EXAM PAPERS PRACTICE

Helping you Achieve Highest Grades in IB

IB Biology SL

Question Paper

Fully in-lined with the First Teaching in 2023 & First Assessment Examinations in 2025 & Beyond

Paper: 2 (Data-based Questions Across All Themes)

- **Theme A: Unity & Diversity**
- **Theme B: Form & Function**
- **Theme C: Interaction & Interdependence**
- **Theme D: Continuity & Change**

Marks: 617

Total Marks: / 617

Suitable for Students sitting the 2026 exams onwards
However, students in HL might find it useful

Questions

19M.2.SL.TZ1.1

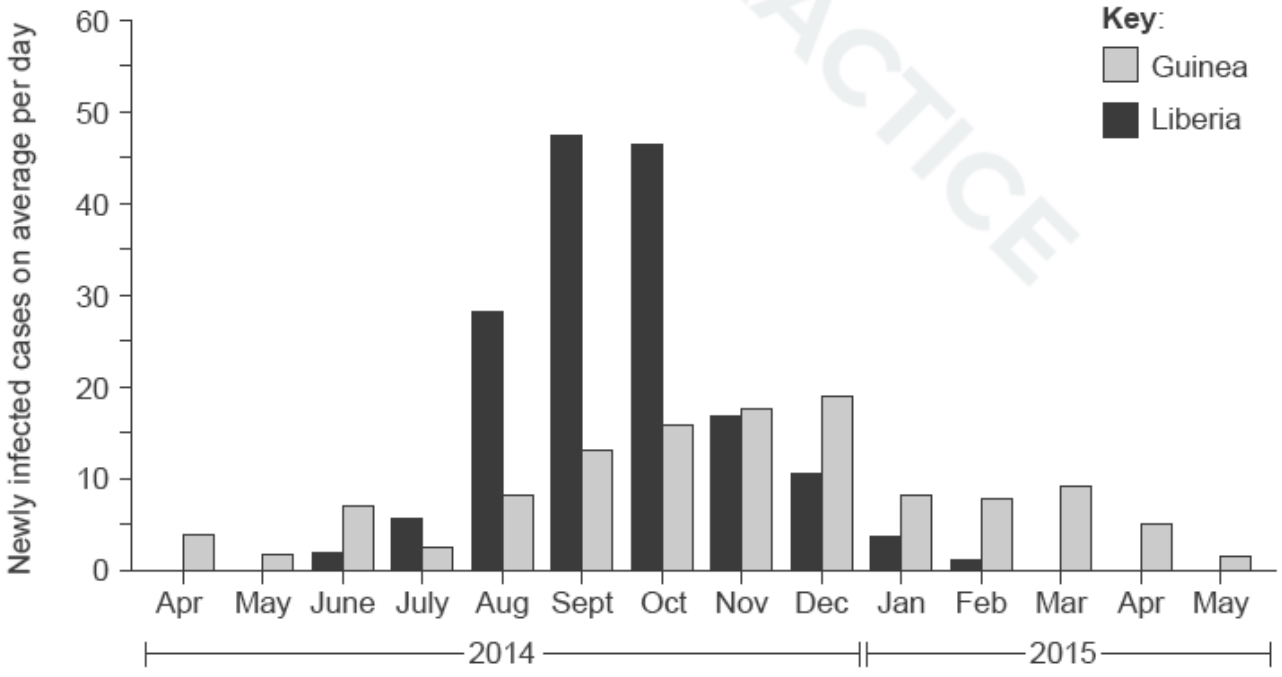
Ebola virus disease (EVD) is the disease in humans and other primates that is caused by the Ebola virus. Fruit bats are the reservoir for the virus and are able to spread the disease without being affected. Humans can become infected by contact with fruit bats or with people infected by the virus, their body fluids or equipment used to treat them.

The table shows data for four African countries that were affected by the 2014–2015 Ebola outbreak.

Country	Total population / millions	Population density / inhabitants km^{-2}	Number of Ebola cases	Number of deaths	Death rate (as a percentage of Ebola cases) / %
Liberia	4.5	40	10672	4808	45.1
Sierra Leone	6.3	79	13250	3949	29.8
Guinea	12.3	53	3783	2512	66.4
Mali	16.3	14	8	6	75.0

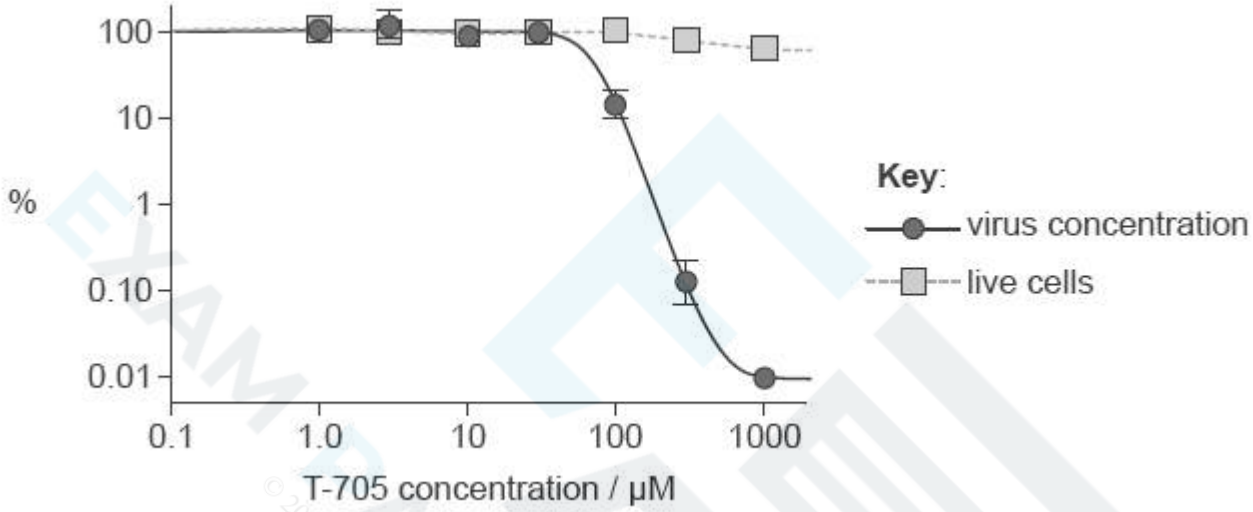
[Source: adapted with permission, from Ebola Situation Report, figure 1, http://apps.who.int/ebola/current-situation/ebolasituation-report-2-march-2016, March 2016, and from Successful treatment of advanced Ebola virus infection with T-705 (favipiravir) in a small animal model, Oestereich, L. *et al*, 2014, under CC BY 3.0]

The graphs show the progress of the EVD epidemic in Guinea and Liberia for the period April 2014 to May 2015.



[Source: Ebola Situation Report 2 March 2016 and data from *International Journal of Infectious Diseases*, 38,
Ligui Wang *et al*, Epidemiological features and trends of Ebola virus disease in West Africa, 52-53.,
Copyright 2015, with permission from Elsevier]

An antiviral drug, T-705, was tested in order to establish whether it has potential to treat EVD. The graph shows the data from an in vitro trial of T-705 on cells that had been infected with Ebola virus five days previously. Virus concentration and live cells are shown as percentage of the control.



[Source: Oestereich, Lisa & Rieger, Toni & Neumann, Melanie & Bernreuther, Christian & Lehmann, Maria & Krasemann,
Susanne & Wurr, Stephanie & Emmerich, Petra & de Lamballerie, Xavier & Ölschläger, Stephan & Günther, Stephan. (2014).
Evaluation of Antiviral Efficacy of Ribavirin, Arbidol, and T-705 (Favipiravir) in a Mouse Model for Crimean-Congo
Hemorrhagic Fever. *PLoS neglected tropical diseases*. **8**. e2804.
10.1371/journal.pntd.0002804.]

a.i. Identify the country with the largest number of Ebola cases. [1]

a.ii. Identify the country with the largest number of deaths. [1]

b.

Analysis of the data suggests that the number of deaths from EVD is not related to the total population size. State piece of evidence from the data that would support this analysis.

[1]

c.

Based on the mode of transmission of the Ebola virus, suggest a possible reason for the relationship between population density and the number of Ebola cases in these four countries.

[1]

d.

Based on the data, compare and contrast the progress of the epidemic in Liberia and Guinea.

[3]

e.

Suggest possible reasons for the drop in the daily numbers of newly infected cases after October 2014 in Liberia.

[2]

f.

Based on these data, outline the evidence that T-705 has potential to be used as a treatment for EVD.

[2]

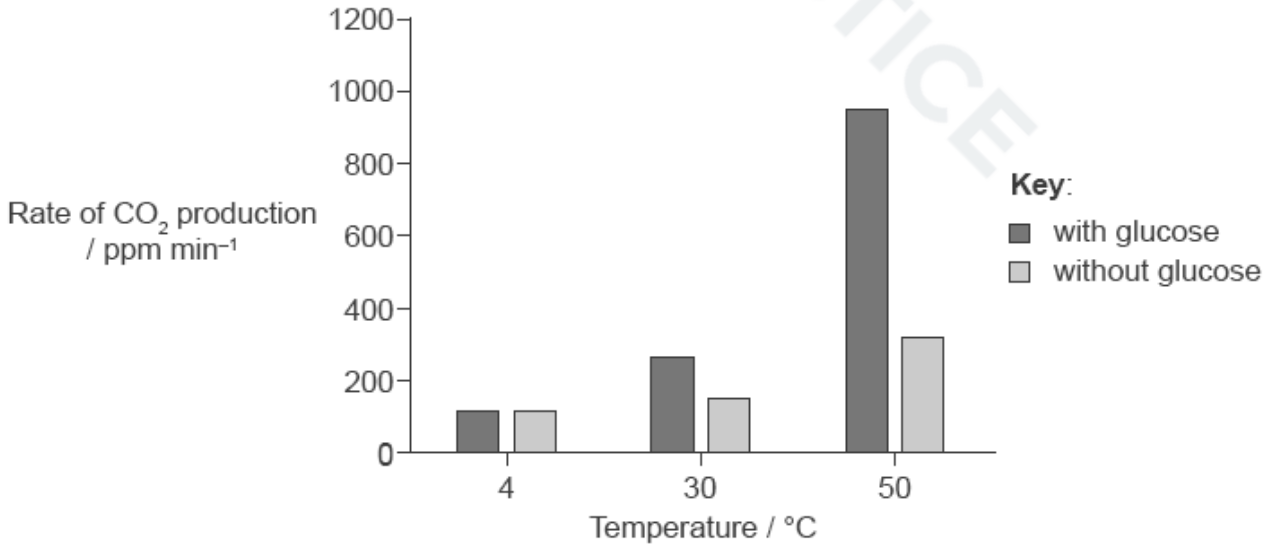
g.

District administrators combatting the 2014 Ebola epidemic in West Africa were assisted by international organizations such as the World Health Organization, who provided data on the progress of the epidemic. Suggest other way in which international organizations can assist with combatting an epidemic of Ebola.

[1]

19M.2.SL.TZ1.11

Yeast cells, *Saccharomyces cerevisiae* , were incubated with and without glucose at three different temperatures for a period of four minutes, during which the rate of CO_2 production was measured with a CO_2 sensor.



[Source: © International Baccalaureate Organization 2019]

What conclusion can be drawn from the results of this experiment?

A. Yeast uses lipids rather than glucose in respiration at low temperatures.
B. Addition of glucose has a greater impact on rates of cell respiration at lower temperatures.
C. Rates of cell respiration increase with temperature.
D. More glucose is produced at higher temperatures.

[1]

(a)

From the data, identify the depth along the transect where the greatest species richness is observed.

[1]

(b) Outline the relationship between *Zooxanthellae* and reef-building coral reef species.

[2]

(c) Suggest way in which depth may act as a limiting factor for coral. [1]

19M.2.SL.TZ1.16

(a.i)

Distinguish between levels of predation in marmots born in the wild and those born in captivity.

[1]

(a.ii) Suggest reasons for the differences in predation. [2]

19M.2.SL.TZ1.2

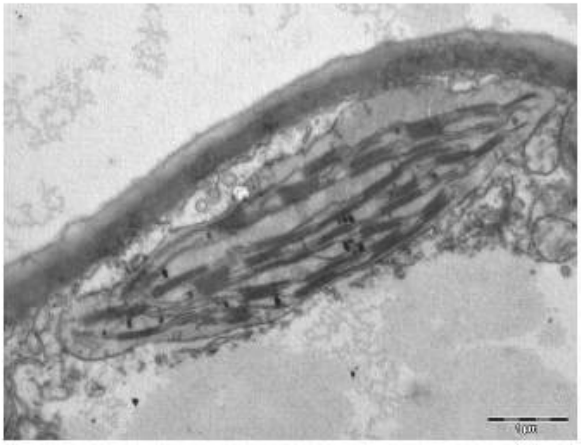
a.

Identify which electron micrograph shows a mitochondrion, providing **one** observation to support your choice.

A

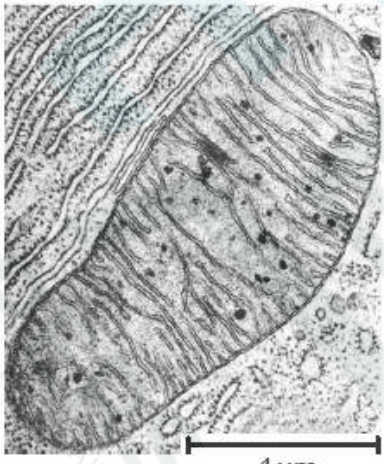
[Source: Pradana Aumars, https://commons.wikimedia.org/wiki/Category:Bacteria#/media/File:Bacteria_cell_division.jpg]

B



[Source: and3k and caper437/ https://bs.wikipedia.org/wiki/Datoteka:Chloroplast_in_leaf_of_Anemone_sp_TEM_12000x.png]

C



[Source: republished with permission of McGraw-Hill Education, from *Harrison's Principles of Internal Medicine*,J L Jameson *et al.*, 16th edition, 2004; permission conveyed through Copyright Clearance Center, Inc]

[1]

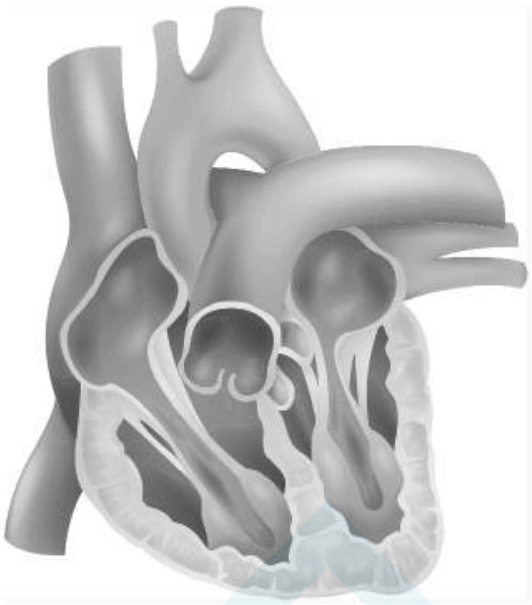
b.

Discuss the evidence for the theory that mitochondria may have evolved from free-living prokaryotes by endosymbiosis.

[3]

19M.2.SL.TZ1.3

The diagram shows the human heart.



[Source: BlueRingMedia/Shutterstock]

a.i. On the diagram, label the aorta. [1]

a.ii. On the diagram, label the right atrium. [1]

b. Explain how valves control the flow of blood through the heart. [2]

c.

