

# Exam Prep DBQs [116 marks]

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.]

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

[1 mark]

.....

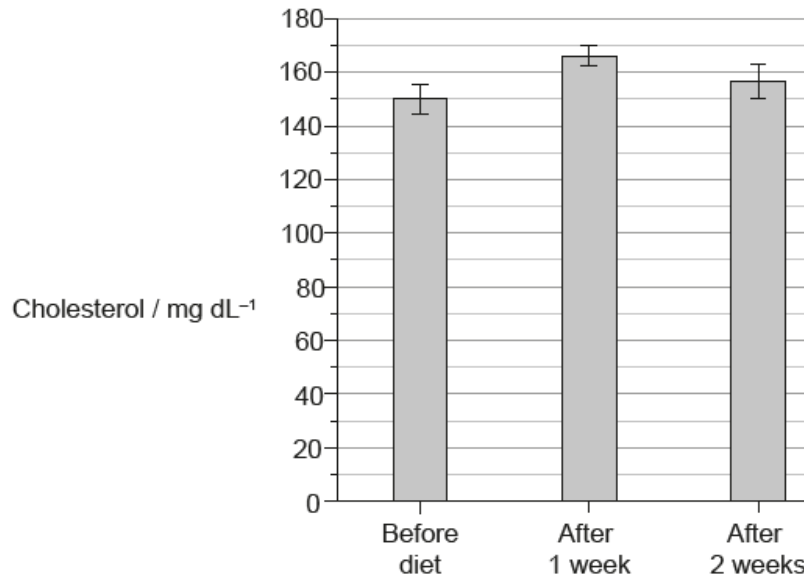
.....

.....

1b. Distinguish between the two diets.

[2 marks]

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.

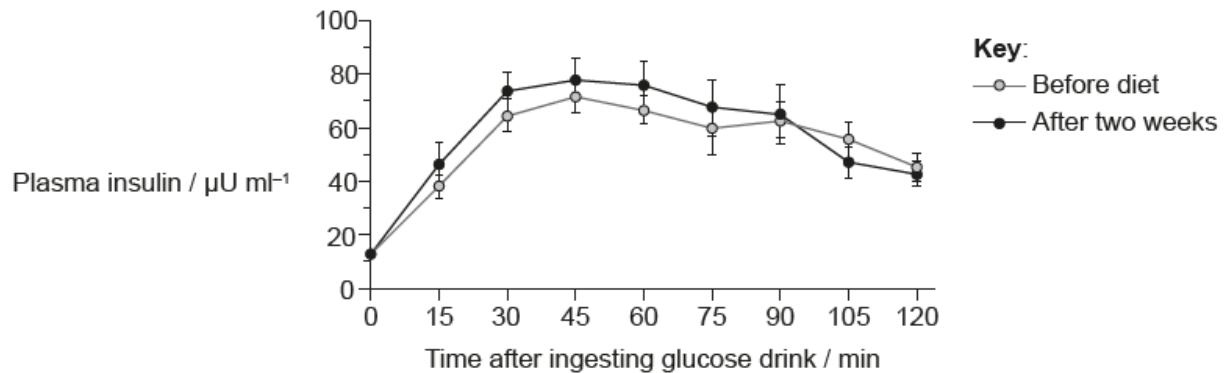


[Source: Horowitz, J.F., Ortega, J.F., Hinko, A., Li, M., Nelson, R.K. and Mora-Rodriguez, R., 2018. Changes in markers for cardio-metabolic disease risk after only 1-2 weeks of a high saturated fat diet in overweight adults. *PLoS ONE*, 13(6), e0198372.]

- 1c. Calculate, showing your working, the percentage change in mean cholesterol level after **one week** on the study diet. [2 marks]

.....%

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.]

- 1d. Compare the data for plasma insulin levels before and after the study diet. [2 marks]

.....

.....

.....

.....

.....

.....

- 1e. State which cells secrete insulin. [1 mark]

.....

.....

.....

- 1f. Outline the reason for plasma insulin levels changing in the first 30 minutes of the test. [1 mark]

<div style="border-bottom: 1px dotted black; margin-bottom: 5px;"></div> <div style="border-bottom: 1px dotted black; margin-bottom: 5px;"></div> <div style="border-bottom: 1px dotted black;"></div>
--

- 1g. The hypothesis made before the study was that saturated fats in the diet [3 marks] 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.

[illegible]

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.]

2a. State the genus of this organism.

[1 mark]

.....  
.....  
.....

2b. State the domain in which it is classified.

[1 mark]

.....  
.....  
.....

2c. Outline the method of nutrition carried out by *P. caudatum*.

[1 mark]

.....  
.....  
.....

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

.....

.....

.....

.....

.....

.....

2e. Apart from the ribosomes, explain the evidence for the endosymbiotic theory of the origin of eukaryotic cells. [3 marks]

.....

.....

.....

.....

.....

.....

3a. Outline how the amphipathic properties of phospholipids play a role in membrane structure. [2 marks]

.....

.....

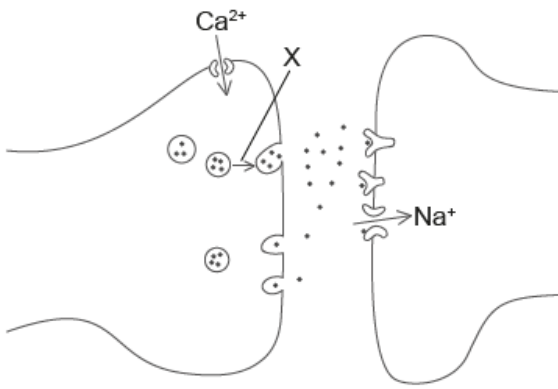
.....

.....

.....

.....

The diagram shows part of two neurons.



[Source: © International Baccalaureate Organization 2020.]

3b. State the name of the structure shown.

[1 mark]

.....
.....
.....

3c. X indicates the movement of a structure in the neuron. Explain what events trigger this movement and what happens next.

[3 marks]

.....
.....
.....
.....
.....
.....



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

		2nd letter					
		U	C	A	G		
1st letter	U	Phe	Ser	Tyr	Cys	U	3rd letter
		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	

4a. Outline the function of codons. [1 mark]

.....

.....

.....

4b. Determine the sequence of amino acids that could be translated from the [1 mark] sequence of mRNA.

.....

.....

.....

4c. Determine the DNA base sequence transcribed to form this sequence of mRNA. [1 mark]

.....

.....

.....

