those occurring at ≥8 different localities (16 in total) and/or ≥75 different specimens (181 in total).

Source: Wood, J. R., Richardson, S. J., McGlone, M. S., & Wilmshurst, J. M. (2020). The diets of moa (aves: Dinornithiformes). *New Zealand Journal of Ecology, 44*(1), 1-21.

Question 47

Which genera of dicot herbs and shrubs are eaten by all species of moa?

- ***A.*** *Ranunculus*
- ***B.*** *Myosotis*
- ***C.*** *Acaena*
- ***D.*** *Podocarpus*
- **E.** None are eaten by all species of moa.

Question 48

Which is the only species of moa that has not been found to eat ferns?

- ***A.*** *Emeus crassus*
- ***B.*** *Euryapteryx curtus*
- ***C.*** *Anomalopteryx didiformis*
- ***D.*** *Pachyornis elephantopus*
- ***E.*** *Dinornis robustus*

Question 49

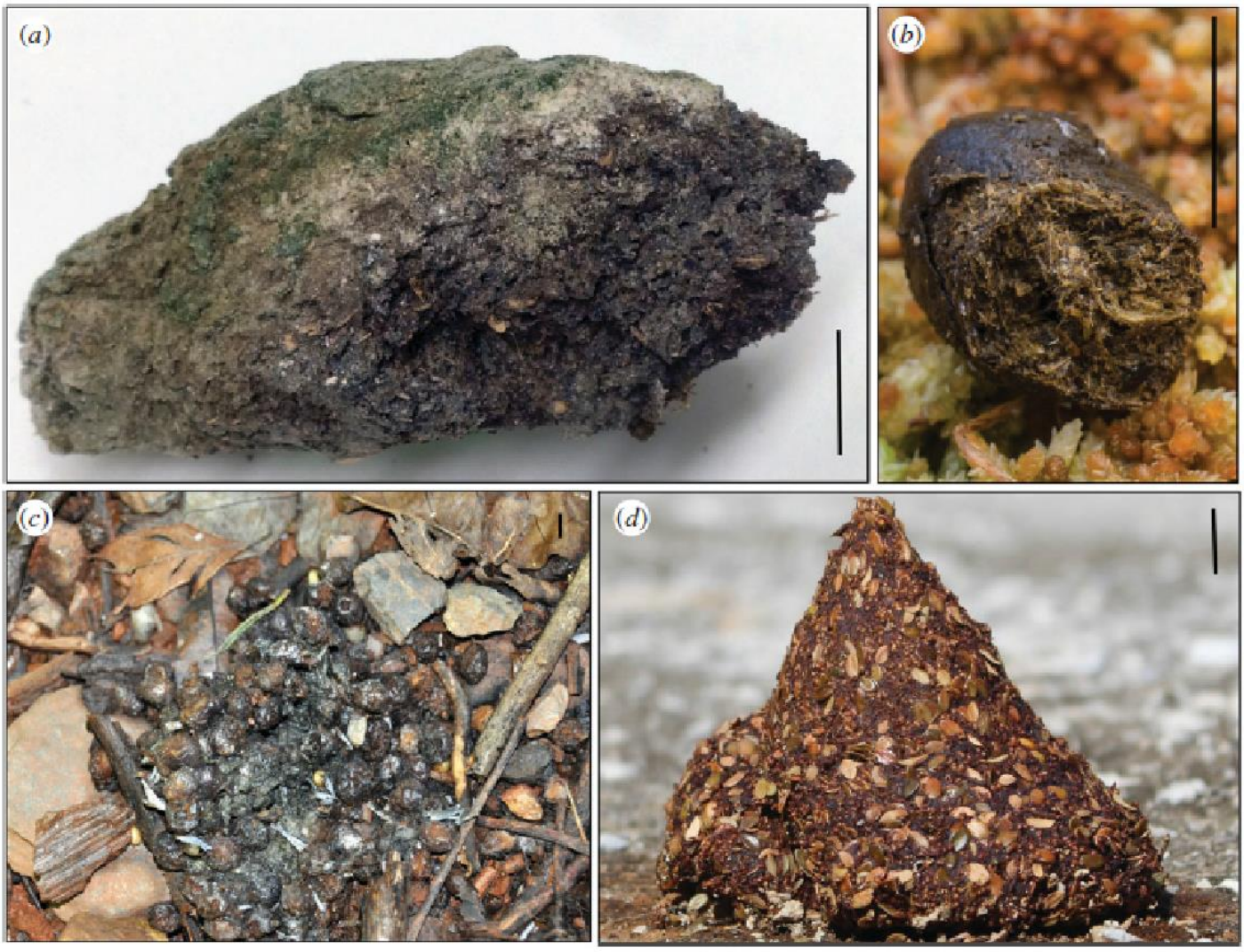
What statement below can be concluded from the data on plant taxa from moa gizzard and coprolite specimens?