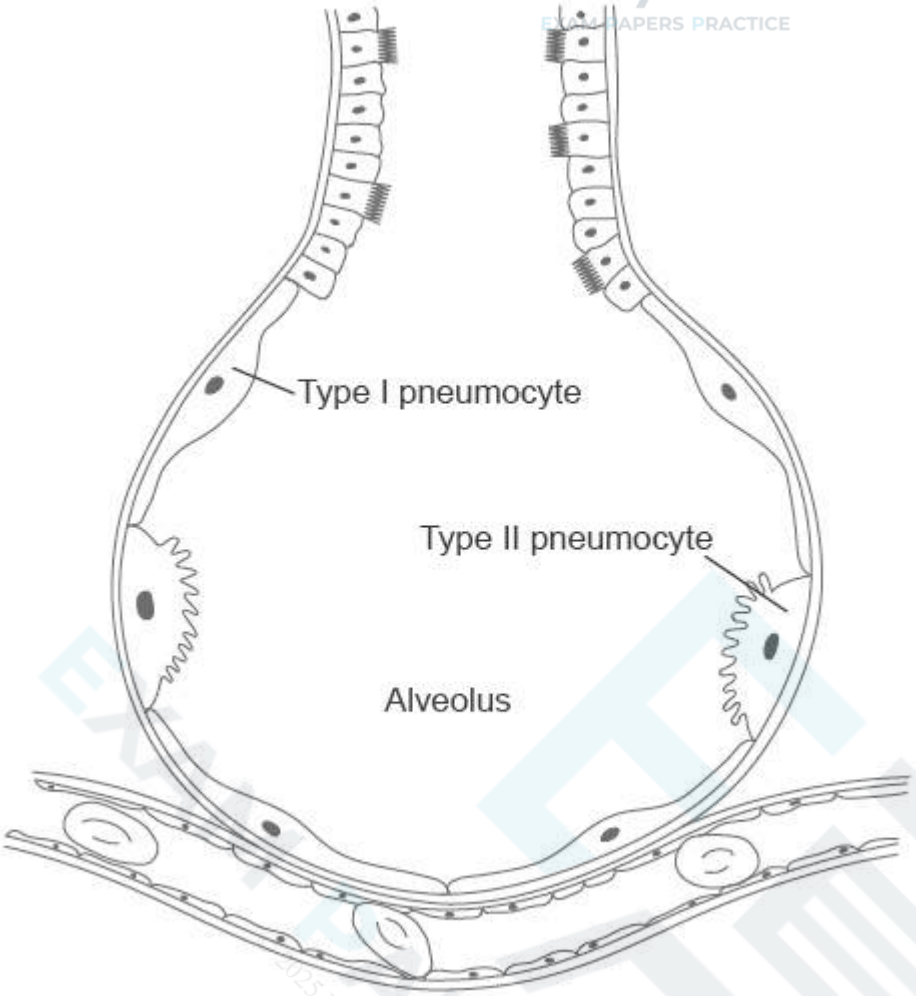
Outline the causes and consequences of blood clot formation in coronary arteries.

[2]

d. Outline the role of lymphocytes in defence against disease. [2]

19M.2.SL.TZ1.4

The diagram shows the structure of an alveolus and an adjacent capillary.



[Source: © International Baccalaureate Organization 2019]

a. Outline the functions of type I and type II pneumocytes. [2]

b.

Explain how gases are exchanged between the air in the alveolus and the blood in the capillaries.

[3]

19M.2.SL.TZ1.5

The table gives common names and binomial names for some mammals.

Common name	Binomial name
Golden bamboo lemur	*Hapalemur aureus*
Golden jackal	*Canis aureus*
Grey wolf	*Canis lupus*
Red fox	*Vulpes vulpes*

a. State feature that characterizes these species as mammals. [1]

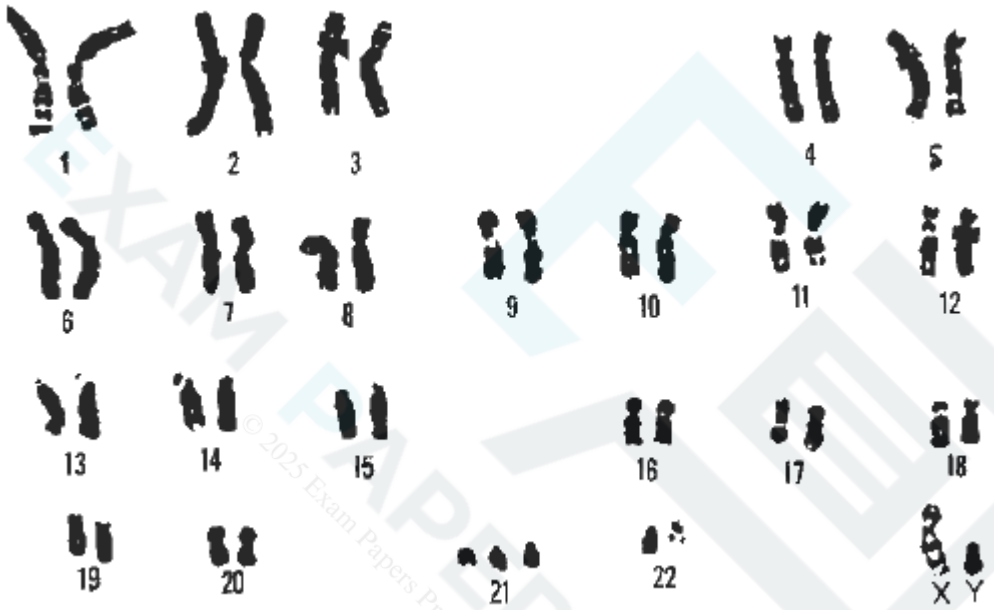
b. Identify the species most closely related. 1. 2. [1]

c. Identify species from the list that are classified in different genera. 1. 2.

[1]

19M.2.SL.TZ1.6

The image shows the chromosomes from a body cell of an adult human.



[Source:
http://www.ornl.gov/sci/techresources/Human_Genome/graphics/slides/elsikaryotype.shtm
U.S. Department of Energy Human Genome Program.]

a. Identify, with a reason, the sex of this individual. [1]

b.

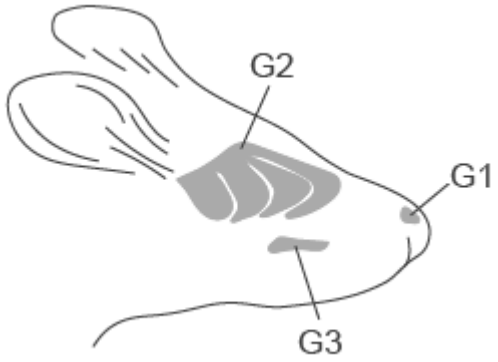
Identify the chromosome that is affected by a trisomy in this individual, naming the condition that this trisomy gives rise to.

Chromosome number: Name of condition: [1]

19M.2.SL.TZ2.1

Mice (*Mus musculus*) have various defence systems against predators such as foxes (*Vulpus vulpus*) or stoats (*Mustela erminea*). The mice release specific alarm compounds when under threat that serve as danger signals for other mice. Predators also release scents that the mice can detect.

In one study, mice were exposed to paper soaked in compounds taken from other mice, foxes or stoats in a test chamber. The scientists then measured the reaction of three different groups of neurons used in smelling: G1, G2 and G3, as shown in the diagram.



The percentage of G1, G2 and G3 neurons responding to the mouse, fox and stoat compounds, as well as a control compound, are shown in the chart.

	Mouse alarm compound	Fox scent	Stoat scent	Control
G1				
G2				
G3				

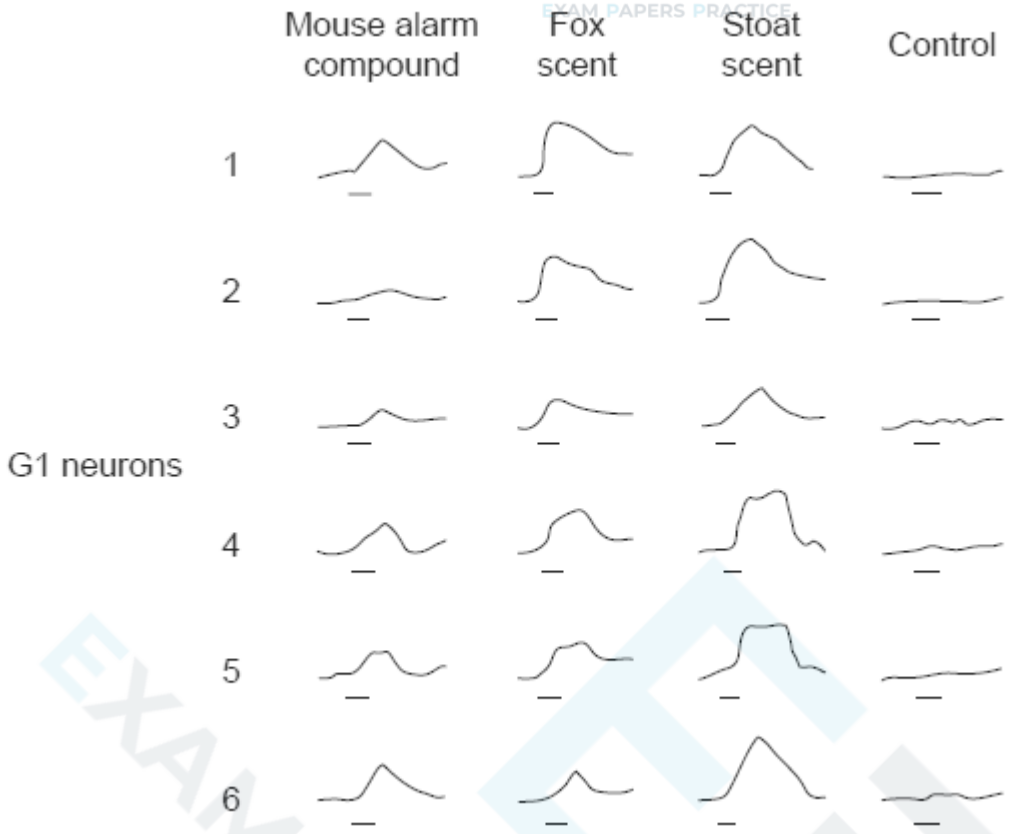
Key:

>75% 25–75% 10–25% <10% 0%

Percentage of response of neurons in mice

[Source: Julien Brechbühl, *et al.*, (2013), *PNAS*, **110** (12), pages 4762–4767]

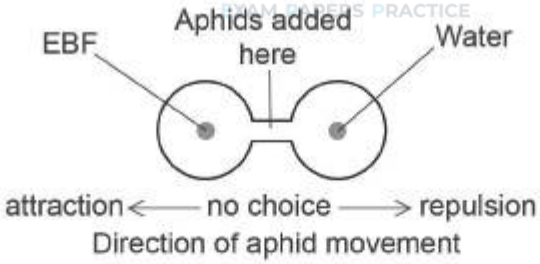
The scientists recorded the neural traces (action and resting potentials) of six G1 neurons exposed to the compounds from the different animals. The horizontal bar beneath each trace corresponds to the time of exposure to the test compound.

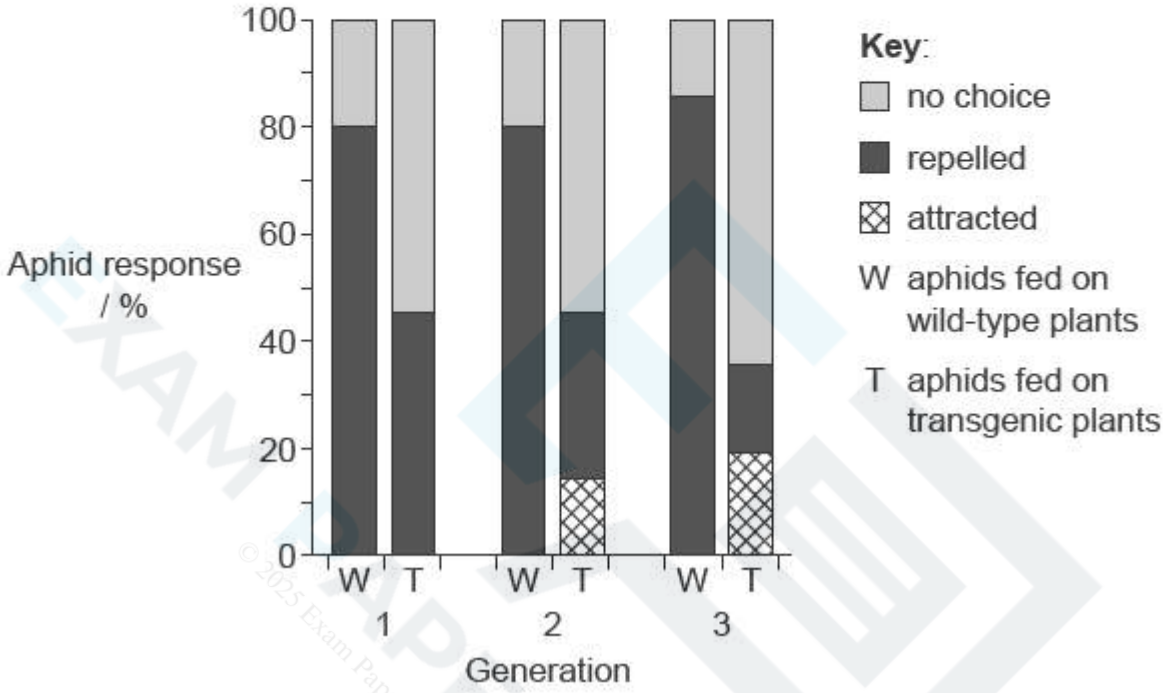


[Source: adapted from J Brechbühl, *et al.*, (2013), *PNAS*, **110** (12), pages 4762–4767]

Another study was carried out on the defence systems in aphids (*Myzus persicae*) which feed on thale cress plants (*Arabidopsis thaliana*). Individual aphids release an alarm compound containing the chemical (E)-β-farnesene (EBF) when attacked by a predator. Other aphids are repelled and leave the thale cress plant or hide.

The gene for EBF was inserted to produce transgenic (T) thale cress plants to test aphid reaction to EBF over several generations. Aphids were raised on wild type (W) thale cress and then allowed to feed for three generations on either W or T thale cress. Aphids were tested in each generation for their reaction when EBF was added to a choice chamber. The percentages of aphids attracted to or repelled by EBF and those which made no choice were recorded.





[Source: M De Vos, *et al.*, (2010), *PNAS*, (33), pages 14673–14678]

a. State the percentage of G2 neurons in the mice that respond to the fox scent.

. . . . . .%

[1]

b.

Using evidence from the chart, identify, giving a reason, which group of neurons responded most to the chemicals.

[1]

c. State the name of the instrument used to make these traces. [1]

d.

Distinguish between the effects of the mouse alarm compound and the effects of the control compound on the G1 neurons.

[1]

e.

Compare and contrast the effects of the mouse alarm compound and stoat scent on the G1 neurons.

[2]

f.

Deduce whether there is a correlation between the neural traces and the percentage of responding G1 neurons.

[2]

g.

The molecular structures of the mouse alarm compound and fox scent are very similar. Suggest an evolutionary advantage for this chemical similarity.

[1]

h. Identify, with a reason, the aphids that were most strongly repelled by EBF. [1]

i.

Outline the conclusions that can be drawn from the data in the graph for the group of aphids fed for three generations on transgenic thale cress plants (T).

[2]

j.