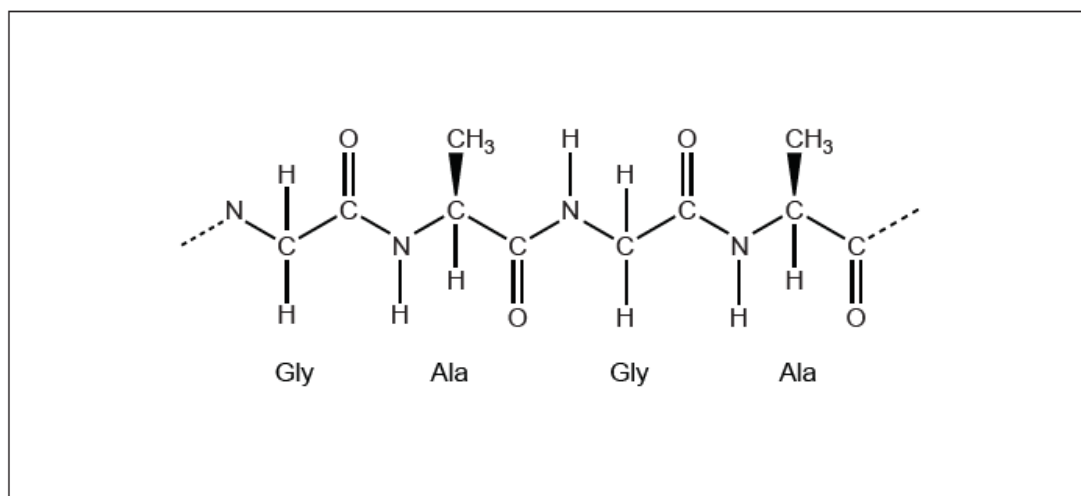
4d. Suggest a hypothesis that accounts for the slightly different meaning of some codons in a very limited number of organisms. [1 mark]

.....

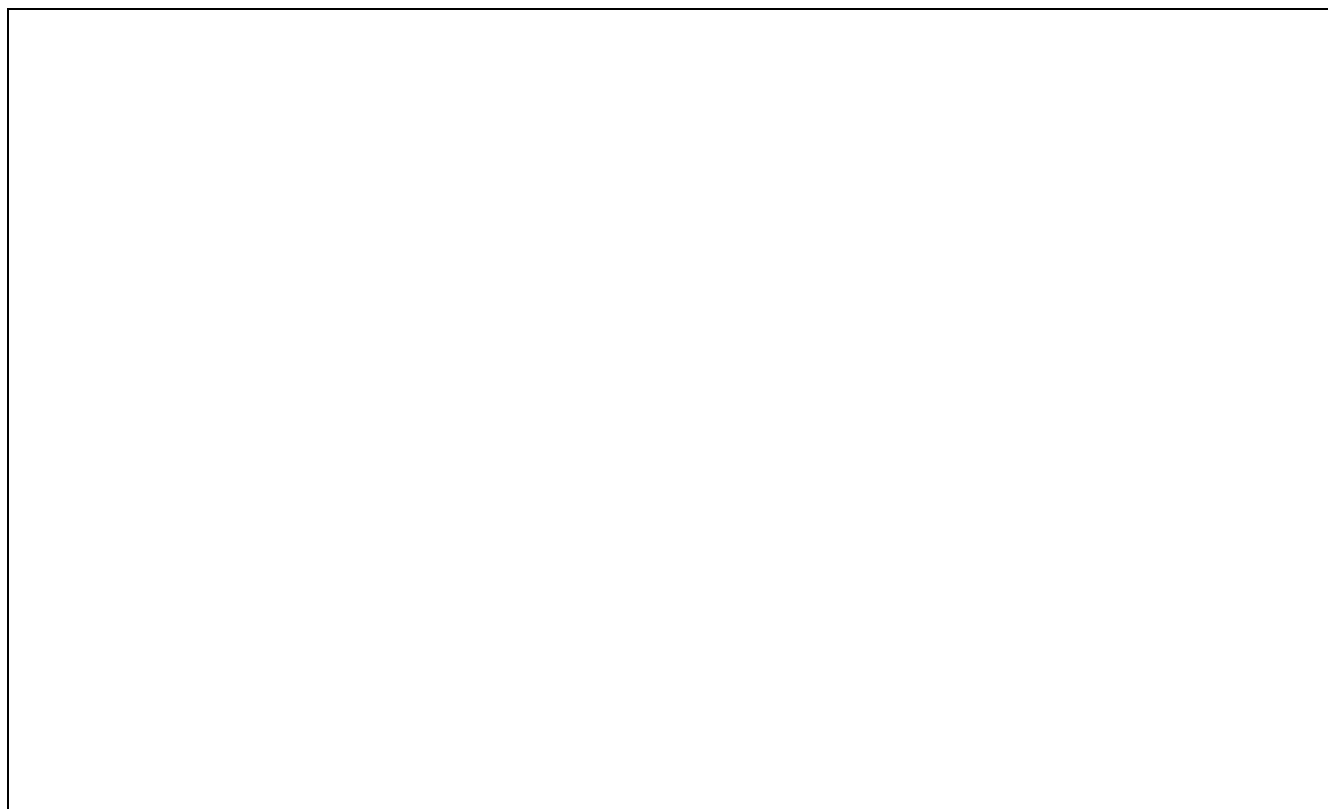
.....

.....

The diagram shows a section of a polypeptide.



4e. Annotate the diagram to show a peptide bond between two amino acids. [1 mark]



4f. State the type of reaction that removes water while linking amino acids together to form polypeptides. [1 mark]

.....

.....

.....

4g. Outline the function of Rubisco and of spider silk in relation to their three-dimensional conformation. *[2 marks]*

	Function	Conformation
Rubisco		
Spider silk		

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 <sup>-2</sup>	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]

5a. Identify the country with the largest number of Ebola cases. [1 mark]

.....

.....

.....

5b. Identify the country with the largest number of deaths. [1 mark]

.....

.....

.....

5c. Analysis of the data suggests that the number of deaths from EVD is not related to the total population size. State **one** piece of evidence from the data that would support this analysis. *[1 mark]*

.....

.....

.....