- **A.** All moa species grazed in ancient forests rich in podocarps (family Podocarpaceae, genus *Podocarpus*).
- **B.** All moa species ate ferns on the forest floor.
- **C.** *Coprosma* was a favoured food plant for moa.
- **D.** Moa ate a limited range of plants.
- **E.** Grasses (Poaceae) were commonly eaten by all species of moa.

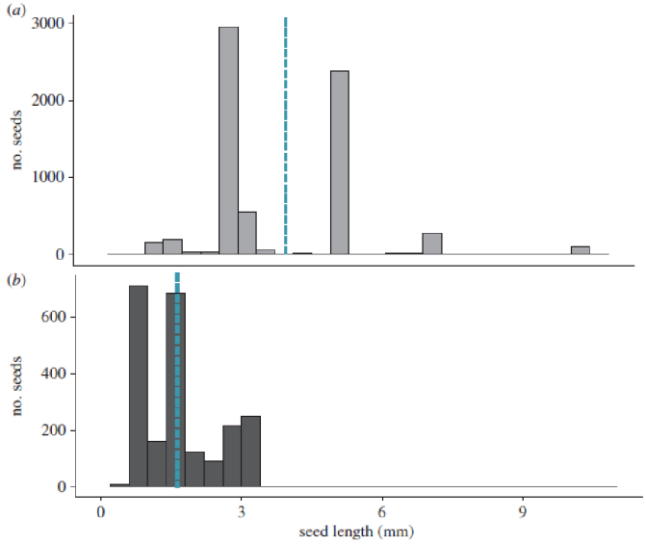
Question 50

Large trees belonging to the genera *Fuscospora*, *Dacrydium*, and *Podocarpus* are wind pollinated and produce large amounts of pollen. How could this affect the scientist's estimation of the importance of these species in the diet of moa?

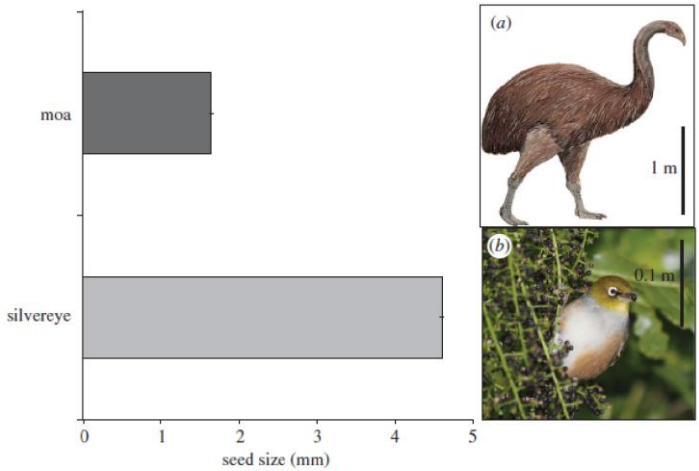
- **A.** It would have no effect; if the pollen is found in the coprolites, then it is an important food for the moa.
- **B.** It may lead to an inflated estimate of their importance in the moa's diet.
- **C.** It may lead to an under-estimation of their importance in the moa's diet.
- **D.** Pollen is not eaten by the moa so its presence in the moa coprolites is not informative about the moa diet.
- **E.** Wind-pollinated plants are not eaten by the moa.