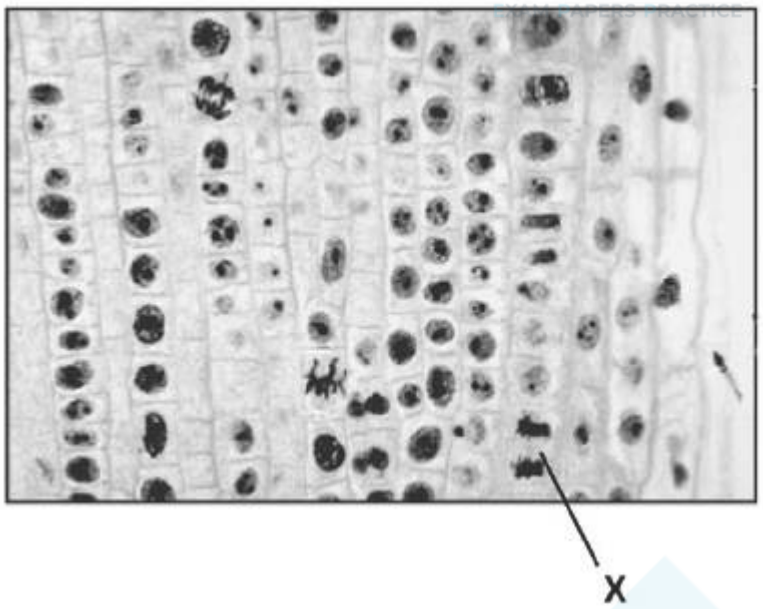
Discuss whether natural selection would favour the transgenic EBF-producing thale cress plants if they were released into the wild.

[2]

19M.2.SL.TZ2.2

a.

Identify the stage of mitosis labelled X in the image, giving a reason.



[Source: Copyright 2002, The Trustees of Indiana University]

[1]

b. Outline the use of a karyogram during pregnancy. [3]

19M.2.SL.TZ2.3

a.i.

State **two** causes of the decrease of biomass along food chains in terrestrial ecosystems.

[2]

a.ii.

The table shows the global carbon budget over two decades; the years 1990 to 1999 and 2000 to 2009.

Carbon	Global carbon budget / $\times 10^{12}$ kg	
	1990 to 1999	2000 to 2009
Atmospheric carbon dioxide	3.0	4.0
Fossil fuel and cement	6.5	8.0
Land use change	1.5	1.0
Carbon storage in land	2.5	2.0
Carbon storage in oceans	2.0	2.5

[Source: © International Baccalaureate Organization 2019]

Using the table, explain causes of the changes in carbon flux over the two decades.

[3]

b.

Suggest how climate change can influence the natural selection of organisms that live in the Arctic oceans.

[3]

19M.2.SL.TZ2.4

a.

The images show parts of plants belonging to two different phyla.

Plant X

[Source: DanielCD / https://commons.wikimedia.org/wiki/File:SoriDicksonia.jpg]

Plant Y

[Source: tbenedict/Pixabay https://pixabay.com/photos/pine-cones-tree-evergreen-cone-581557/]

State the phylum of plant X and of plant Y.

X:

Y:

[2]

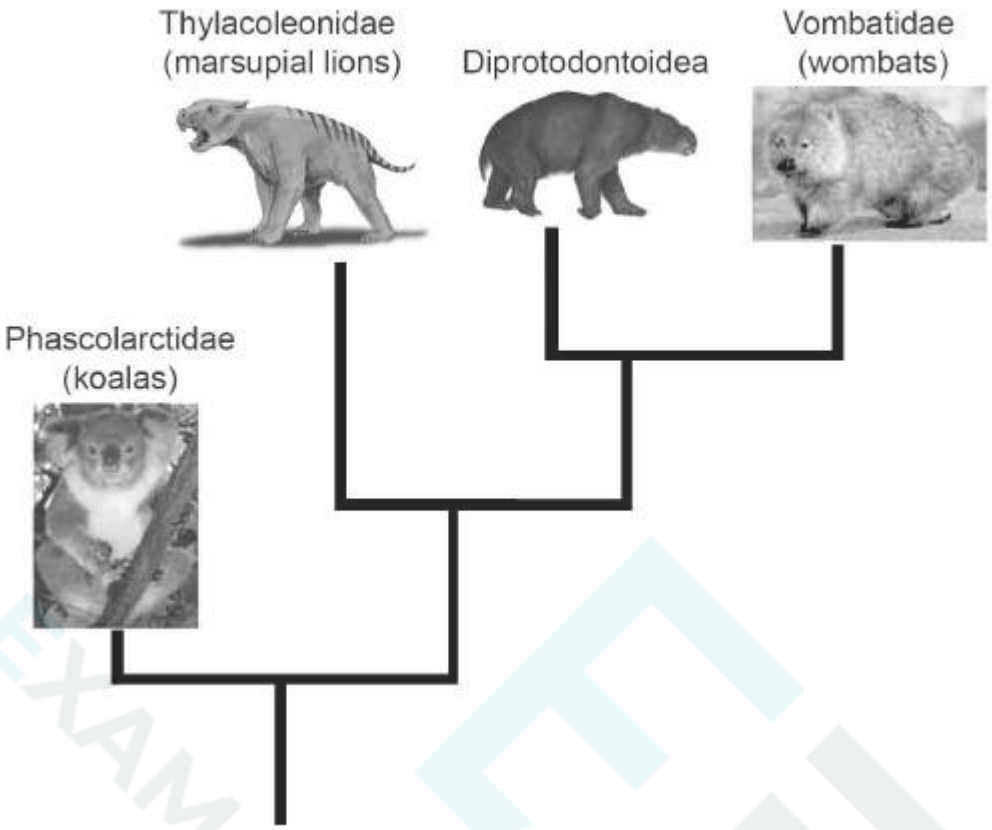
b. Explain **one** cause of mutation. [2]

c.

Outline the types of evidence that can be used to place a species in a particular clade.

[3]

d. The cladogram includes four marsupial (non-placental mammal) families.



[Source: Koala image: Quartl, https://commons.wikimedia.org/wiki/Phascolarctos_cinereus#/media/File:Friendly_Female_Koala.JPG; Wombat image: JJ Harrison, https://en.wikipedia.org/wiki/Wombat#/media/File:Vombatus_ursinus_-Maria_Island_National_Park.jpg; Marsupial lion: Nobu Tamura, https://en.wikipedia.org/wiki/Marsupial_lion#/media/File:Thylacoleo_BW.jpg; Diprotodontoidea image: Anne Musser]

Deduce the family that is most closely related to the Diprotodontoidea. [1]

19M.2.SL.TZ2.5

a.

Outline **four** types of membrane transport, including their use of energy.

[4]

b. Draw the structure of a dipeptide. [3]

c.

Explain the action of enzymes in digestion and the different roles of at least **two named** enzymes that are produced in the pancreas.

[8]

19M.2.SL.TZ2.6

a.

Describe briefly the endosymbiotic theory.

[3]

b. Outline how photosynthesis produces glucose. [4]

c.

Discuss the control of blood glucose levels and the consequences if they are not maintained.

[8]

19M.2.SL.TZ2.7

(a) Distinguish between the structures of DNA and RNA. [3]

(b)

Mendel found the same pattern of inheritance in all the crosses that he performed. Outline, with examples, different types of inheritance that produce non-Mendelian ratios.

[4]

(c) Explain the cause of sickle cell anemia and how this disease affects humans. [8]

19M.2.SL.TZ2.8

(a) Outline energy flow through a food chain. [4]

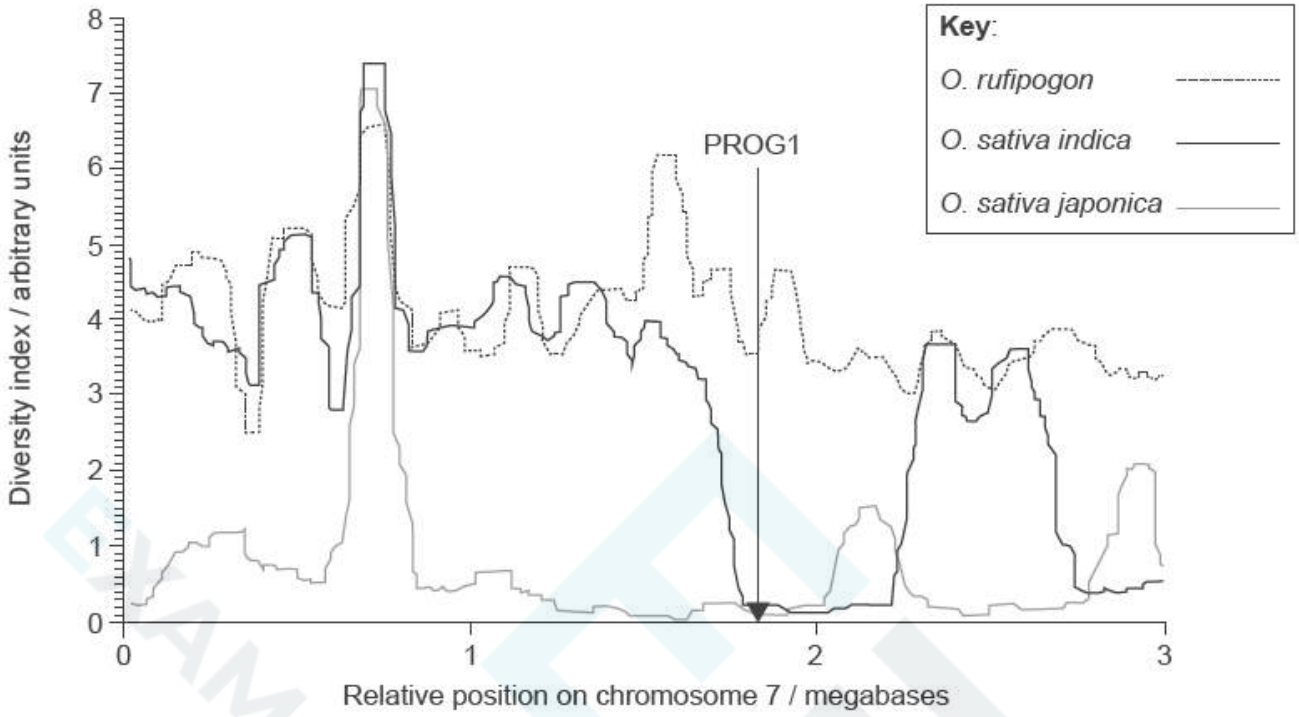
(b) Draw a fully labelled graph of the action spectrum for photosynthesis. [3]

19N.2.SL.TZ0.1

Cultivated rice, *Oryza sativa*, is one of the most important human foods. The two main sub-species of cultivated rice are *O. sativa indica* and *O. sativa japonica*. *O. rufipogon* is a wild species from which they probably evolved.

To investigate whether the sub-species of cultivated rice evolved independently from the wild species, scientists analysed their chromosomes to find areas with similar DNA base sequences. Wild species tend to have many different alleles of genes present on each chromosome, but during the development of a crop plant by artificial selection from a wild species, this diversity drops considerably, increasing the base sequence similarity. The number of different alleles of the genes on a chromosome can be represented by a diversity index. The following graph of part of chromosome 7 shows the diversity index of *O. rufipogon* and two varieties of cultivated rice, *O. sativa indica* and *O. sativa japonica*.

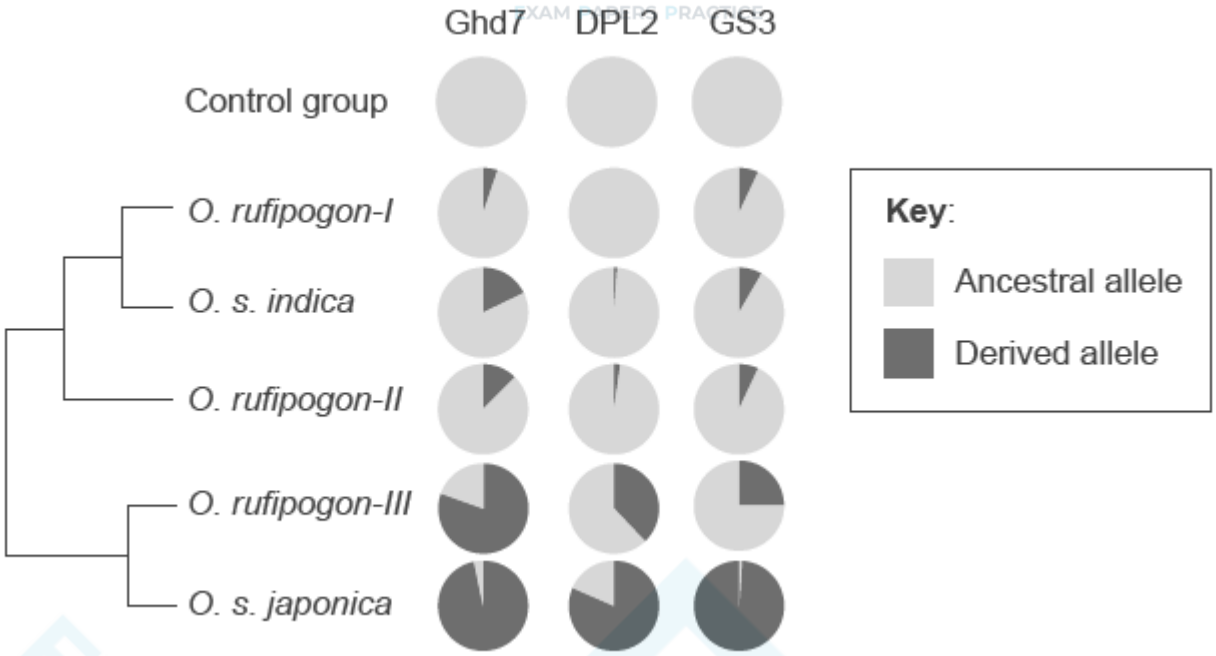
The gene PROG1 allows the plant to stand upright, which is typical of cultivated rice. Its position is indicated by the vertical arrow on the graph.



[Source: He Z, Zhai W, Wen H, Tang T, Wang Y, Lu X, *et al.* (2011) Two Evolutionary Histories in the Genome of Rice:
the Roles of Domestication Genes. *PLoS Genet* **7**(6): e1002100.
https://doi.org/10.1371/journal.pgen.1002100]

In another experiment, scientists retrieved genome sequences of the wild rice *O. rufipogon* taken from a wide range of geographical sites (I, II and III) and those of the two sub-species of *O. sativa* from gene banks.

The pie charts, presented along with a cladogram, show the proportion of alleles for three genes which confer specific characteristics to *O. sativa*. Mutations can produce derived alleles that are different from the original ancestral alleles. The control group represents wild rice species other than *O. rufipogon*.



[Source: reprinted by permission from Springer Nature: Nature, Huang, X., Kurata, N., Wei, X. *et al.* A map of rice genome variation reveals the origin of cultivated rice. *Nature* , 497–501 (2012) doi:10.1038/nature11532]

a.

State the reason that *O. sativa* and *O. rufipogon* are classified as different species.

[1]

b. Determine which type of rice has the lowest overall diversity index. [1]

c. Compare and contrast the trends for *O. rufipogon* and *O. sativa indica*. [2]

d.

State the proportion of the ancestral allele for the gene GS3 in the *O. rufipogon-III* population.

[1]

e.

Distinguish between the proportion of ancestral and derived alleles for all three genes in *O. sativa indica* and *O. sativa japonica*.

[2]

f. State reason for having a control group. [1]

g.

Using of the data, discuss whether there is evidence that the two sub-species of *O. sativa* might have evolved independently from *O. rufipogon*.

[4]

19N.2.SL.TZ0.13

(a)

Explain why some biologists think protecting keystone species would help preserve biological diversity in an ecosystem.

[1]

(b) Compare and contrast fundamental and realized niche of a species. [2]

19N.2.SL.TZ0.2

A short base sequence of mRNA and a table of the genetic code are shown below.