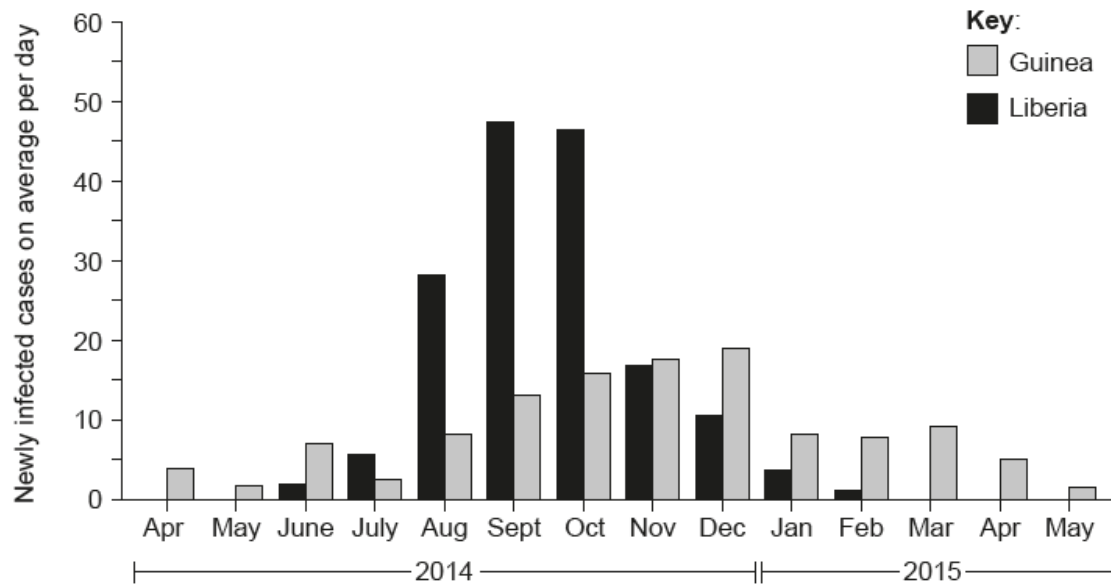
5d. Based on the mode of transmission of the Ebola virus, suggest a possible reason for the relationship between population density and the number of Ebola cases in these four countries. *[1 mark]*

.....

.....

.....

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]

5e. Based on the data, compare and contrast the progress of the epidemic in[3 marks]  
Liberia and Guinea.

.....

.....

.....

.....

.....

.....

.....

.....

.....

5f. Suggest **two** possible reasons for the drop in the daily numbers of newly *[2 marks]* infected cases after October 2014 in Liberia.

.....

.....

.....

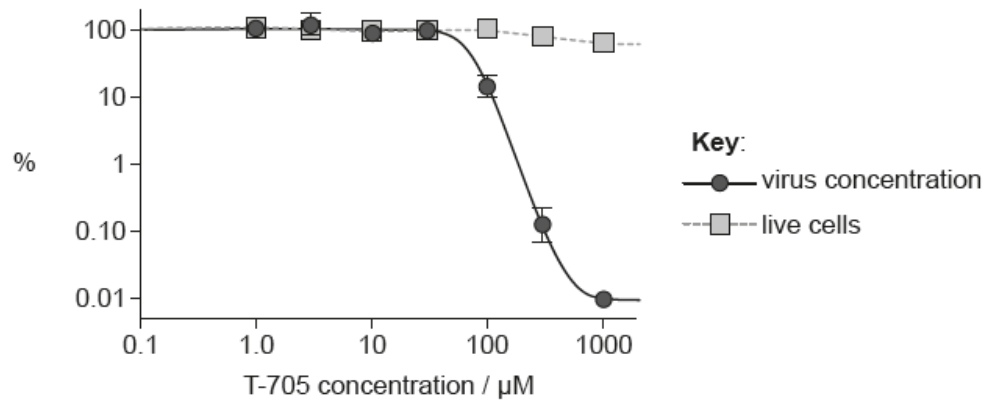
.....

.....

.....



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.]

5g. Based on these data, outline the evidence that T-705 has potential to be used as a treatment for EVD. [2 marks]

.....

.....

.....

.....

.....

.....

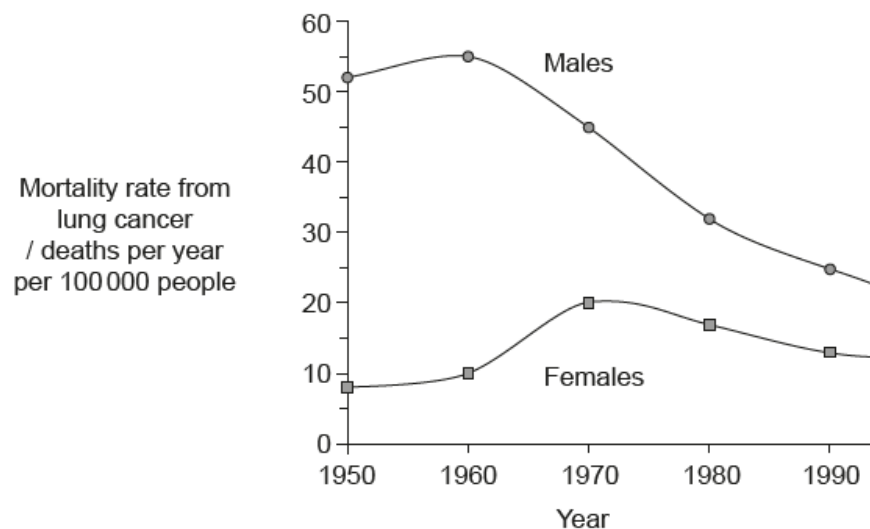
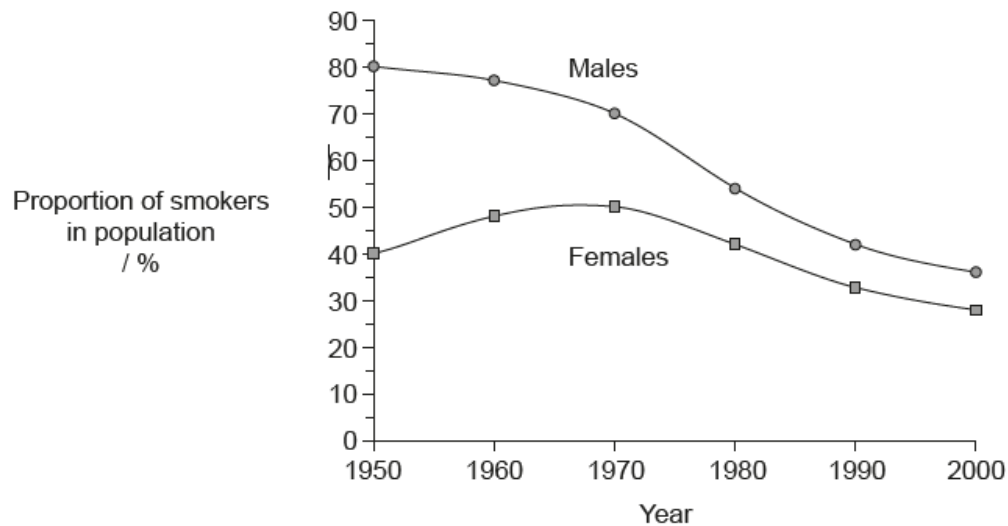
5h. District administrators combatting the 2014 Ebola epidemic in West Africa[1 mark] were assisted by international organizations such as the World Health Organization, who provided data on the progress of the epidemic. Suggest **one** other way in which international organizations can assist with combatting an epidemic of Ebola.

.....

.....

.....