The photos above show the consistency of faecal deposits from (a) moa, (b) red deer *Cervus elaphus*, (c) cassowary *Casuarius* sp. and (d) emu *Dromaius novaehollandiae*. The small pale objects in the moa coprolite are *Coprosma* seeds (approx. 2 mm length). Scale bars are 1 cm.



Frequency distributions of seed length for seeds found in moa gizzards (light grey, a) and moa coprolites (dark grey, b). Means are marked by the dashed lines. Note the different y-axis scales.



Mean seed size dispersed by (a) moa, weighing from 15–250 kg, and (b) silvereyes (*Z. lateralis*), weighing 0.01–0.013 kg.

Source: Carpenter JK, Wood JR, Wilmshurst JM, Kelly D. 2018 An avian seed dispersal paradox: New Zealand's extinct megafaunal birds did not disperse large seeds. Proc. R. Soc. B 285: 20180352.

The largest-seeded species found in gizzards was from *Elaeocarpus hookerianus* (10.25 mm average length), while the largest found in coprolites was *Muehlenbeckia axillaris* (3.3 mm average length). Almost half of the moa gizzards examined contained the large, thick-endocarp seeds of *Prumnopitys* and *Elaeocarpus*.

Question 51

Which of the statements below is not correct?

- **A.** The faeces of all large birds are finely ground.
- **B.** Moa and deer faeces are finely ground.
- **C.** Moa gizzards grind plant material so fine that no seeds pass through their guts intact.
- **D.** Emu faeces have lots of unground material, including seeds.
- **E.** Cassowary faeces contain lots of unground seeds.

Question 52

What is the length of the seeds most commonly consumed by the moa?

- **A.** 0.8 mm
- **B.** 1.6 mm
- **C.** 2.5 mm
- **D.** 3.0 mm
- **E.** 4.0 mm

Question 53

Estimate the difference in mean seed length of intact seeds found in moa gizzards and moa coprolites.

- **A.** 1.6 mm
- **B.** 2.0 mm
- **C.** 2.4 mm
- **D.** 3.0 mm
- **E.** None of the above.

Question 54

The extinction of megafauna such as moa may have significant consequences for the ecosystem as a result of the loss of the ecosystem services they provided. The ecosystem services of extinct fauna are generally inferred based on plausible assumptions, and one of the most commonly held assumptions about seed dispersal is that there is a correlation between fruit size and disperser size.

Given all of the data above and that the large extinct moa where frugivores (fruit eaters) and subfossils have been found with large seeds in their gizzards, what conclusion could be drawn about their role in seed dispersal?

- **A.** Moa consumed and dispersed the largest fruits.
- **B.** The extinction of moa has led to a decrease in the dispersal of large-seeded plants.
- **C.** Extant species are not able to disperse large-seeded plants and so these species are becoming increasingly rare in NZ forests.
- **D.** Moa did not disperse large-seeded plants.
- **E.** The larger the bird the larger seeds they can disperse.

DUNG BEETLES – IMPROVING PASTURE HEALTH & REDUCING RUNOFF IN NEW ZELAND

Dung beetles are the unsung heroes of grasslands around the world: wherever you find large herbivores grazing you will find dung beetles processing the dung they leave behind them. Their tunnelling and burial of dung improves the soils, resulting in increased pasture productivity. Their actions also result in a reduction in the runoff of urine and fertiliser, which decreases nitrogen enrichment of waterways and improves water quality. The burial of the dung also reduces the re-infection rates for gastro-intestinal parasites, such as nematodes, in stock and results in less flies in and on the dung.