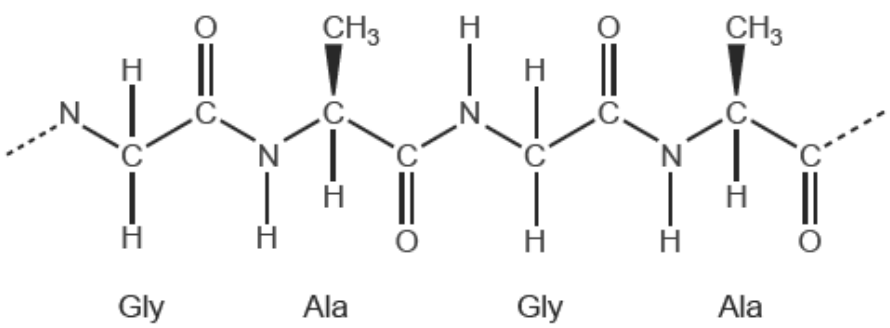
Sequence of mRNA

AUGAGCCGAAGGUAGCUG

Table of the genetic code

1st letter	2nd letter: U	2nd letter: C	2nd letter: A	2nd letter: G	3rd letter
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met/START	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

The diagram shows a section of a polypeptide.



a. Outline the function of codons. [1]

b.i.

Determine the sequence of amino acids that could be translated from the sequence of mRNA.

[1]

b.ii.

Determine the DNA base sequence transcribed to form this sequence of mRNA. [1]

c.

Suggest a hypothesis that accounts for the slightly different meaning of some codons in a very limited number of organisms.

[1]

d.i. Annotate the diagram to show a peptide bond between two amino acids. [1]

d.ii.

State the type of reaction that removes water while linking amino acids together to form polypeptides.

[1]

e.

Outline the function of Rubisco and of spider silk in relation to their three-dimensional conformation.

	Function	Conformation
Rubisco		
Spider silk		

[2]

19N.2.SL.TZ0.3

a.

Outline the cell theory.

[2]

b. State **two** functions of life. [2]

c. List **three** characteristics of eukaryotic homologous chromosomes. [3]

d.

Using the following table, compare and contrast anaerobic cell respiration in yeasts and in humans. The first row has been completed as an example.

	Yeasts	Humans
Small yield of ATP	yes	yes
Require oxygen		
Produce ethanol and CO_2		
Produce lactate		

[3]

19N.2.SL.TZ0.5

a.

Draw a section of the Singer-Nicolson model of an animal cell membrane.

[4]

b. Outline the principles used by scientists to classify organisms. [4]

c. Explain the movement of energy and inorganic nutrients in an ecosystem. [7]

19N.2.SL.TZ0.6

a.

Outline how cuts in the skin are sealed to prevent blood loss.

[4]

b.

Outline how two parents could have a child with any of the four ABO blood groups.

[4]

c. Explain how ventilation and lung structure contribute to passive gas exchange.

[7]

19N.2.SL.TZ0.7

(b) Outline how two parents could have a child with any of the four ABO blood groups.

[4]

(c) Explain the control mechanism of the heart rate. [7]

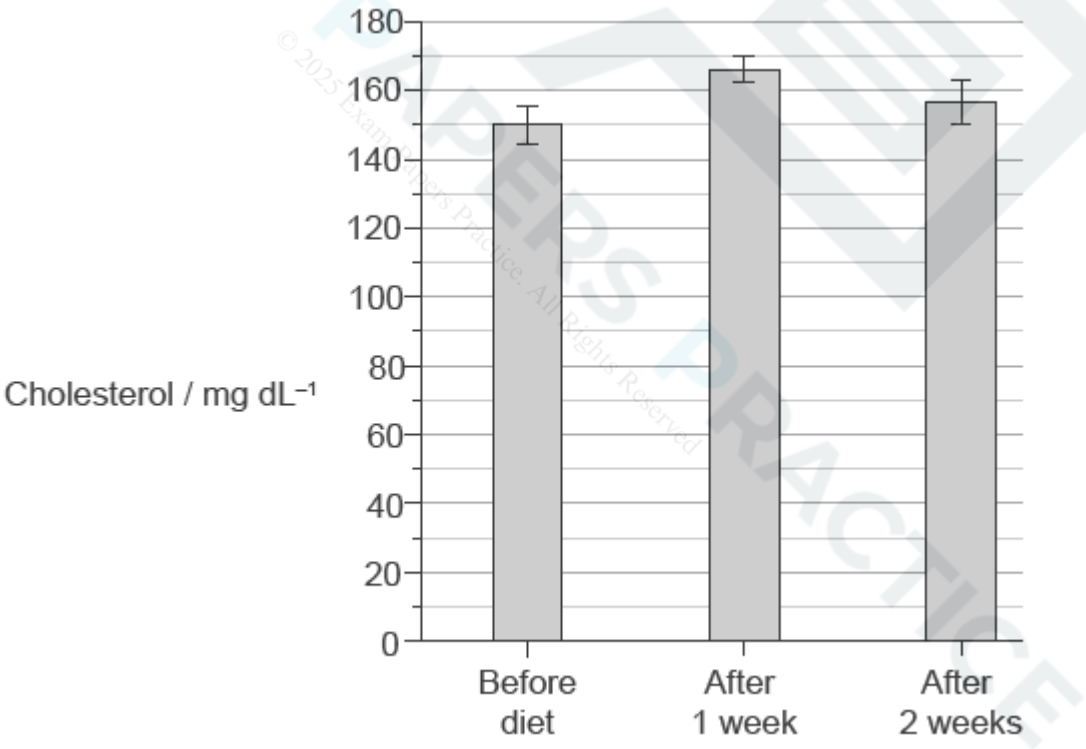
20N.2.SL.TZ0.1

A study was conducted to look at the short-term effects of a change in diet on the risk of disease in young adults. The table shows data on the habitual diet of the participants as well as the study diet followed for two weeks.

	Mean daily intake ± standard deviation	
	Habitual diet	Study diet
Energy / kJ	10 143±949	9992±479
Fat / g	100±6	99±5
Saturated fat / % total fat	37±2	60±1
Unsaturated fat / % total fat	63±2	40±1
Monounsaturated fat / % total fat	46±1	32±1
Polyunsaturated fat / % total fat	17±1	8±1
Carbohydrate / g	248±23	232±16
Protein / g	119±12	120±9

[Source: Horowitz, J.F., Ortega, J.F., Hinko, A., Li, M., Nelson, R.K. and Mora-Rodriguez, R., 2018. Changes in markers for cardio-metabolic disease risk after only 1-2 weeks of a high saturated fat diet in overweight adults. *PLoS ONE*, 13(6), e0198372.]

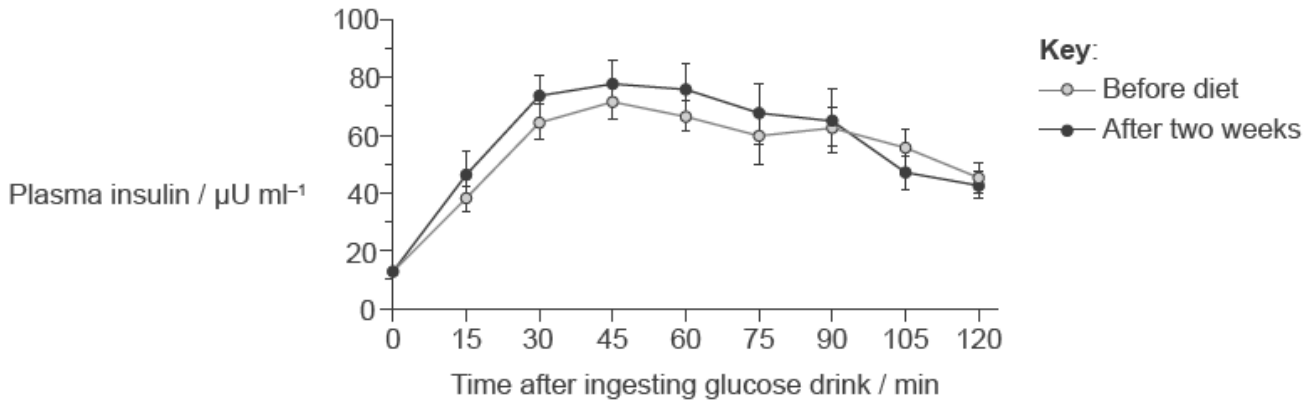
Total blood plasma cholesterol levels were measured before the study began and once a week after starting the study diet. Mean results are shown in the bar chart, including the standard deviation.



[Source: Horowitz, J.F., Ortega, J.F., Hinko, A., Li, M., Nelson, R.K. and Mora-Rodriguez, R., 2018. Changes in markers for cardio-metabolic disease risk after only 1-2 weeks of a high saturated fat diet in overweight adults. *PLoS ONE*, 13(6), e0198372.]

Control of blood glucose concentration was investigated using an oral glucose tolerance test. For this test, the person was given a concentrated glucose drink (at time zero) and then blood samples were taken every 15 minutes to determine the plasma insulin level.

This test was done before the study diet and after two weeks on the study diet. Mean results are shown in the graph, including the standard deviation.



[Source: Horowitz, J.F., Ortega, J.F., Hinko, A., Li, M., Nelson, R.K. and Mora-Rodriguez, R., 2018. Changes in markers for cardio-metabolic disease risk after only 1-2 weeks of a high saturated fat diet in overweight adults. *PLoS ONE*, 13(6), e0198372.]

a. Comment on the total energy content of the two diets. [1]

b. Distinguish between the two diets. [2]

c.

Calculate, showing your working, the percentage change in mean cholesterol level after on the study diet.

. . . . . .% [2]

d.i. Compare the data for plasma insulin levels before and after the study diet. [2]

d.ii. State which cells secrete insulin. [1]

d.iii.

Outline the reason for plasma insulin levels changing in the first 30 minutes of the test.

[1]

e.

The hypothesis made before the study was that saturated fats in the diet affected the risk of coronary artery blockage and diabetes. Using all the data in question 1, evaluate whether this hypothesis is supported by the study.

[3]

20N.2.SL.TZ0.14

(a.i)

Two components of biodiversity are richness and evenness. Deduce which of the two pools was higher in richness.

[1]

(a.ii)

Two components of biodiversity are richness and evenness. Deduce which of the two pools was higher in evenness.

[1]

(b)

Calculation of Simpson's reciprocal diversity index for both rockpools gives the following results.

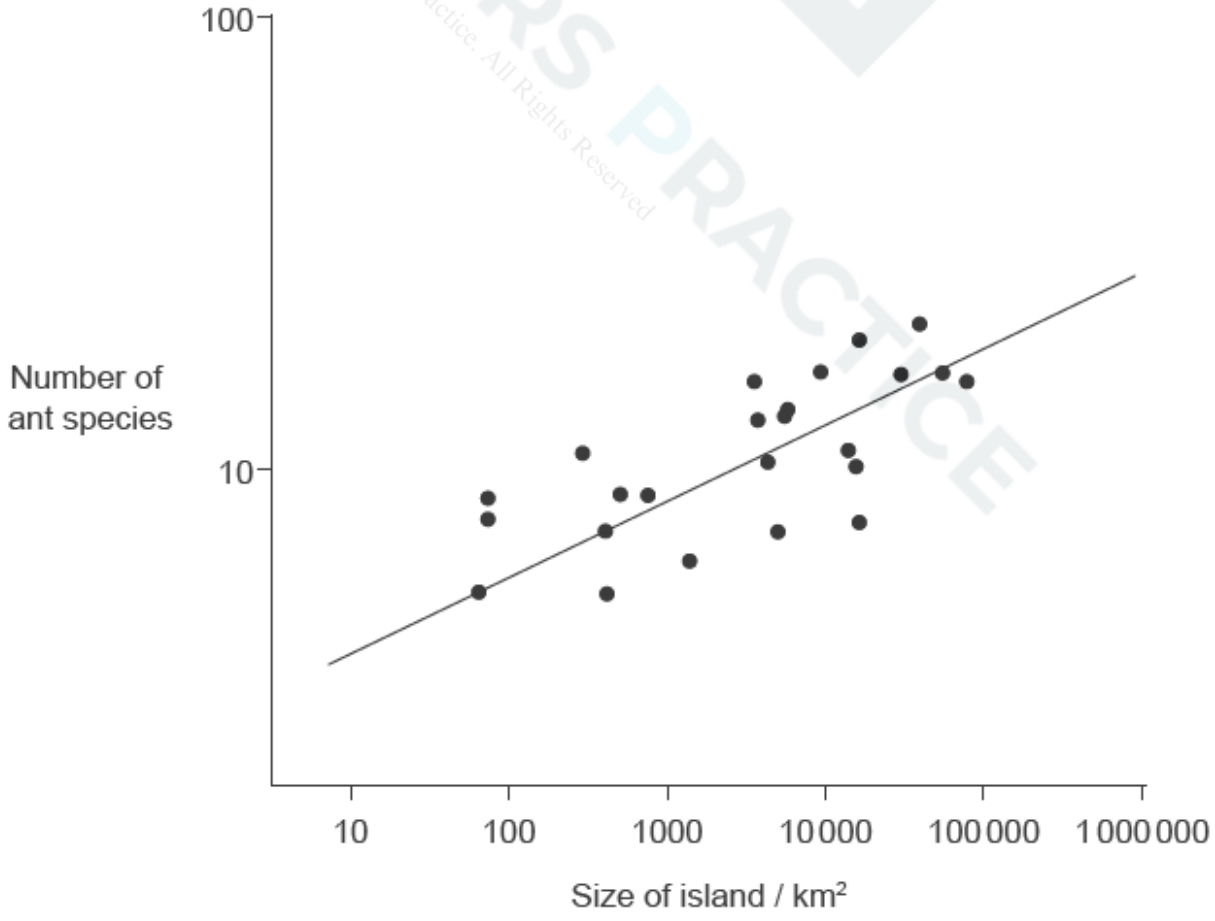
Pool	Simpson's reciprocal diversity index
A	1.5
B	2.1

Outline what conclusion can be drawn from the results.

[1]

(c)

The graph shows how the number of ant species found on isolated islands near New Guinea depends on the size of the island.



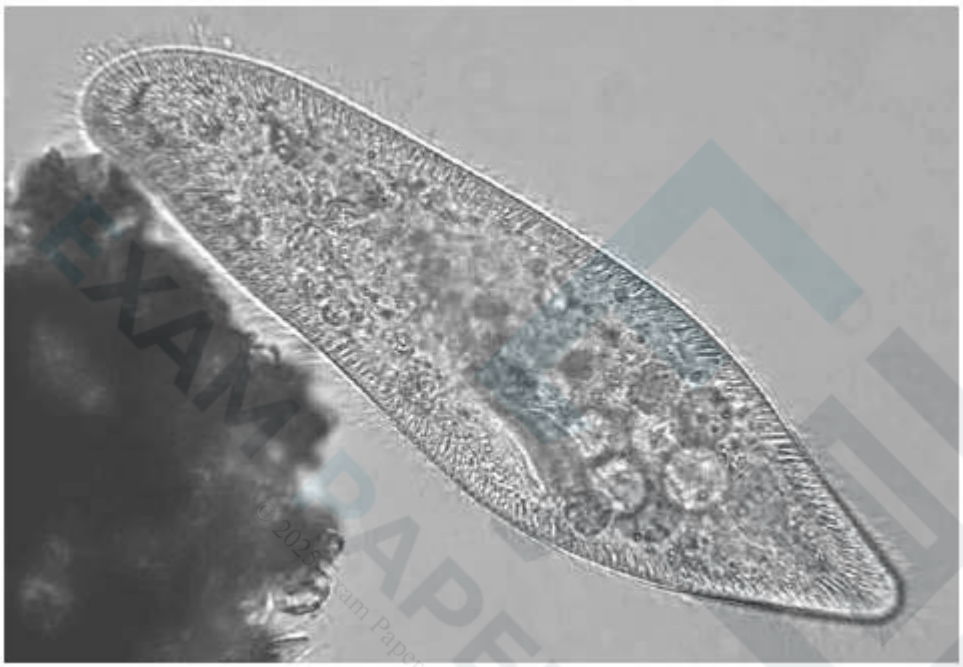
[Source: University of Windsor, *The Theory of Island Biogeography* . Available at: http://web2.uwindsor.ca/courses/biology/macisaac/55437/lecture9.htm.]