Trends in tobacco smoking and mortality due to lung cancer were measured in male and female smokers aged 35 to 59 living in the United Kingdom from 1950 to 2000. The first graph represents the proportion of smokers in the population. The second graph represents the mortality rate (deaths per year per 100 000 people) from lung cancer.



[Source: Figure 1 (adapted) from R Petro, *et al.*, (2000), *British Medical Journal*, **321**, number 7257, pages 323–329, <https://www.bmj.com/content/321/7257/323>. Reproduced with permission from the BMJ Publishing Group.]

6a. Calculate the change in the percentage of the male population that smoked from 1950 to 2000.

[1 mark]

..... %

6b. Compare and contrast the trends in smoking behaviour between males and females between 1950 and 2000. [2 marks]

.....

.....

.....

6c. Evaluate the evidence provided by the data in the graphs for smoking as a cause of lung cancer. [3 marks]

.....

.....

.....

.....

.....

.....

The incidence of lung cancer in 75-year-old males was studied comparing current smokers, former smokers and non-smokers.

Smoking status in males aged 75 years		Sample size	Incidence of lung cancer	Percentage incidence / %
Former smokers	Current smokers	981	379	38.6
	< 10 years since stopping smoking	485	146	30.1
	10–19 years since stopping smoking	398	92	23.1
	20–29 years since stopping smoking	252	31	12.3
	≥ 30 years since stopping smoking	256	16	6.3
Lifelong non-smokers		403	3	0.7

[Source: adapted from R Peto, *et al.*, (2000), *British Medical Journal*, **321**, number 7257, pages 323–329]

6d. Describe the relationship between the incidence of lung cancer and stopping smoking. [2 marks]

.....

.....

.....

6e. Explain evidence from the data in the table that could be used to persuade a smoker to give up smoking. [2 marks]

.....

.....

.....

6f. Among 75-year-old lifelong non-smokers the percentage incidence of lung cancer was 0.01 %. Suggest **one** possible cause of lung cancer in non-smokers. [1 mark]

.....

.....

.....

6g. State **two** respiratory diseases, other than lung cancer, caused by smoking. [2 marks]

1. ....

2. ....

Boreal forests stretch across Canada, Russia and Scandinavia. This northern ecosystem accounts for 29 % of the world's forest areas. The long, cold winters favour tall evergreen trees with either needles or scale-like leaves. These trees are wind-pollinated and their seeds are not enclosed in a fruit. The photograph shows a typical boreal forest in winter.



[Source: TTphoto /Shutterstock]

7a. Identify the dominant plant phylum in the boreal forest. [1 mark]

.....

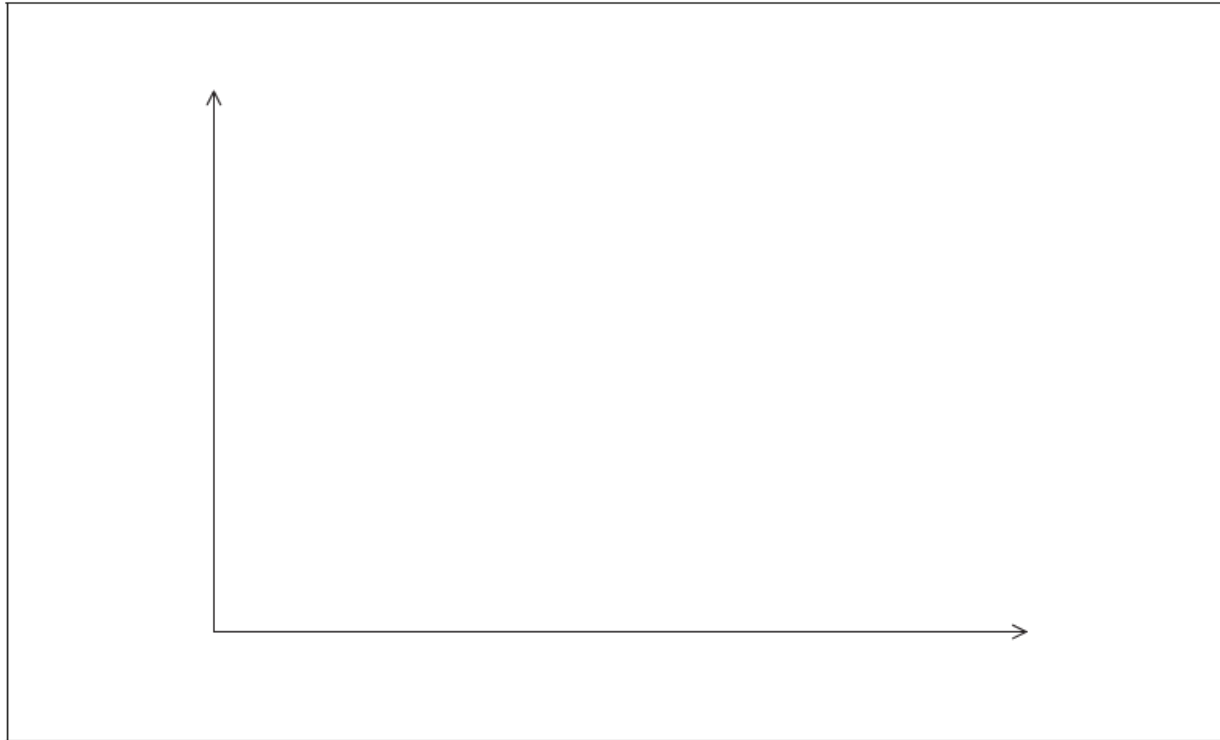
.....

.....

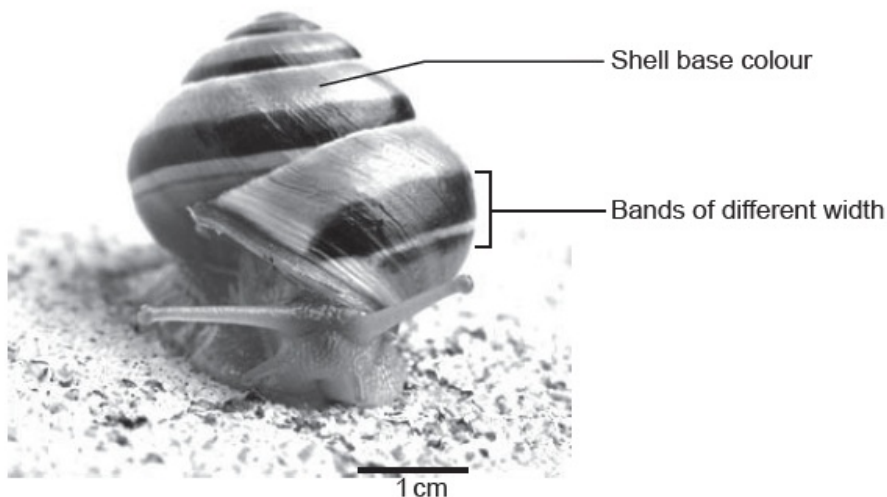
7b. In some areas there are gaps in the boreal forest where trees fail to grow and peat tends to accumulate. Suggest reasons for this. [2 marks]