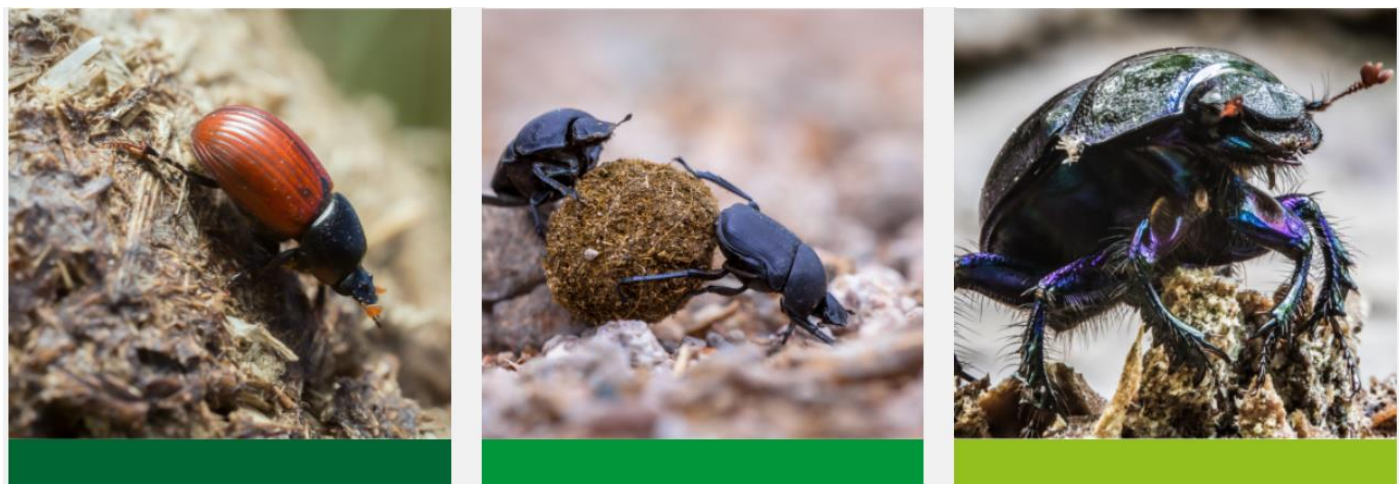
"There are 6.5 million dairy cows in New Zealand, each producing on average 27 kilograms of dung a day. By the time you add in another 3.6 million cattle and 27.4 million sheep that is over 100,000,000 tonnes of dung each year."