Explain the relationship between island size and number of ant species.

[1]

20N.2.SL.TZ0.2

The photomicrograph below shows the protozoan *Paramecium caudatum*.



[Source: Deuterostome, CC BY-SA 3.0 https://creativecommons.org/licenses/by-sa/3.0, via Wikimedia Commons.]

a.i. State the genus of this organism. [1]

a.ii. State the domain in which it is classified. [1]

b. Outline the method of nutrition carried out by *P. caudatum*. [1]

c. Outline **one** aspect of how *P. caudatum* carries out homeostasis. [2]

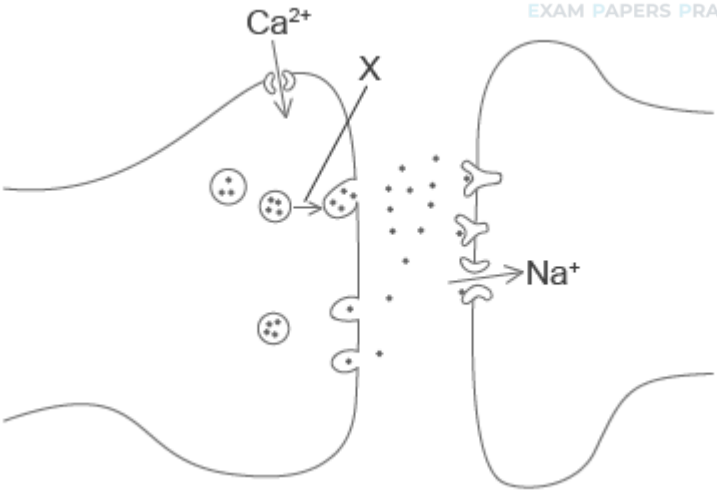
d.

Apart from the ribosomes, explain the evidence for the endosymbiotic theory of the origin of eukaryotic cells.

[3]

20N.2.SL.TZ0.3

The diagram shows part of two neurons.



[Source: © International Baccalaureate Organization 2020.]

a.

Outline how the amphipathic properties of phospholipids play a role in membrane structure.

[2]

b.i. State the name of the structure shown. [1]

b.ii.

X indicates the movement of a structure in the neuron. Explain what events trigger this movement and what happens next.

[3]

20N.2.SL.TZ0.4

a.

Sketch the complementary strand to complete the section of a DNA diagram.

[3]

b.i. Define mutation. [1]

b.ii. Explain how evolution by natural selection depends on mutations. [4]

20N.2.SL.TZ0.5

Life is based on carbon compounds.

a. Draw a molecular diagram of alpha-D-glucose. [3]

b. Outline how carbon compounds are produced in cells using light energy. [5]

c. Explain the transformations of carbon compounds in the carbon cycle. [7]

20N.2.SL.TZ0.7

(a) Outline how hydrogen bonds form in water. [3]

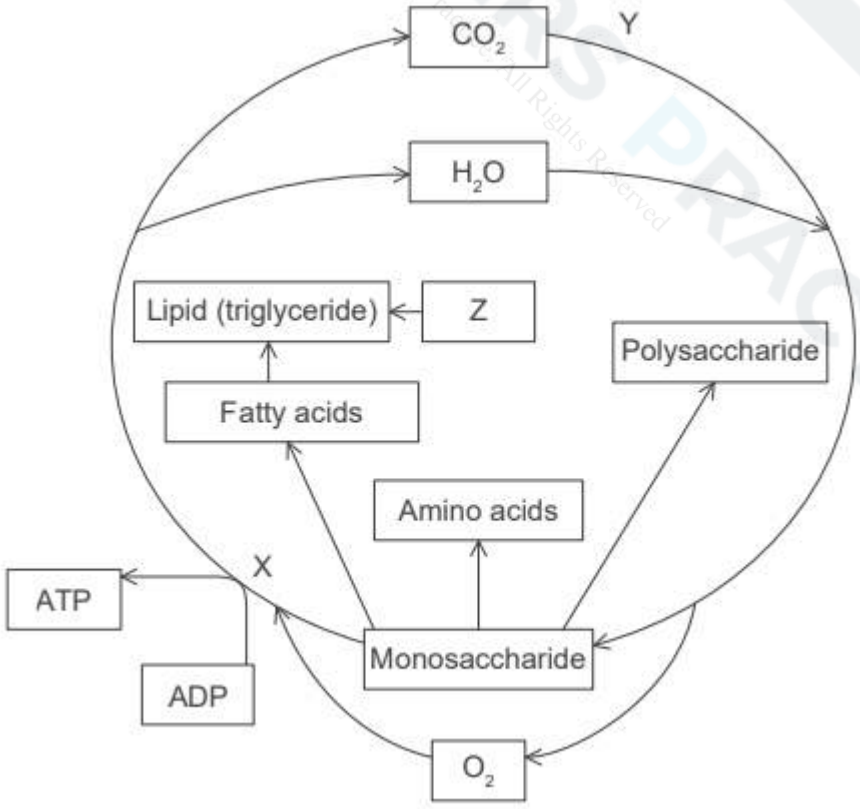
(b)

Describe the processes that cause water to move from the roots of plants to their leaves.

[4]

21M.2.SL.TZ1.2

The diagram shows some of the metabolic processes taking place in a plant cell.



a.i.

Identify the process Y and state the name of the organelle where it takes place in a plant cell.

Process Y: Name of the organelle: [1]

a.ii. Identify the molecule Z. [1]

b.

State the type of reaction which converts excess monosaccharides to polysaccharides.

[1]

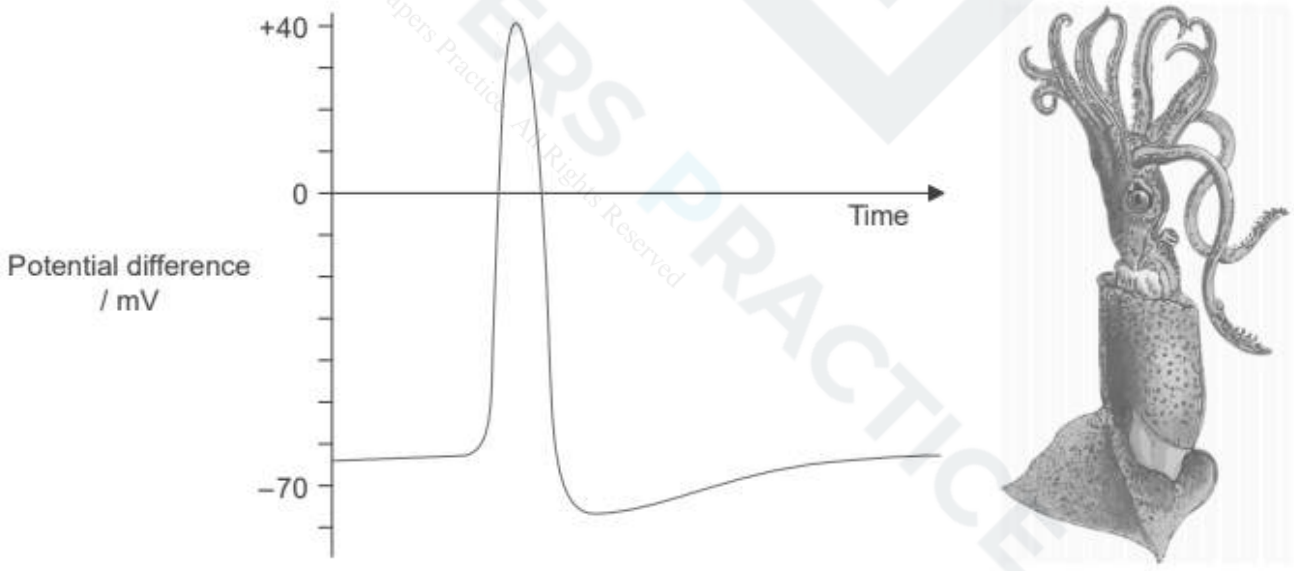
c. The process X uses oxygen and produces ATP. Identify the process X. [1]

d. Outline the uses of ATP in plant cells. [2]

e. With reference to the diagram, identify example of catabolism. [1]

21M.2.SL.TZ1.4

Squid have been used for research on nerve impulses. The mechanism of nerve transmission in these animals is the same as that in humans. The image shows an oscilloscope trace from a nerve impulse in a squid's giant axon.



[squid] Pixabay.

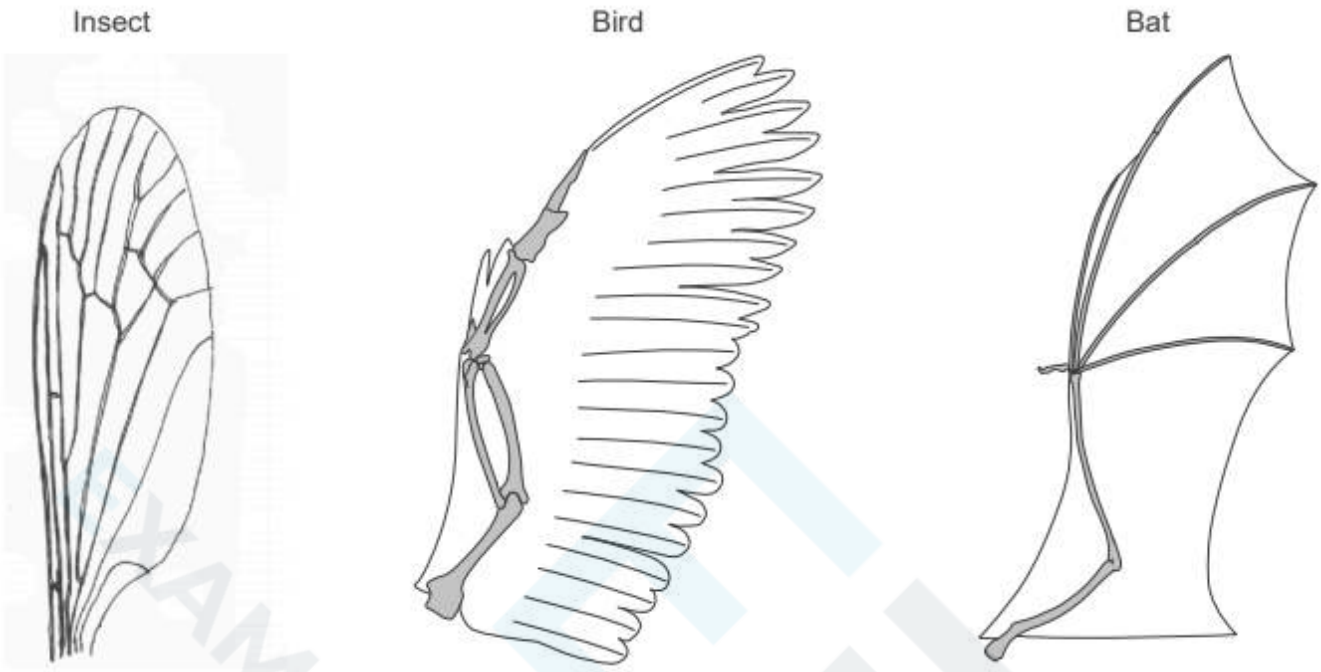
a. Estimate the resting potential for this axon. [1]

b.

Outline the role of the sodium–potassium pump in maintaining the resting potential.

[2]

The image shows the wings of an insect, bird and bat.



[Source: [insect wing] Halvard Hatlen https://upload.wikimedia.org/wikipedia/commons/0/0f/Dip-trichoceridae-wing.png. [bird wing] University of Maryland, Department of Geology. [bat wing] University of Maryland, Department of Geology.]

a.i.

Based on their structure, the insect and bat wings are analogous. Outline what is meant by an analogous trait.

[2]

a.ii.

The bird and bat wings share homologous bone structures whereas the insect wing does not. Outline the conclusion that can be drawn about the evolution of these wings, based on homologous structures.

[1]

b. Explain how cladistics can be used to investigate evolutionary relationships.

[2]

c.

Cladistics and other evolutionary evidence suggest that mammals and birds have a more recent common ancestor than mammals and amphibians. Draw a cladogram to show the relationships between mammals, birds and amphibians.

[1]

21M.2.SL.TZ1.6

a.

Outline the structure of proteins.

[3]

b.

Cells produce a large variety of proteins with different sequences of amino acids. Explain how this is done.

[7]

c. Outline the range of functions of proteins in cells. [5]

21M.2.SL.TZ1.7

a.

Outline the process of inhalation.

[4]

b. Explain the process of gas exchange taking place in the alveoli. [7]

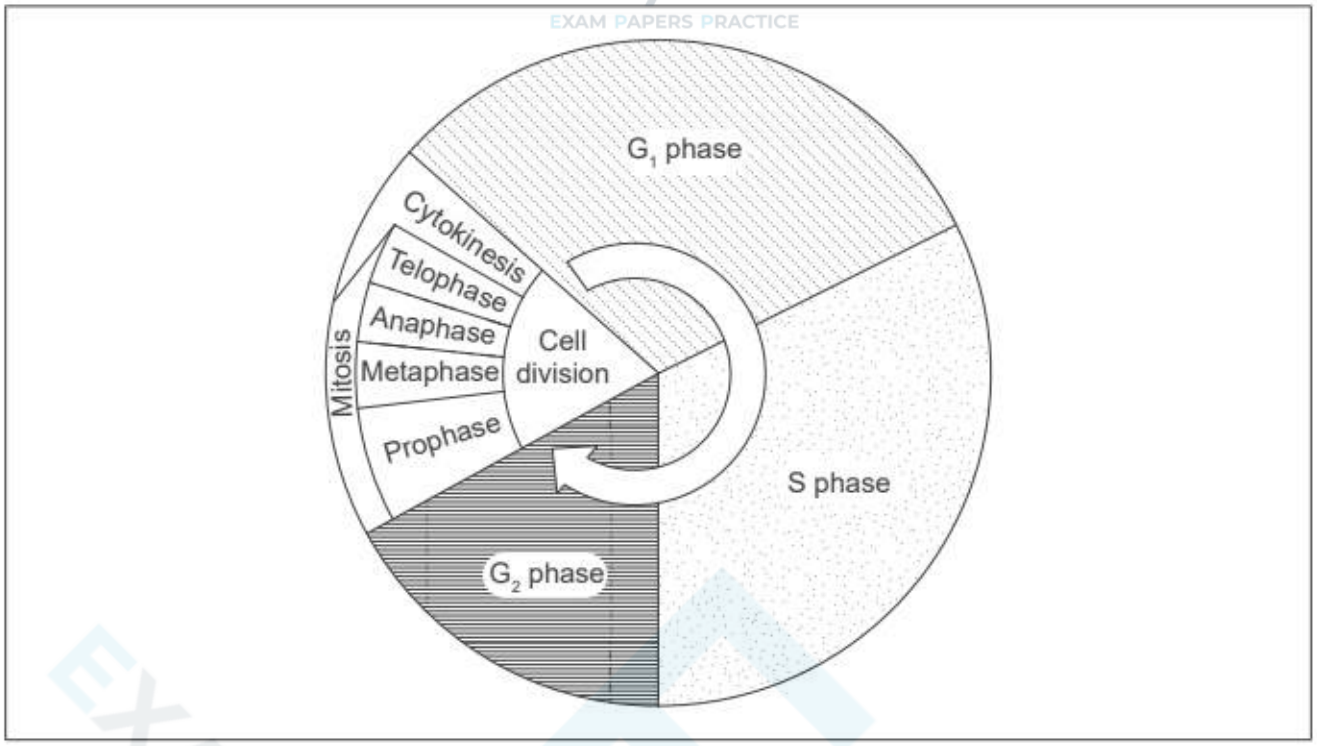
c.