7c. An increase in global temperatures poses a critical threat to boreal forests. Explain the consequences of climate change to this northern ecosystem. [2 marks]

- 7d. The boreal forests are situated close to the north pole and even in summer the intensity of sunlight is lower than at the equator. Sketch a graph showing the effect of light on the rate of photosynthesis, labelling the axes. [2 marks]



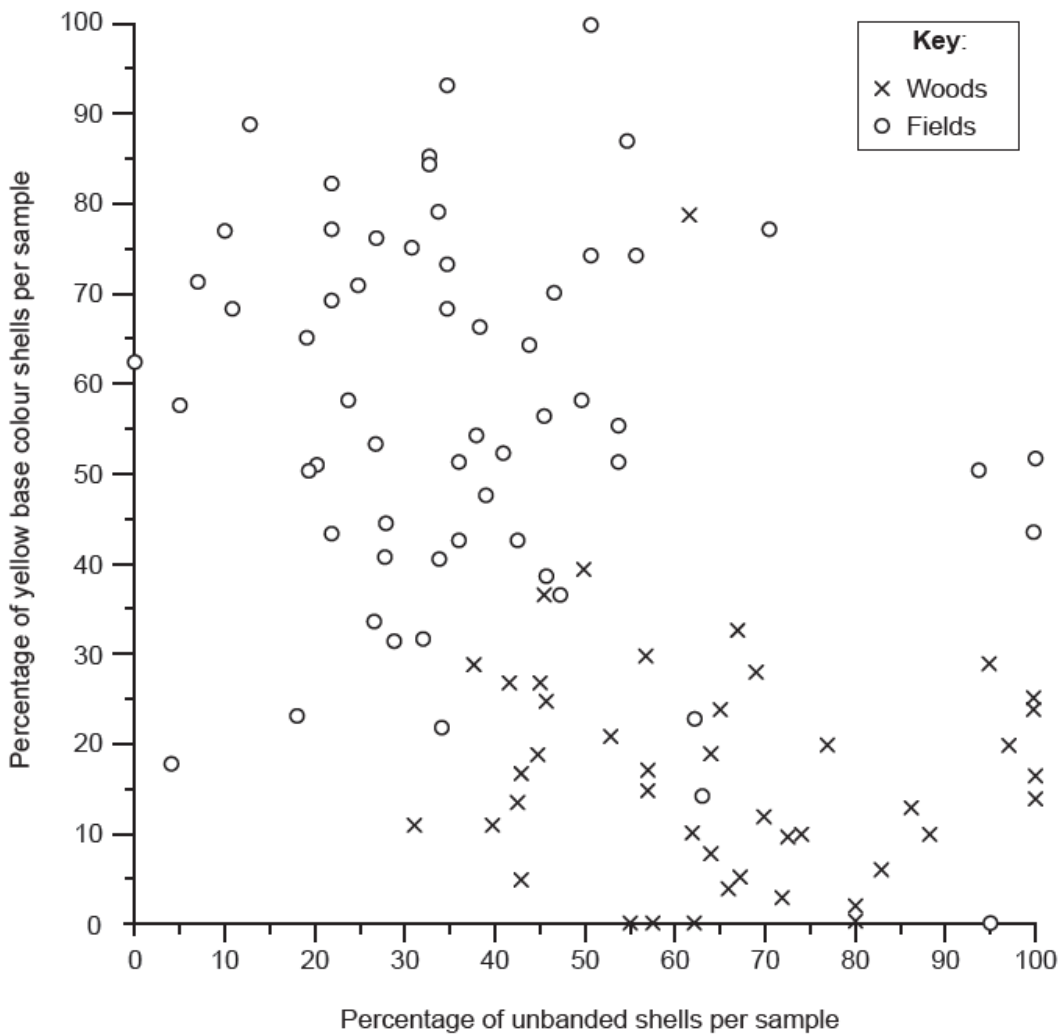
The land snail *Cepaea nemoralis* is very common in North America and in Europe. The base colour of its shell varies between brown, pink and yellow, and also in its intensity. Some shells are unbanded, but most show one to five bands of different width on top of the shell base colour.



[Source: © International Baccalaureate Organization 2018]

In the early 1950s, scientists studied the proportion of colours and banding of *C. nemoralis* in woods and fields near Oxford, UK, which differed in the type of plants and background colour. Each data point on the graph represents the percentage of yellow base colour shells and unbanded shells in a sample from either one type of wood or field, although other snail colours were present.





[Source: Adapted from Cain, A J and Sheppard, PM (1954), Natural Selection in *Cepaea*, *Genetics* 39 no. 1, p. 99.]

8a. Determine the maximum percentage of yellow base colour shells found in [1 mark] woods.

8b. Suggest **either one** possible advantage **or one** disadvantage of having a [1 mark] banded shell, stating whether it is an advantage or disadvantage.

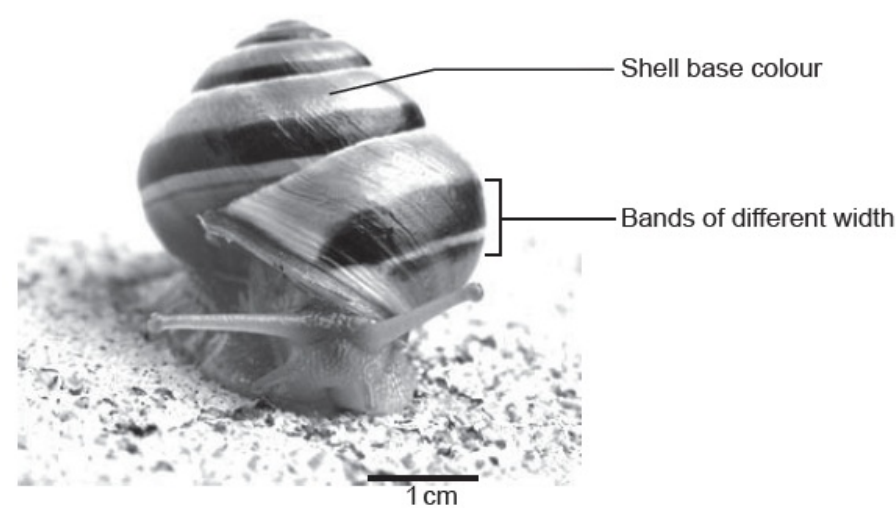
.....

.....

.....