Source: Dung beetle innovations. https://dungbeetles.co.nz/about-beetles/

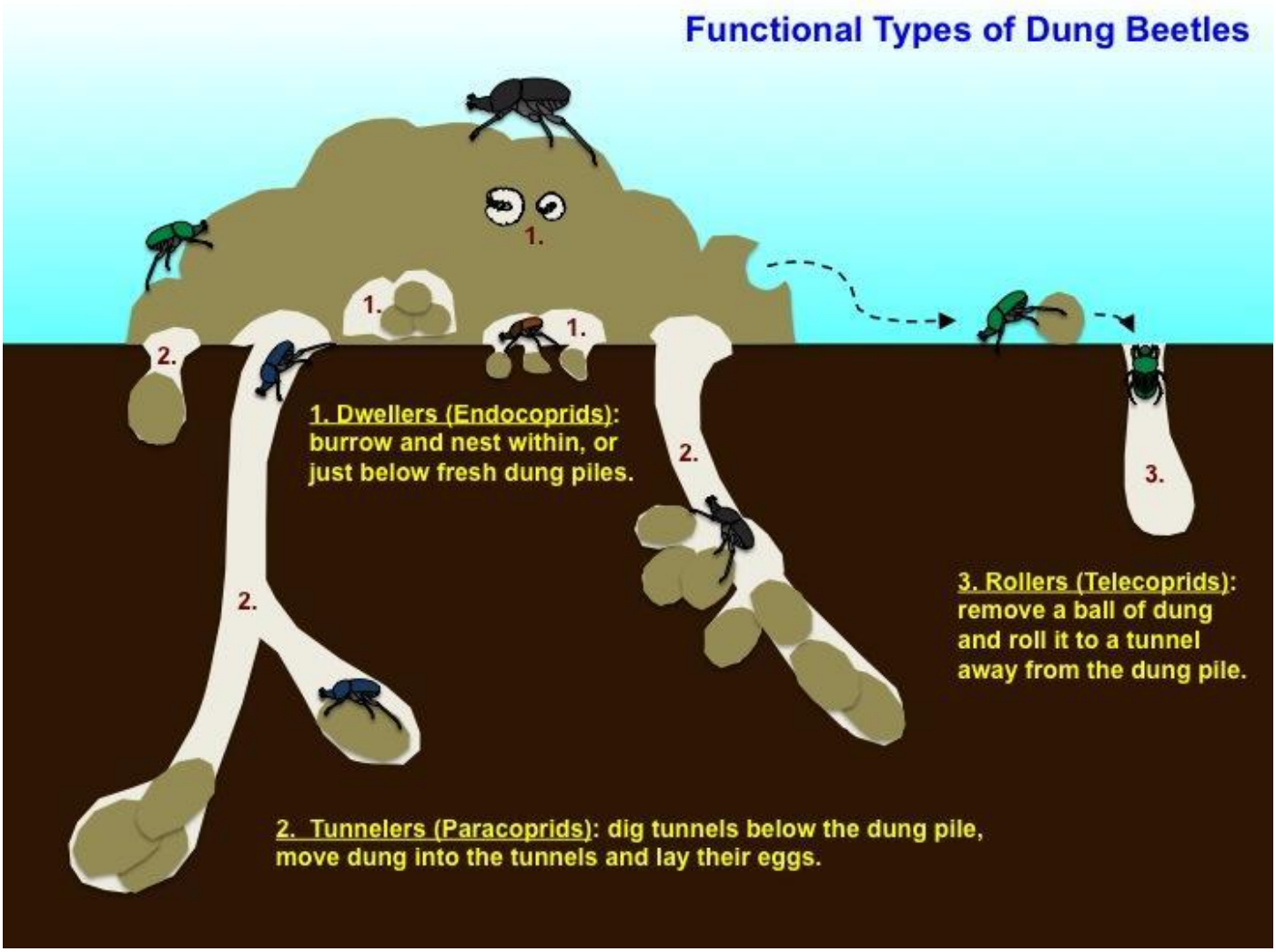
Scientists at Landcare Research │Manaaki Whenua have been providing the scientific research underlying the dung beetle project since 2008. The aim of this project is to improve the health of New Zealand's pastures and decrease the environmental impact of pastoral farming by controlled release of dung beetles.

Why are we introducing dung beetles? Doesn't New Zealand have its own dung beetles? The answer is yes, we do have 15 species of endemic (native) dung beetle populations, but most are highly specialized for forest living. Modern farming of large herbivores was only introduced about 150 years ago and our local dung beetles have not evolved to process the dung of domesticated livestock on lush grassy pastures composed of introduced species.

There are three functional types of dung beetles: dwellers, rollers, and tunnellers.



Source: Dung beetle innovations. https://dungbeetles.co.nz/about-beetles/



Source: https://entomology.unl.edu/scilit/dung-beetles

Question 55

The purpose of introducing dung beetles to New Zealand is to improve soil structure and decrease runoff of urine and fertiliser into waterways. Which types of dung beetles should be introduced to ensure the maximum benefit to both the farmer and the environment?

A. Endocoprids
B. Paracoprids
C. Telecoprids
D. Both Endocoprids and Paracoprids.
E. Both Endocoprids and Telecoprids.

"Scientists have observed around 4,000 dung beetles converge on a fresh pile of elephant scat within 15 minutes. And they work hard too; one dung beetle can bury 250 times its own weight in a night."