Discuss the relationship between atmospheric carbon dioxide concentration and global temperatures.

[4]

21M.2.SL.TZ2.2

The diagram shows the stages in the cell cycle.



a. State processes occurring during interphase. [2]

b.i.

Using the letter C, label the stage on the diagram where chromosome supercoiling occurs.

[1]

b.ii.

Using the letter M, label the stage on the diagram where sister chromatids migrate to opposite poles.

[1]

c. Distinguish between the outcomes of a cell dividing either by mitosis or meiosis.

[2]

d.

The mitotic index is an important prognostic tool for predicting the response of cancer cells to chemotherapy. Outline how the mitotic index is calculated.

[1]

21M.2.SL.TZ2.3

The image represents the structure of the enzyme Rubisco from common pea (*Pisum sativum*).

a. State **one** function of Rubisco. [1]

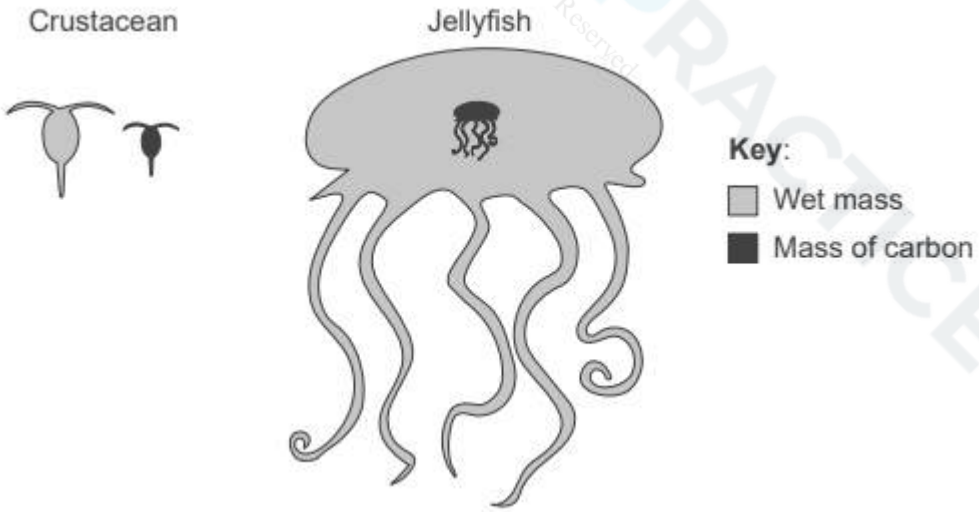
b. State a role of the active site of an enzyme. [1]

c. State the genus of the plant where this Rubisco is found. [1]

d. Outline factor that could affect the activity of Rubisco. [2]

21M.2.SL.TZ2.4

The mass of an individual organism can affect its physiology and feeding ecology. The diagram shows the relative mass of carbon (black) and total wet mass (grey) of a marine crustacean, *Calanus hyperboreus* and a jellyfish, *Bathocyroe fosteri*.



[Source: Kristian McConville, Angus Atkinson, Elaine S. Fileman, John I. Spicer, Andrew G. Hirst. Disentangling the counteracting effects of water content and carbon mass on zooplankton growth. *Journal of Plankton Research*. 2017, Volume 39, Issue 2, Pages 246–256. https://doi.org/10.1093/plankt/fbw094. Adapted (and translated) by permission of Oxford University Press.]

a.

State **one** process that results in the loss of carbon dioxide from a marine organism such as a crustacean or a jellyfish.

[1]

b.

The crustacean and the jellyfish obtain carbon compounds by feeding. State source of carbon for marine organisms, other than feeding.

[1]

c. Explain how energy enters, flows through and is lost from marine food chains.

[3]

d.i.

Deduce whether jellyfish or crustacea are a richer source of carbon in a food chain.

[1]

d.ii.

Suggest with a reason whether having a large body mass is an advantage or disadvantage for jellyfish.

[1]

21M.2.SL.TZ2.5

Pastry cream or confectioners' custard is made with a combination of milk (rich in casein and lactose), egg yolks, sugar, starch and a flavouring such as vanilla.

a. Describe the structure of starch. [5]

b.

Explain how amino acids in casein could reach the liver, starting from the moment when the person takes a bite of pastry cream pie.

[7]

c.

Congenital lactase deficiency is a type of lactose intolerance that occurs in infants. It is inherited in an autosomal recessive pattern. Calculate the chance of congenital lactose intolerance in a child whose parents are both carriers for the disorder, showing fully how you reached your answer.

[3]

21M.2.SL.TZ2.6

Tuberculosis (TB) is an infectious disease caused by the bacterium *Mycobacterium tuberculosis*.

a. Outline the structures in *M. tuberculosis* that are not present in a human cell.

[3]

b.

Explain the production of antibodies when a patient is infected with the TB bacterium.

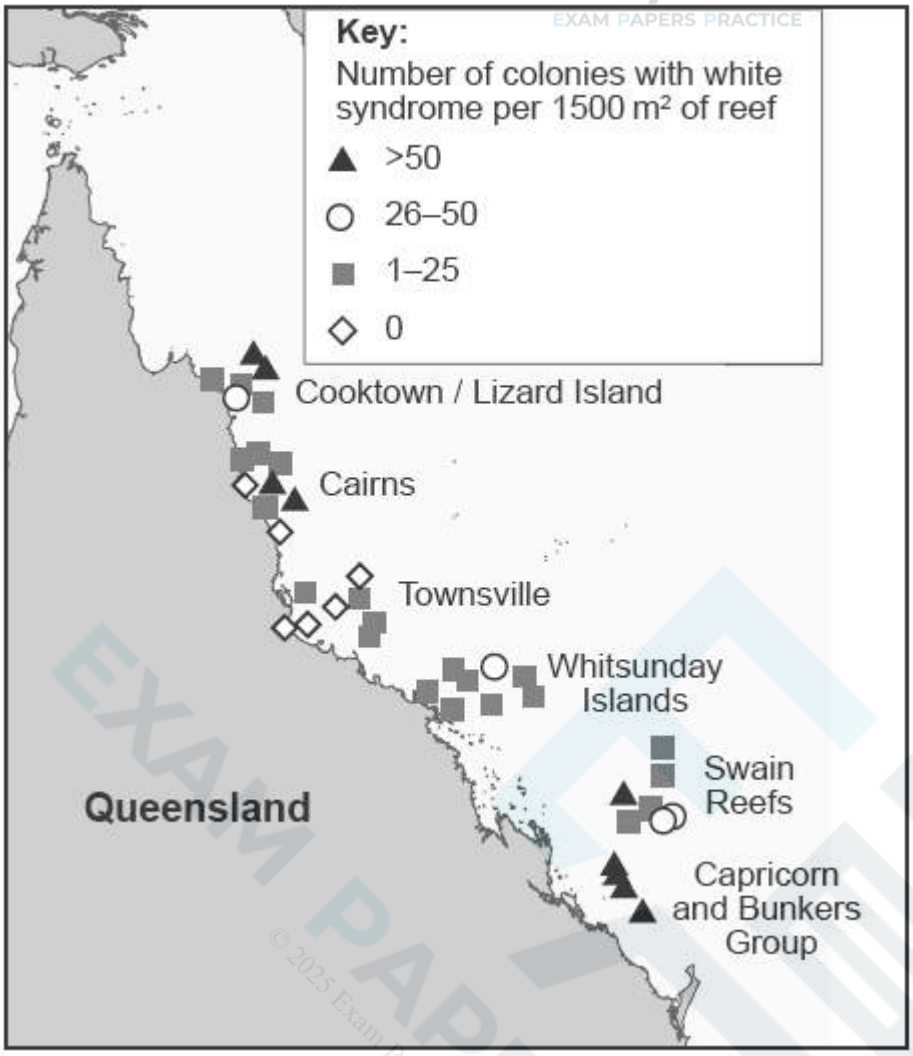
[7]

c. Describe the risk to the human population of indiscriminate use of antibiotics.

[5]

21N.2.SL.TZ0.1

The incidence of white syndrome, an infectious disease of coral, was investigated in a six-year study on Australia's Great Barrier Reef. The map shows disease conditions on coral reefs at six study sites.



[Source: adapted from Bruno, J.F., Selig, E.R., Casey, K.S., Page, C.A., Willis, B.L., Harvell, C.D., Sweatman,
H. and Melendy, A.M., 2007. *PLOS Biology*, [e-journal] 5(6), e124.
https://doi.org/10.1371/journal.pbio.0050124.]

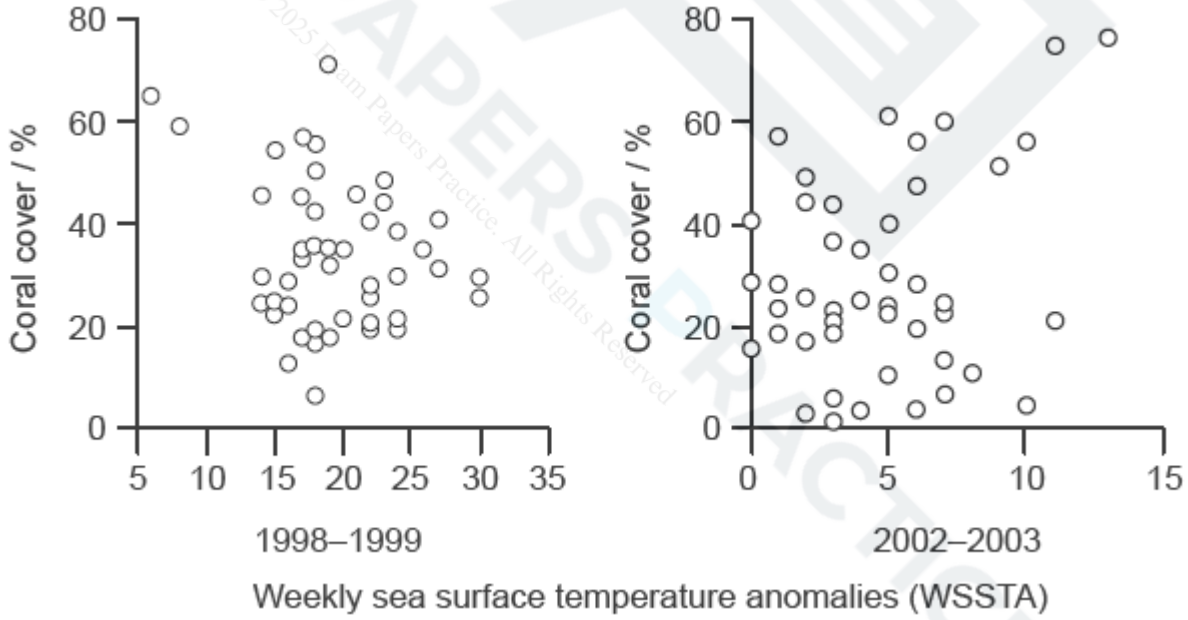
Satellites were used to record sea surface temperatures. The temperatures each week above a reef were compared with mean temperatures for that week between 1985 and 2004. If the sea surface temperature was 1 °C or more above the mean, this was recorded as a weekly sea surface temperature anomaly (WSSTA). The number of WSSTAs was calculated for the twelve months preceding the date on which a reef was surveyed for white syndrome.

On each reef, the number of cases of white syndrome in a 1500 m^2 sample area was surveyed once per year. The table shows these cases in relation to numbers of WSSTAs and coral cover on the reef. Low coral cover was 0–24 % and high coral cover was 50–75 %.

	Mean number of corals with white syndrome per 1500 m^2		
	Coral cover / %		
WSSTAs per year	0–24	25–49	50–75
0	0.9	0.9	10.4
1 to 5	3.6	9.8	23.3
> 5	4.7	4.5	80.1

[Source: adapted from Bruno, J.F., Selig, E.R., Casey, K.S., Page, C.A., Willis, B.L., Harvell, C.D., Sweatman, H. and Melendy, A.M., 2007. *PLOS Biology*, [e-journal] 5(6), e124. https://doi.org/10.1371/journal.pbio.0050124.]

The graphs show the relationship between the weekly sea surface temperature anomalies (WSSTA) and coral cover during two twelve-month periods (1998–99 and 2002–03), which were the warmest in the six-year study. Each dot represents one studied reef.



[Source: adapted from Bruno, J.F., Selig, E.R., Casey, K.S., Page, C.A., Willis, B.L., Harvell, C.D., Sweatman, H. and Melendy, A.M., 2007. *PLOS Biology*, [e-journal] 5(6), e124. https://doi.org/10.1371/journal.pbio.0050124.]

a.i. Identify the site with the highest incidence of diseased colonies. [1]

a.ii.

Deduce whether there is a trend in the incidence of white syndrome over the north-south range of latitude.

[1]

b.i.

Describe the evidence that is provided by the data in the table for the harmful effects of rising sea temperatures on corals.

[2]

b.ii.

The researchers concluded that there was a threshold coral cover percentage, below which infection rates tended to remain fairly low. Using the data in the table, identify this threshold level.

[1]

b.iii.

Suggest a reason for a larger percentage of corals being infected with white syndrome on reefs with a higher cover of corals.

[1]

c.i. Compare and contrast the data for 1998–1999 and 2002–2003. [2]

c.ii.

Suggest a reason for the correlation between coral cover and WSSTA in 1998–1999.

[1]

d.

Some scientists predict that, if humans continue to produce carbon dioxide at the current rate, the pH of the oceans will become more acidic. Suggest possible effects on the coral reefs.

[3]

e.

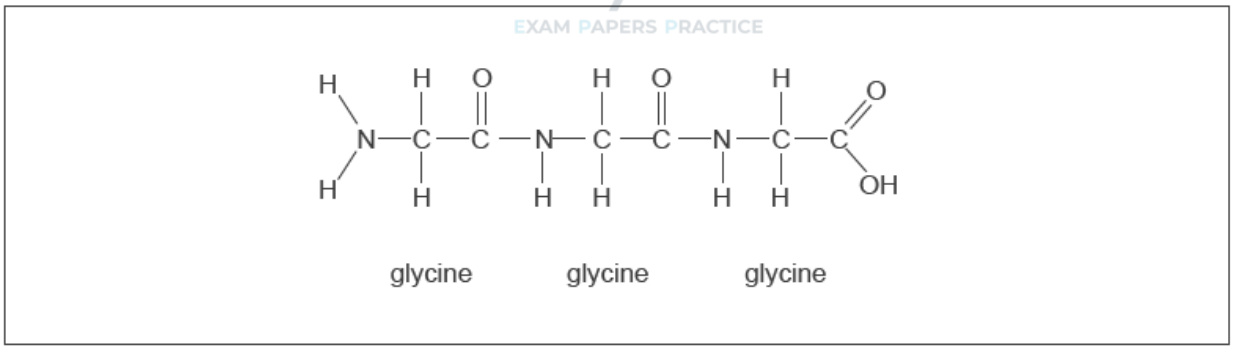
This study was carried out over six years on the Australian Great Barrier Reef. State advantage of field investigations compared with mesocosm experiments to study ecological processes.

[1]

21N.2.SL.TZ0.2

a.

The figure shows a tripeptide.



Label **one** peptide bond in this molecule.