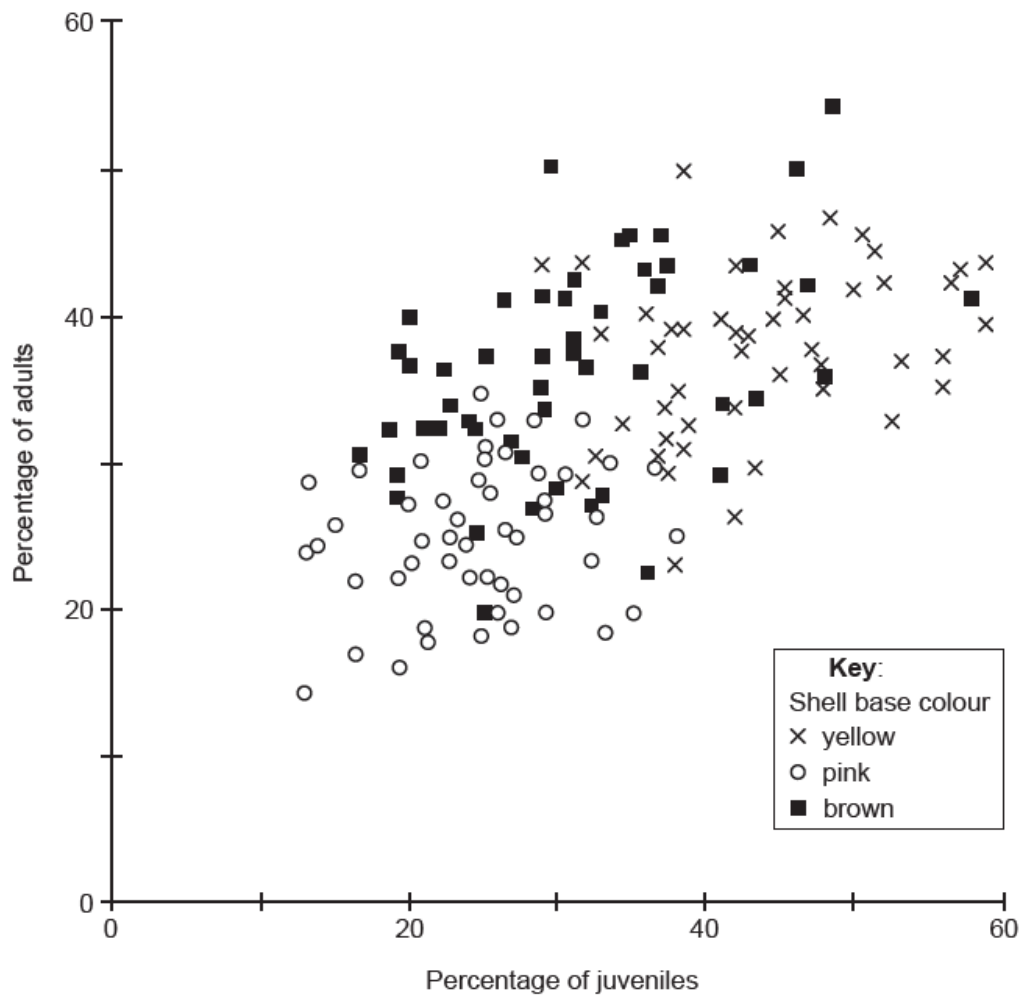
8c. Using the data in the graph, distinguish between the distribution of *C. nemoralis* shells in woods and fields. [2 marks]

The land snail *Cepaea nemoralis* is very common in North America and in Europe. The base colour of its shell varies between brown, pink and yellow, and also in its intensity. Some shells are unbanded, but most show one to five bands of different width on top of the shell base colour.



[Source: © International Baccalaureate Organization 2018]

The population of *C. nemoralis* has been studied for many years in open fields in a similar area. In the graph, each data point represents the percentage of adults of a given base colour plotted against the percentage of juveniles of the same base colour collected each year.



[Source: Adapted from Cain, A J, *et al.*, Population size and morph frequency in a long-term study of *Cepaea nemoralis* (1990), *Proceedings of the Royal Society B*, 240, page 239, DOI: 10.1098/rspb.1990.0036, <http://rspb.royalsocietypublishing.org/content/240/1298/231>; permission conveyed through Copyright Clearance Center, Inc.]

8d. Deduce from the data in the graph which shell base colours are on average most and least frequent among adult snails. [2 marks]

Most frequent:

Least frequent:

.....

.....

.....

8e. Discuss whether there is evidence in the data that colour plays a role in the survival of the snails. [3 marks]

.....

.....

.....

.....

.....

.....

8f. Using the theory of natural selection, explain the differences shown in the graph between the three colours of snail. [3 marks]

.....

.....

.....

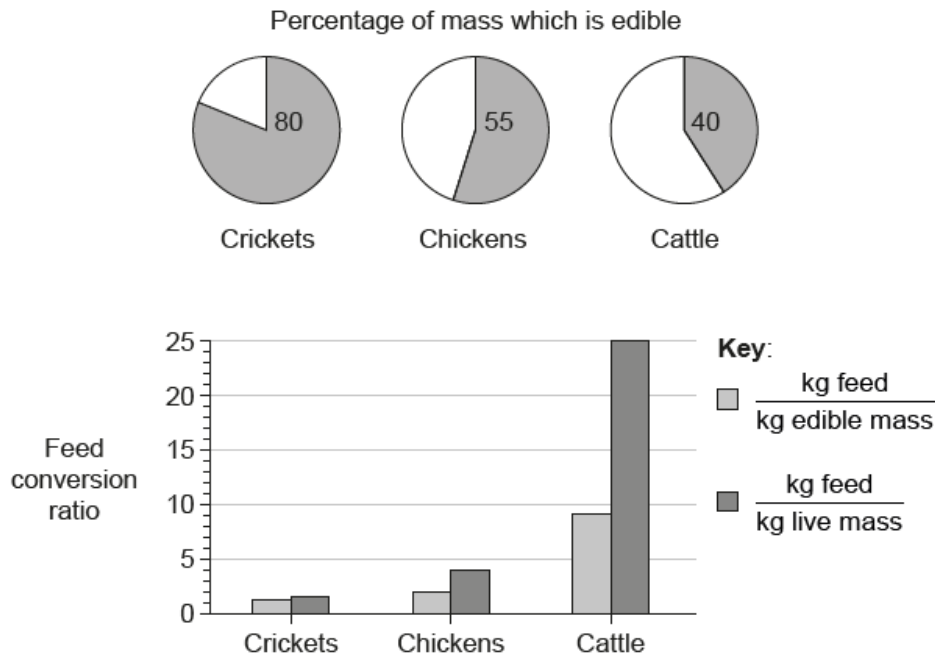
.....

.....

.....

Edible insects have been a part of traditional human diets in many countries. For example, crickets are insects commonly eaten in Asia and Africa. Many studies have looked at the prospects of raising insects on a commercial scale for direct human consumption as food or indirectly by feeding insects to farm animals.