Source: Dung beetle innovations. https://dungbeetles.co.nz/about-beetles/

Dung Beetle Innovations was started in 2014 with the aim of "improving water quality and soil health – through leadership, education and the establishment of dung beetles as a sustainable farm management practice." They currently import 11 species of dung beetle, with each species having its own unique characteristics, behaviours, and life cycle. The table below summarises the characteristics of 8 species. Species that are active during the day are referred to as diurnal and those active at night, nocturnal. Some species are active when light levels are low at dawn and dusk and this activity pattern is referred to as crepuscular.

SPECIES	GEOGRAPHICAL ORIGIN	MAX SIZE	ACTIVE	LIFE CYCLE (EGG – ADULT)	GENERATIONS PER SEASON	Maximum TUNNEL DEPTH	SOIL PREFERENCE
Onthophagus binodis	Southern Africa	13mm	Diurnal. Late Spring to Autumn	8-10 weeks	2-3	20-30cm	Sandy loam, clays
Onthophagus taurus	South-west Europe,	9mm	Diurnal. Spring to Autumn	8-10 weeks	2-3	10-20cm	Heavy clays, loams, silts
Digitonthophagus gazella	Southern Africa	11mm	Dusk and dawn, Late Spring-Summer	6-8 weeks	2-3	20-30cm	Clays, sand, loams
Geotrupes spiniger	South-west Europe (incl. Southern England)	22mm	Dusk and dawn, Autumn-winter	4 -6 months	1-2 per year	30-45cm	Wet soils, clay or loams
Copris hispanus	South-west Europe	22mm	Nocturnal, Spring-late Autumn	3-4 months	1	20-40cm	Clays, loams, silt
Copris incertus	Central America	15mm	Nocturnal, Spring-late Autumn	2-3 months	2	15-30cm	Clays, loams
Bubas bison	South-west Europe	16mm	Dawn and dusk, Winter	1-2 years	1	30-110cm	Clays, loams, silts
Onitis alexis	Southern Africa	18mm	Dawn and dusk, Summer-mid Autumn	4-6 months	1	10-30cm	Clays, sand, loams

Source: Dung beetle innovations. https://dungbeetles.co.nz/about-beetles/

Question 56

When would you be most likely to see introduced dung beetles actively processing dung on a farm near you?

A. At night.
B. During the day.
C. At dawn.
D. Just as the sun is setting.
E. At dawn and dusk when the light is low.

Question 57

The dung beetle project is introducing 11 different species of beetle to New Zealand pastures across New Zealand. Why have they decided on multiple introductions rather than choosing the 'best' species for New Zealand conditions?

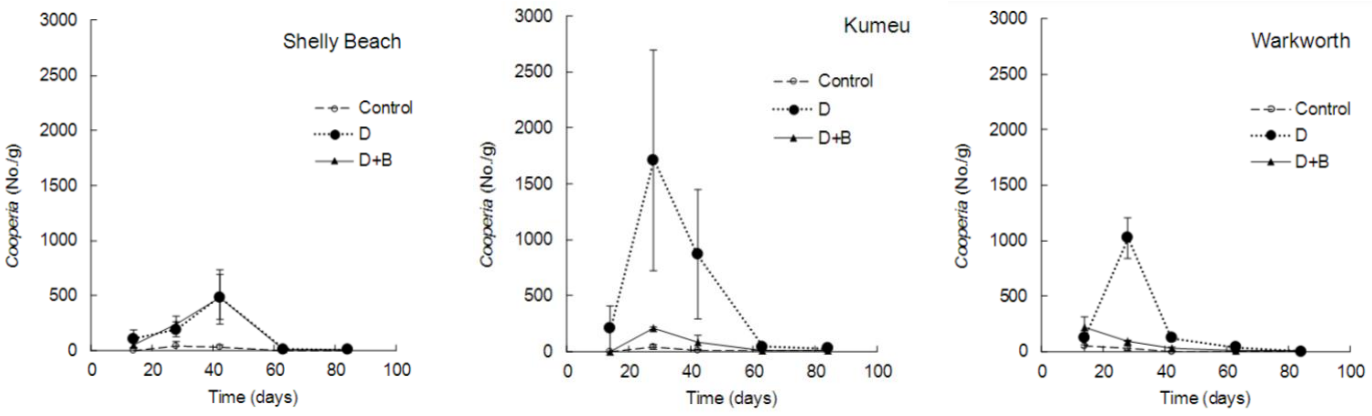
- **A.** To ensure that dung removal efficiency is optimized all year long, day and night, across a variety of soil types throughout New Zealand.
- **B.** To make sure that a single beetle species doesn't out-compete our native species.
- **C.** Because dung beetles can only process dung from specific species of herbivores.
- **D.** To form a 'more natural' dung beetle community in New Zealand.
- **E.** Because each dung beetle reproduces at a different time of the year.