[1]

b. Outline the specific functions of **three named** proteins. [3]

c. Outline the action taken by the diaphragm during inhalation. [1]

21N.2.SL.TZ0.3

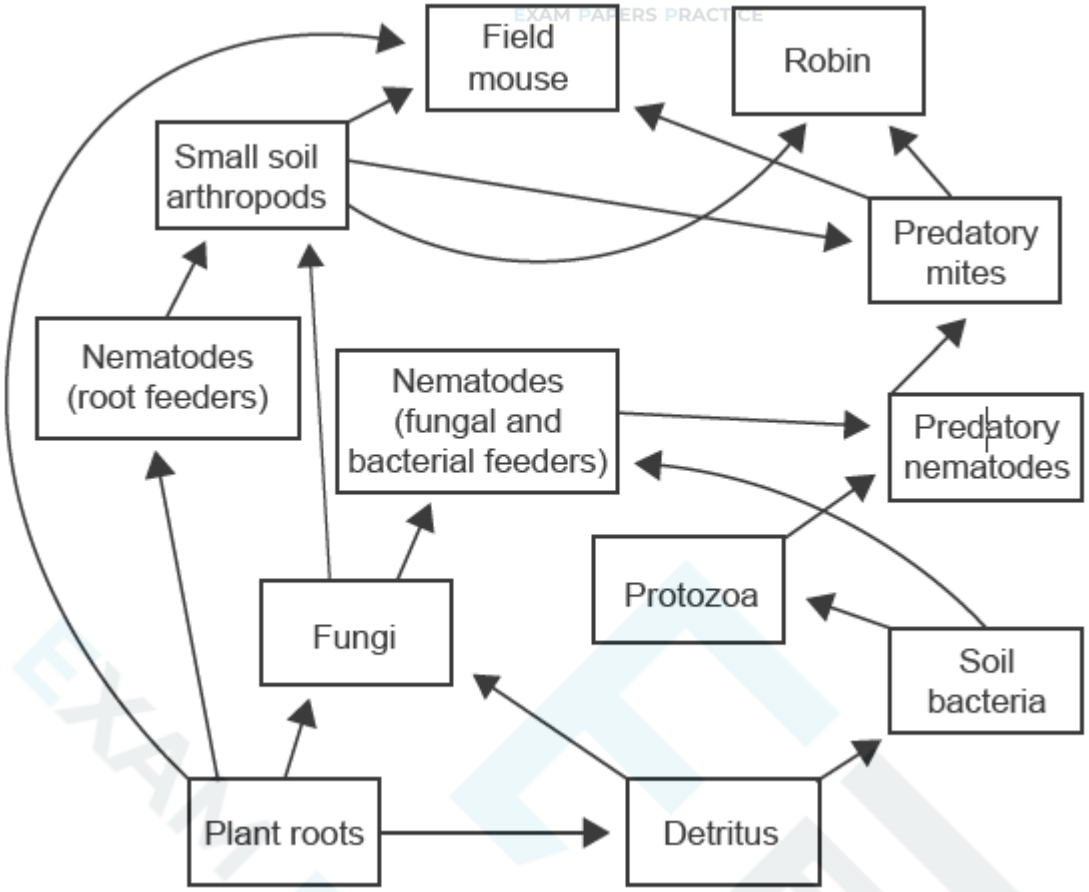
a.

Compare and contrast the mode of nutrition of detritivores and saprotrophs.

	Detritivores	Saprotrophs
Similarity		
Difference		

[2]

b.i. The image shows an example of a soil food web.



[Source: Anon., n.d. The Soil Food Web. [image online] Available at: https://www.nrcs.usda.gov/wps/portal/nrcs/photogallery/soils/health/biology/gallery/?cid=1788&position=Promo [Accessed 11 March 2020].]

Draw a food chain from this food web, showing at least three organisms. [1]

b.ii.

Explain the reasons for food chains rarely containing more than four or five trophic levels.

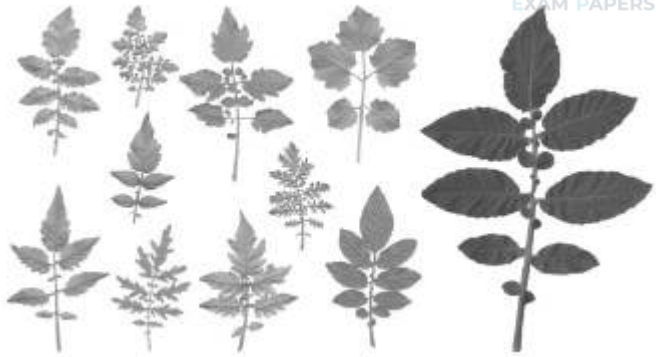
[3]

c.

The amount of food passing into food chains can be affected by the rate of photosynthesis. Explain the effect of limiting factor on photosynthesis.

[3]

d. All of the leaves in the image are from *Solanum*, a wild genus of tomato.



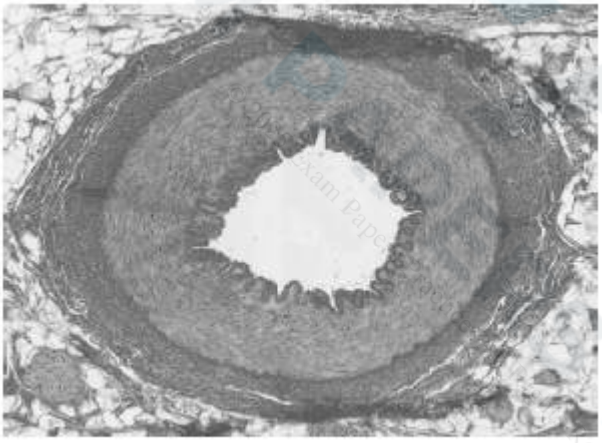
[Source: Courtesy: National Science Foundation, Credit Leonie Moyle.]

State cause of variation in a plant such as the tomato. [1]

21N.2.SL.TZ0.4

a.

This micrograph shows a transverse section of an artery.



x 100

[Source: OpenStax College, 2013. Comparison of artery and vein. [image online] Available at: https://en.wikipedia.org/wiki/File:2102_Comparison_of_Artery_and_Vein.jpg Attribution 3.0 Unported (CC BY 3.0) https:/creativecommons.org/licenses/by/3.0/deed.en [Accessed 11 March 2020].]

Explain how the specialized structures of arteries help them to achieve their functions.

[3]

b.i. State **one** process that produces ATP. [1]

b.ii. Outline the use of ATP. [1]

c. State function of epinephrine in the human body. [1]

21N.2.SL.TZ0.5

Substances can move into and out of cells through the cell membrane.

a.

Outline the significance of surface area to volume ratio in the limitation of cell size.

[4]

b. Describe transport across cell membranes by osmosis. [4]

c. Explain the adaptations of the small intestine to its function. [7]

21N.2.SL.TZ0.6

Organisms have evolved a great diversity of cell types.

a. Describe the endosymbiotic theory. [4]

b.

Explain the need for halving the chromosome number during a sexual life cycle and how this is done.

[7]

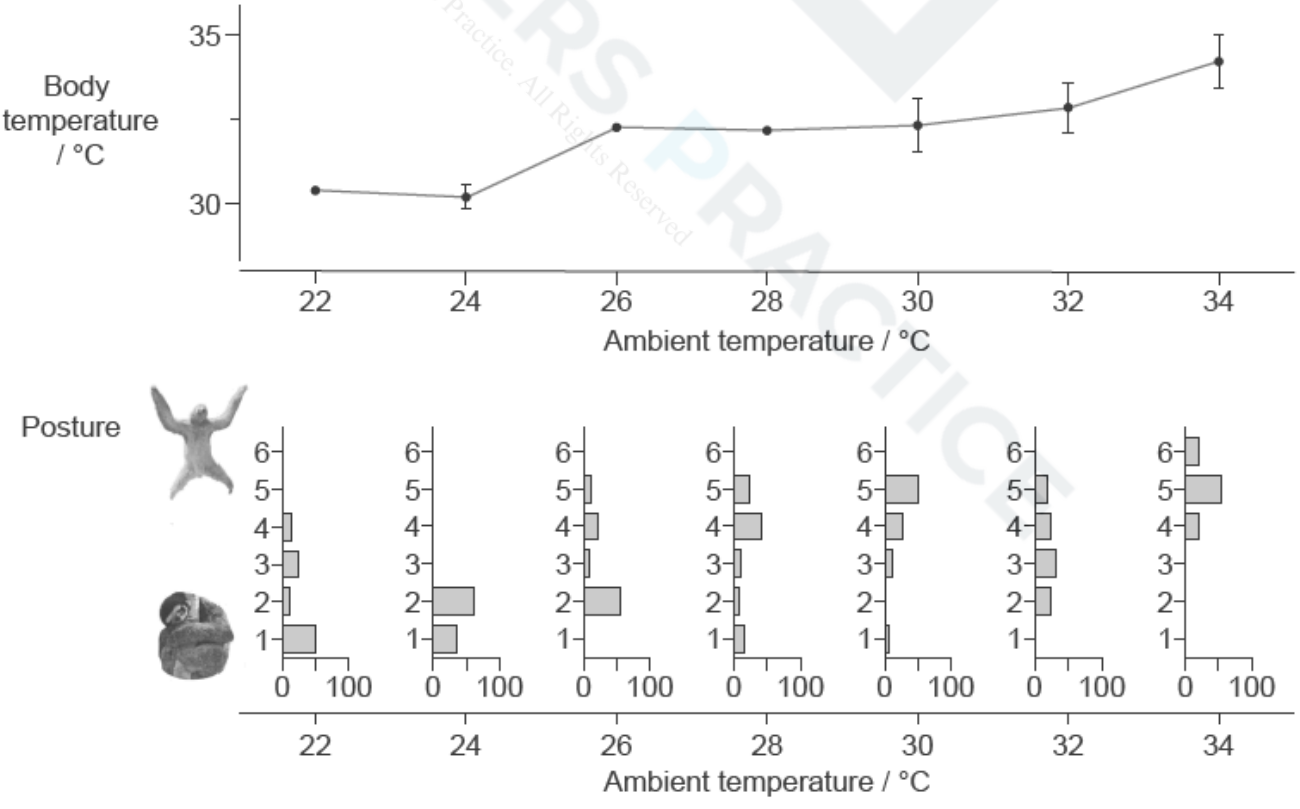
c. Outline the binomial system of classification. [4]

22M.2.SL.TZ1.1

Three-toed sloths (*Bradypus variegatus*) are placental mammals that live in trees in Central and South America. They eat leaves and fruit and get almost all their water from succulent plants.

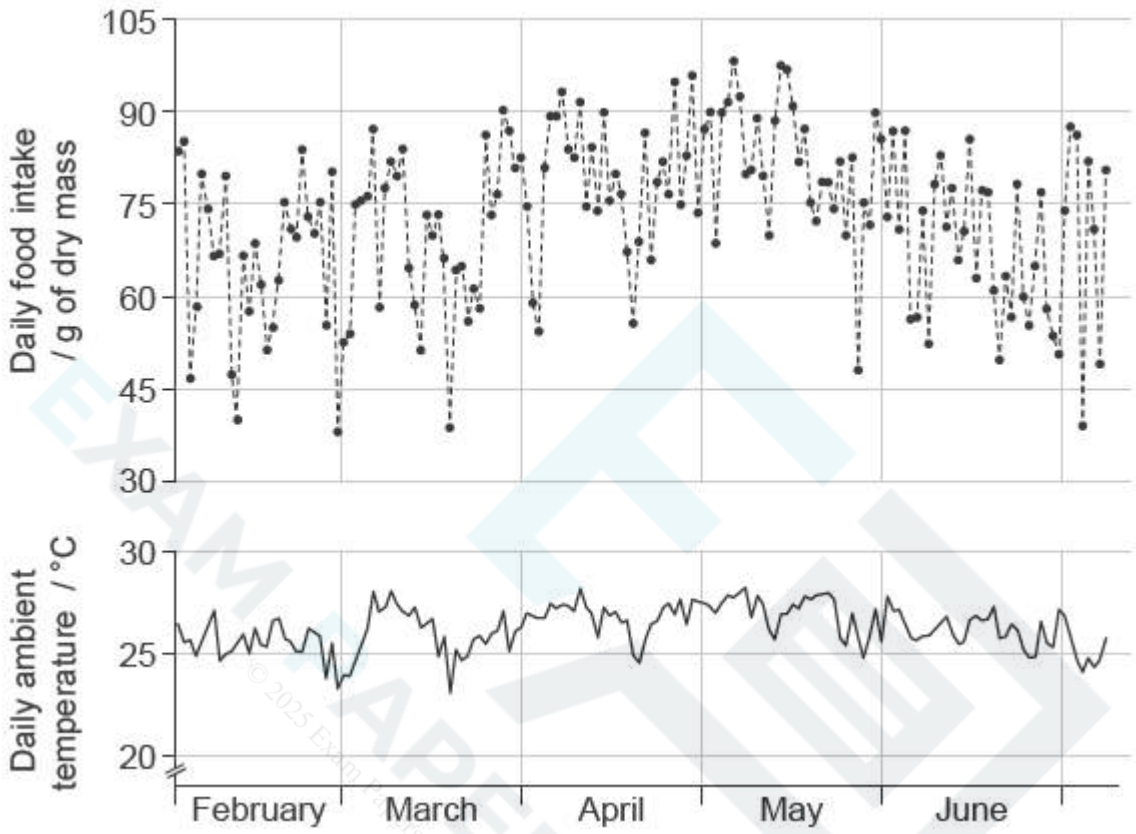
[Source: Adapted from Laube, S., 2003. Three-toed-sloth (*Bradypus variegatus*), Lake Gatun, Republic of Panama. [image online] Available at: https://meta.wikimedia.org/wiki/User:Bradipus#/media/File:Bradypus.jpg]

Three-toed sloths change their body posture in response to the temperature of their environment (ambient temperature). Researchers assessed posture on a scale from 1 to 6, with 1 being when the sloth was curled into a tight ball and 6 when it had all limbs spread. The percentage of time the sloths were observed in each position was recorded at ambient temperatures from 22 °C to 34 °C. The researchers also measured the body temperature of the sloths over the same range of ambient temperatures.



[Source: Adapted from Cliffe, R.N., Scantlebury, D.M., Kennedy, S.J., Avey-Arroyo, J., Mindich, D. and Wilson, R.P., 2018. The metabolic response of the Bradypus sloth to temperature. *PeerJ*, [e-journal] 6: e5600. http://dx.doi.org/10.7717/peerj.5600. Licensed

The daily food intake of three-toed sloths and daily ambient temperatures were monitored over a 160-day period from February to early July. The graphs show the mean results.



[Source: Cliffe et al. (2015), Sloths like it hot: ambient temperature modulates food intake in the brown-throated sloth (*Bradypus variegatus*). PeerJ 3:e875; DOI 10.7717/peerj.875
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https://creativecommons.org/licenses/by/4.0/.]

a.i.

State the relationship between sloth body temperature and ambient temperature.

[1]

a.ii. Explain how this relationship differs from that in humans. [1]

b.i.

Describe the trend in body posture as ambient temperature rises from 22 to 34 °C.

[1]

b.ii. Suggest reasons for this trend. [2]

f.

The mean daily food intake fluctuated from day to day. State the month that contains the day on which the mean intake of food was highest.

[1]

g.

Outline the relationship between ambient daily temperature and food intake in March.

[2]

h.

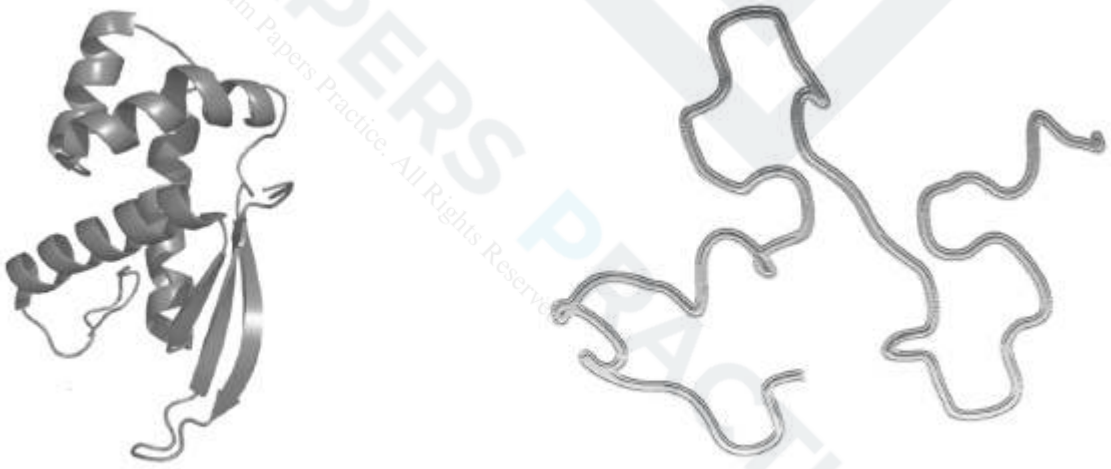
Suggest, with a reason, how the activity of the sloth varies with ambient temperature.