One factor to consider is which organisms are most efficient at converting the feed they eat into animal protein that can be consumed. A study compared the percentage of mass that was edible in two common farm animals and in crickets.



[Source: Food and Agriculture Organization of the United Nations. 2013. van Huis, *et al.*, *Forestry Paper* 171, page 60. <http://www.fao.org/docrep/018/i3253e/i3253e00.htm>. Reproduced with permission.]

9a. Identify which organism has the highest percentage of edible mass. [1 mark]

.....

.....

.....

9b. Calculate how much more feed is required by cattle than chickens to produce 1 kg of live mass. [1 mark]

.....

.....

.....

9c. Identify which organism requires the least feed to produce 1 kg of edible [1 mark]  
mass.

.....

.....

.....

The yellow mealworm (*Tenebrio molitor*) is native to temperate regions of the world and has been studied as a possible means of producing food in countries with that type of climate. The amino acid content of yellow mealworms and cattle was analysed. The table shows the results for seven amino acids that are required in the human diet.

Amino acid	Yellow mealworms / g kg <sup>-1</sup> dry matter	Cattle / g kg <sup>-1</sup> dry matter
Isoleucine	25	16
Leucine	52	42
Lysine	27	45
Methionine	6	16
Phenylalanine	17	24
Threonine	20	25
Valine	29	20

[Source: Food and Agriculture Organization of the United Nations. 2013. van Huis, *et al.*, *Forestry Paper* 171, page 60.  
<http://www.fao.org/docrep/018/i3253e/i3253e00.htm>. Reproduced with permission.]

9d. Distinguish between the amino acid contents of yellow mealworms and [1 mark]  
cattle.

.....

.....

.....

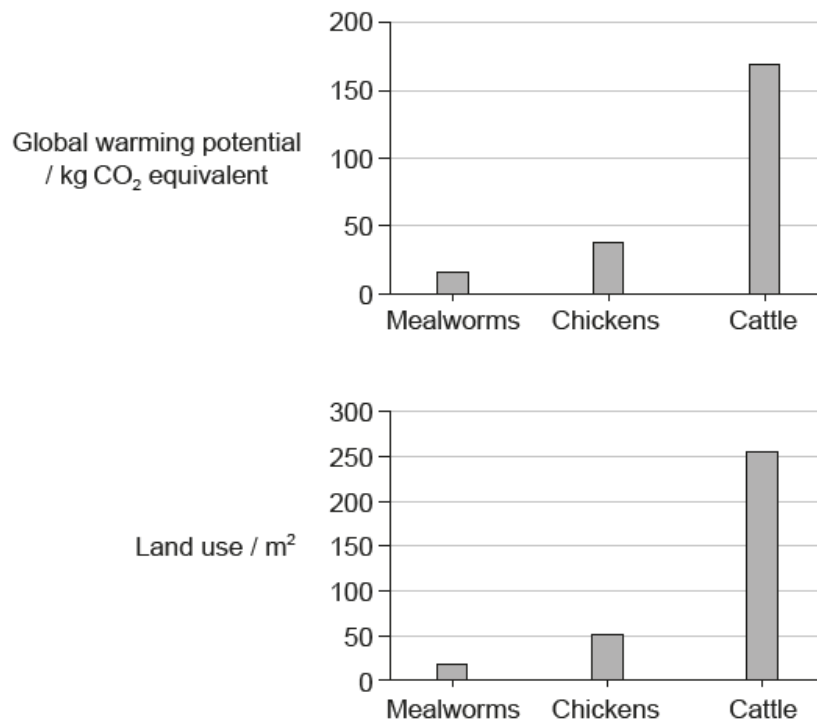
9e. Predict, with a reason, whether the amino acid composition of yellow [1 mark]  
mealworms **or** cattle is more suitable for a human diet.

.....

.....

.....

The environmental impact of producing protein from mealworms was compared with the impact of producing traditional protein sources. The graphs show the greenhouse gas production (global warming potential) and land use due to the production of 1 kg of protein from mealworms, chickens and cattle.



[Source: Food and Agriculture Organization of the United Nations. 2013. van Huis, *et al.*, *Forestry Paper* 171, page 60. <http://www.fao.org/docrep/018/i3253e/i3253e00.htm>. Reproduced with permission.]

- 9f. Outline the differences between the environmental impact of using mealworms and traditional farm livestock for protein production. [2 marks]

.....
.....
.....
.....
.....
.....

9g. Birds and mammals maintain constant body temperature despite considerable losses of body heat to the environment. In insects such as mealworms, body temperature is variable and is often the same as the temperature of the environment or only slightly above it. Analyse the data in the bar charts, using this information. [2 marks]

9h. Using all the relevant data in this question, discuss the use of insects as a major food source for humans. [3 marks]



Chronic Obstructive Pulmonary Disease (COPD) is characterized by progressive airflow limitation. Classification of COPD as mild, moderate or severe is based on measurement of Forced Expiratory Volume (FEV), which is the maximum volume of air that can be exhaled in one second.

The table shows the numbers of individuals in each COPD class and their mean FEV for a Swedish study of 349 people.

	Normal	Mild COPD	Moderate COPD	Severe COPD
Never smoked	96	12	6	0
Ex-smokers	95	29	19	3
Regular smokers	32	18	17	2
Occasional smokers	11	8	1	0
FEV / litres	$2.9 \pm 0.68$	$2.6 \pm 0.60$	$2.0 \pm 0.46$	$1.3 \pm 0.24$

[Source: Reproduced with permission of the © ERS 2012. European Respiratory Journal Apr 2012, 39 (4) 839–845; DOI: 10.1183/09031936.00064611]

10a. State the level of COPD that has the lowest FEV.

[1 mark]

.....
.....
.....

10b. Explain how a low FEV can be used to indicate emphysema.

[2 marks]

.....
.....
.....

The elasticity and resilience of the lungs are mainly provided by the protein elastin. Degradation of elastin produces peptides called desmosines.

Desmosines in urine or blood plasma have been proposed as biomarkers of lung degradation. The relationship between urine desmosines, plasma desmosines and COPD severity in patients was assessed.

Disease severity	Urine desmosines / nmol mmol <sup>-1</sup> of creatinine	Plasma desmosines / nmol L <sup>-1</sup>
	Median	Median
No disease	2.5 (1.3–5.7)	0.46 (0.16–1.4)
Mild COPD	2.6 (1.5–5.0)	0.49 (0.30–1.3)
Moderate COPD	2.9 (1.7–6.0)	0.55 (0.33–1.2)
Severe COPD	2.8 (2.0–4.1)	0.64 (0.47–1.1)

[Source: Reproduced with permission of the © ERS 2012. European Respiratory Journal Apr 2012, 39 (4) 839–845; DOI: 10.1183/09031936.00064611]

10c. State the disease severity group that has the highest range of plasma desmosines. *[1 mark]*

.....