The introduction of exotic species carries significant risks: you only have to think about the effect of possums, rats, and stoats on our New Zealand's forests to be concerned about possible risks. The science underlying this project is therefore strongly focused on the quantification of the risks and benefits posed by introducing exotic species of dung beetles to New Zealand pastures.

One of the possible risks from the introduction of dung beetles raised by the technical advisory group is that burial of dung containing gastro-intestinal parasites such as nematode worms might increase the survival of the nematodes and result in higher infection rates in the stock.

Landcare Research carried out some field trials to investigate whether there was an increased load of nematodes in the pasture in the presence of dung beetles. They set up secure field cages on three farms with different soils: sandy loam (Shelly Beach), clay loam (Kumeu) and compacted clay (Warkworth). At each site there were three different treatments: dung + beetles, dung only, and controls without either dung or dung beetles. Each treatment was replicated three times on each farm.

The experiment used three species of dung beetles, *Geotupes spiniger* (2), *Onthophagus binodis* and *Digitonthophagus gazella* (40 each). Nematode infected dung was added to the field cages once and then the grass was clipped every 2-3 weeks and all nematodes counted. The results from the three different farms are shown in the graphs below. D – dung only, D+B – dung plus beetles.



Source: https://www.landcareresearch.co.nz/uploads/public/Events/Link-series/Dung_Beetles.pdf

Question 58

The control shows us ….

- **A.** There are no parasitic nematodes in the soils unless there is dung from herbivores.
- **B.** The initial number of parasitic nematodes in the pasture depended on the soil type.
- **C.** It allows us to compare between the effect of dung only and dung plus beetle treatments.
- **D.** It establishes the baseline number of nematodes in the pasture at each site before the addition of either dung or dung beetles.
- **E.** This experiment needed to control many factors not just one.

Question 59

Which of the statements below can be correctly concluded from the experiment?

- **A.** The numbers of parasitic nematodes in the pasture were reduced at all sites when dung beetles were present.
- **B.** Dung beetles reduced the number of parasitic nematodes.
- **C.** Parasitic nematodes do not survive for more than 3 weeks in pasture without herbivores.
- **D.** Dung is the only source of parasitic nematodes in pasture.
- **E.** There is no evidence dung beetles increase the parasitic nematode load in pasture.

Gods of Ancient Egypt

Many Ancient Egyptian artworks, jewellery, and hieroglyphics depict dung beetles or scarabs. They were believed to represent the restoration of life – renewing the sun each day by rolling it above the horizon. The sun god Khepri Ra is often depicted as a scarab, or a scarab-headed man.

Source: Dung beetle innovations. https://dungbeetles.co.nz/about-beetles/

Question 60

Let's finish the exam with a lateral thinking puzzle. If ….

2 + 2 = Fish
3 + 3 = Eight
7 + 7 = Triangle
1 + 1 = **X**

What is **X**?

- **A.** Four
- **B.** Ten
- **C.** Circle
- **D.** M
- **E.** Smiley face

Source: question inspired by: https://www.brainsyoga.com/2018/04/lateral-thinking-picture-puzzle.html

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 and on the global stage. 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.