[1]

i. State feature of the sloth that would indicate it is a mammal. [1]

22M.2.SL.TZ1.2

The diagrams represent the structure of a protein before and after it has become denatured.



Native protein

Denatured protein

[Source: Dean Williams, L., 2019. *Molecular Interactions*. [online] Available at: https://ww2.chemistry.gatech.edu/~lw26/structure/molecular_interactions/mol_int.html [Accessed 20 August 2019].]

a.

State how many different types of amino acid there are, which can become part of a polypeptide when mRNA is translated.

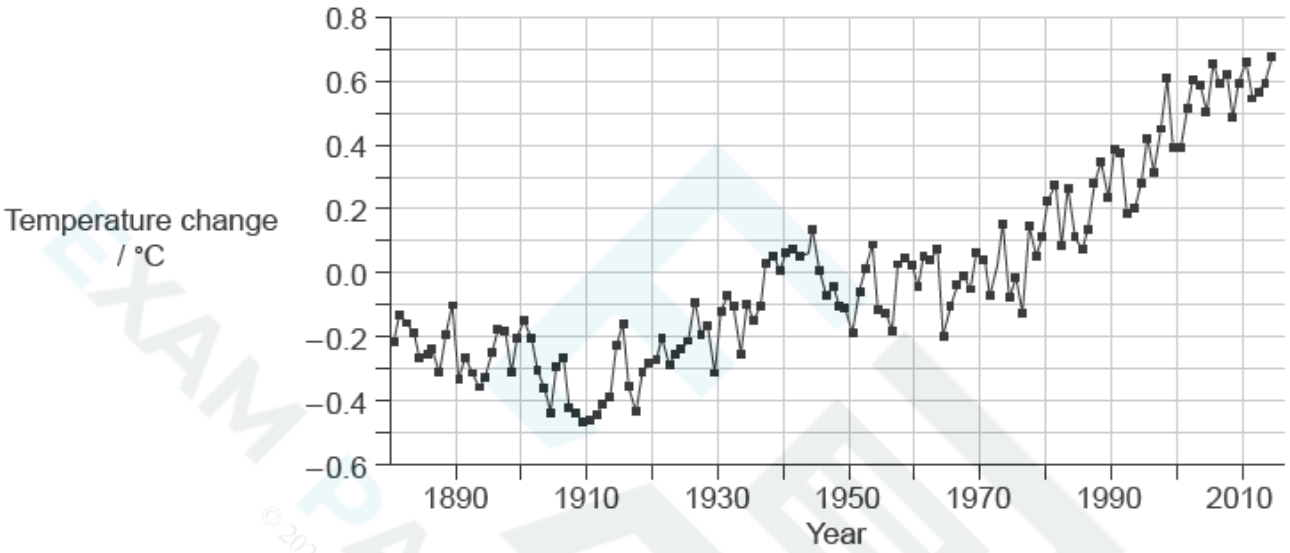
[1]

b. Outline cause of denaturation in proteins. [1]

c. Explain how denaturation affects the activity of an enzyme. [2]

22M.2.SL.TZ1.3

The graph shows the mean annual changes in global temperatures between 1880 and 2014. The mean temperature from 1951 to 1980 was used as the value of zero change in temperature.



[Source: National Aeronautics and Space Administration, n.d. GISS Surface Temperature Analysis (v3). [online]
Available at: https://data.giss.nasa.gov/gistemp/graphs_v3/ [Accessed 20 August 2019].]

a. Calculate the increase in mean global temperature between 1880 and 2010.

..... °C [1]

b.

Outline how changes in temperature over short time periods could give a misleading impression of changes to the Earth's climate.

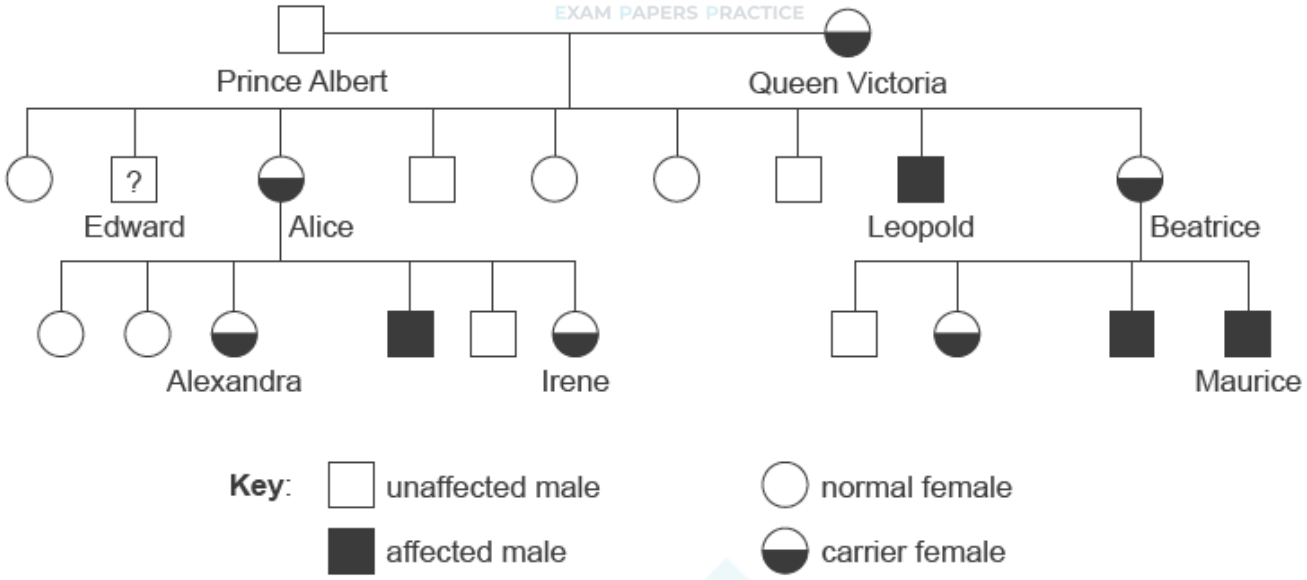
[1]

c. Explain how increased carbon dioxide in the air leads to the greenhouse effect.

[3]

22M.2.SL.TZ1.4

The pedigree chart shows the incidence of hemophilia in some of the descendants of Queen Victoria.



a. State the probability that Edward had hemophilia. [1]

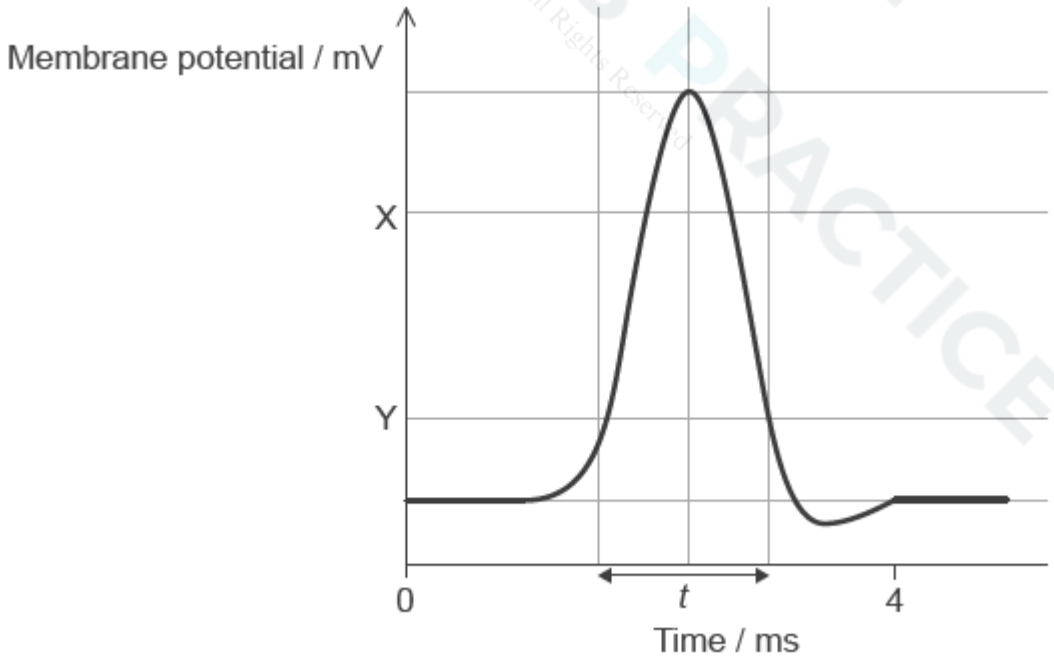
b.

Explain the reasons for none of the females in the pedigree chart having hemophilia.

[3]

22M.2.SL.TZ1.5

The graph shows the change in the membrane potential of an axon during an action potential.



a. State the approximate value of the membrane potential at X. [1]

b.

Y is the threshold potential. State what happens when the threshold potential is reached.

[1]

c. Describe the movements in ions that occur during time *t*. [2]

d. Explain how a nerve impulse is passed on to other neurons. [3]

22M.2.SL.TZ1.6

a.

Outline reasons for the therapeutic use of stem cells.

[3]

b. Describe how leaf cells make use of light energy. [5]

c.

Explain how cells and cell components in the blood defend the body against infectious disease.

[7]

22M.2.SL.TZ1.7

a.

Draw a labelled diagram to show the structure of a single nucleotide of RNA.

[3]

b. Distinguish between the processes of meiosis and mitosis. [5]

c. Explain the development of antibiotic resistance in terms of natural selection.

[7]

22M.2.SL.TZ1.8

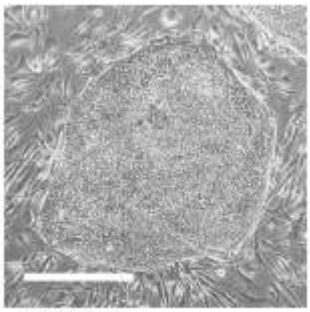
(a) Draw a labelled diagram to show the structure of a single nucleotide of RNA. [3]

(b) Describe how DNA profiling can be used to establish paternity. [5]

(c) Explain the reasons for variation in human height. [7]

22M.2.SL.TZ2.2

An oval-shaped stem cell cluster is shown in the micrograph.



[Source: Sontag, S., Förster, M., Seré, K. and Zenke, M., 2017. [online] Available at: https://bio-protocol.org/e2419 [Accessed 6 December 2019]. Source adapted.]

a. State the main characteristic of stem cells. [1]

b.

Calculate the maximum diameter of the stem cell cluster on the micrograph, showing your working and giving the units.

..... [1]

c. State **one** therapeutic role of stem cells. [1]

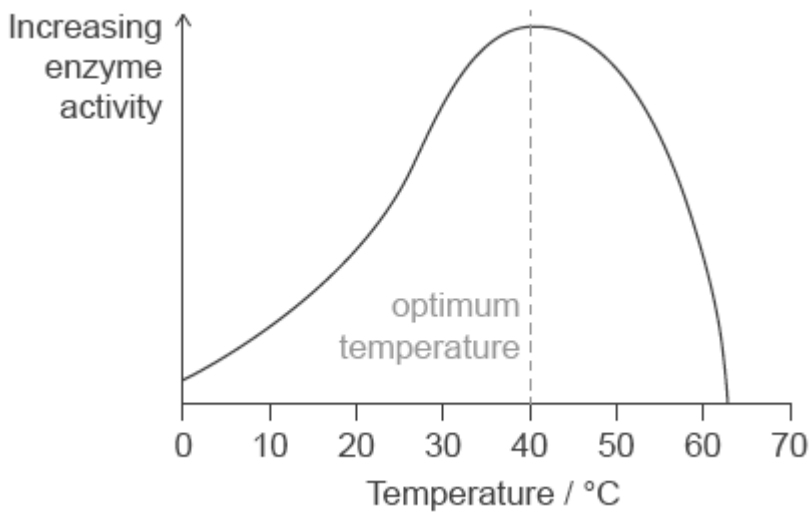
d.

Discuss how the use of stem cells to treat hereditary diseases could affect the person who received the treatment **and** their progeny.

[2]

22M.2.SL.TZ2.5

Enzyme activity is affected by temperature and pH.



a.

Explain the decrease in activity of the enzyme on either side of the optimum temperature.

[2]

b.

In biotechnology, enzymes are used to transfer genes to bacteria. Outline how specific enzymes are used for the transfer.

[2]

22M.2.SL.TZ2.6

People with the inherited disease hemophilia have a deficiency in one of the proteins that act as clotting factors in blood.

a. Outline how a protein is made in a cell by the process of translation. [5]

b.

A family has a history of hemophilia that is caused by a sex-linked recessive allele. A woman from this family is a carrier and marries a man who does not have the allele. Showing your working, determine the probability of their children having the disease.

[3]

c.

Explain how blood clotting occurs and the consequence for a person who has hemophilia.

[7]

22M.2.SL.TZ2.7

The growing human population has an increasing demand for energy derived from crop plants. At the same time, increasing droughts that are part of climate change make it difficult to grow crops in some parts of the world.

a. Outline energy flow through a community in a natural ecosystem. [5]

b.

Explain how natural selection can cause traits such as drought resistance to develop in wild plants.

[7]

c.

Suggest possible benefits risks of using genetic modification to develop varieties of crop plant with traits such as drought resistance.

[3]

22M.2.SL.TZ2.8

(a)

Outline **four** different processes, **with examples** , that allow substances to pass through the plasma membrane.

[4]

(b)

Humans need to balance water and solute concentrations and also excrete nitrogenous wastes. Explain how the different parts of the kidney carry out these processes.

[7]

(c)

Describe adaptations in mammals living in desert ecosystems to maintain osmolarity in their bodies.

[4]

23M.2.SL.TZ1.6

(a) Outline the sequence of events that occurs during mitosis. [5]

(c)

Explain how the presence of a Y chromosome in the cells of a human embryo causes it to develop as a male.

[3]

23M.2.SL.TZ1.7

(a)

Describe how plants are named and classified, including recognition features of plant phyla.

[7]

(a)

Outline the changes to chromosomes that occur during prophase in the first division of meiosis.

[4]

(b)

Outline the stages of the carbon cycle that involve plants or materials made by plants.

[5]

23M.2.SL.TZ2.6

(a) Explain how temperature affects enzymes. [4]

(c)

Describe how human activities have caused average surface air temperatures on Earth to increase.

[7]

23M.2.SL.TZ2.7

(a)

Describe the organelles and other structures in animal cells that are visible in electron micrographs.

[7]

(b) Explain how animal cells produce the ATP that they need. [5]

SPM.2.SL.TZ0.6

(a) Outline how sex is determined in humans. [2]

(b) Explain how sexual reproduction gives rise to genetic variation. [2]

SPM.2.SL.TZ0.7

(a) Outline how mutation can lead to cancer. [4]

(b) Outline **one** example of a human disease caused by an autosomal recessive allele.

[4]

(c) Explain the role of mutations in evolution. [7]

(a) Explain the mechanisms involved in thermoregulation in humans. [7]

(b) Explain the relationship between temperature and the activity of enzymes. [4]

(c)

Distinguish between the thermal properties of air and water as they relate to the habitat of animals.

[4]