.....

.....

10d. Evaluate which of the two biomarkers would be the most useful indicator of COPD severity. *[2 marks]*

.....

.....

.....

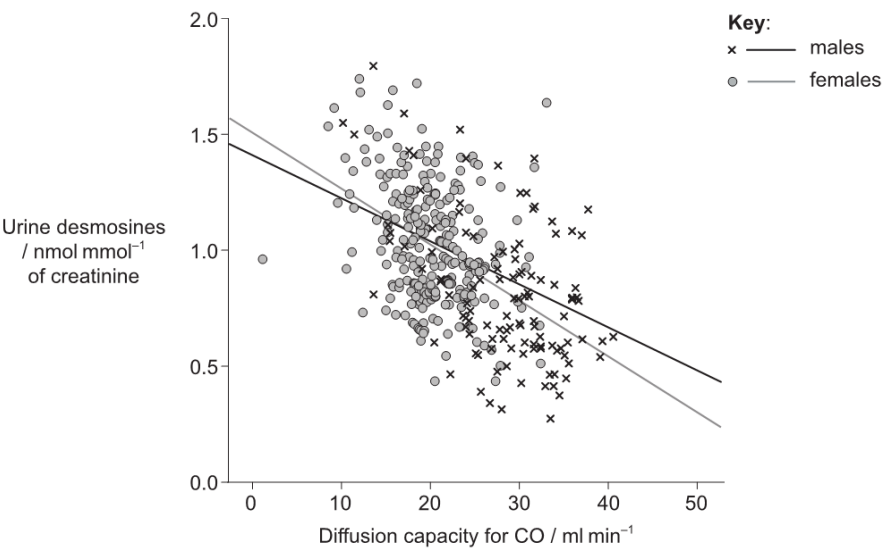
10e. Elastin is also an important component of other tissues such as arteries [2 marks] and ligaments. Evaluate how these other sources of elastin could affect the interpretation of the biomarker as an indicator of COPD.

.....

.....

.....

The graph shows the relationship between the diffusion capacity of the lungs for carbon monoxide (CO) and urine desmosines.



[Source: Reproduced with permission of the © ERS 2012. European Respiratory Journal Apr 2012, 39 (4) 839–845; DOI: 10.1183/09031936.00064611]

10f. State the relationship between diffusion capacity and urine desmosines. [1 mark]

.....

.....

.....

10g. Other studies on pulmonary diseases have shown a wide variety of results. Apart from age, sex and severity of COPD, list **two** other factors that may explain the inconsistent results between studies. [2 marks]

.....

.....

.....

10h. Discuss whether measurements of desmosine concentration would be useful for monitoring changes in the health of a patient. [3 marks]

.....

.....

.....

.....

.....

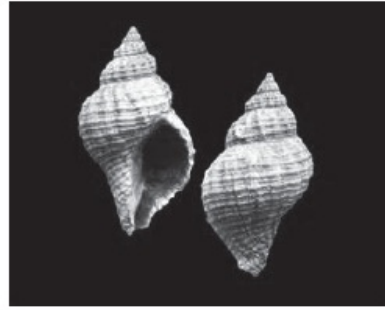
.....

Native oyster populations are decreasing where rivers meet the ocean along the northwest coast of North America. These oyster populations are being attacked by a gastropod.



Adult oyster, *Ostrea lurida*

[Source: © International Baccalaureate Organization  
2017]



Adult gastropod shell, *Urosalpinx cinerea*

[Source: © International Baccalaureate Organization  
2017]

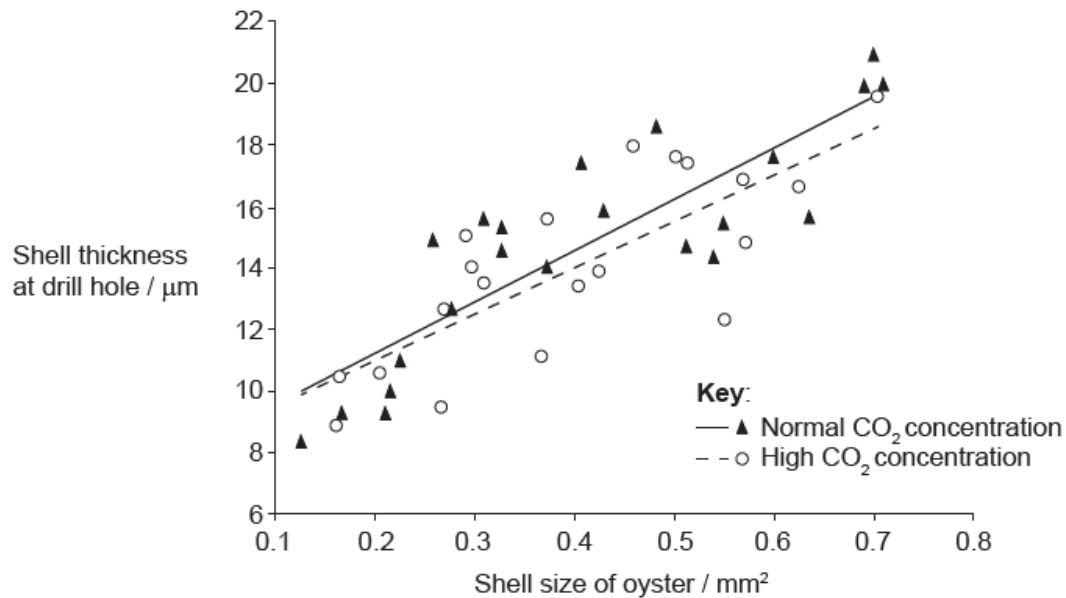
It is known that oysters and gastropods have hard parts composed of calcium carbonate and that ocean acidification is increasing. Studies were carried out using juvenile oysters and gastropods to investigate the effects of acidification on the decrease in the population of oysters.

The first step was to raise oysters in two different mesocosms. One had seawater at a normal concentration of  $\text{CO}_2$  and the other had sea water with a high concentration of  $\text{CO}_2$ . Gastropods were raised in two further mesocosms with normal and high  $\text{CO}_2$  concentrations respectively.

11a. Outline how acidified sea water could affect the shells of the oyster. [1 mark]

.....
.....
.....

A juvenile gastropod will attack a juvenile oyster by using its tongue-like structure (radula) to drill a hole through the oyster shell. Once the hole has been drilled, the gastropod sucks out the soft flesh. Researchers investigated the shell thickness at the site of the drill hole in relation to the size of the oyster. The results are seen in this graph.



[Source: E Sanford *et al.* (2014) *Proceedings of the Royal Society B*, 281, by permission of the Royal Society.]

11b. Outline the trends shown in the data in the graph.

[2 marks]

.....

.....

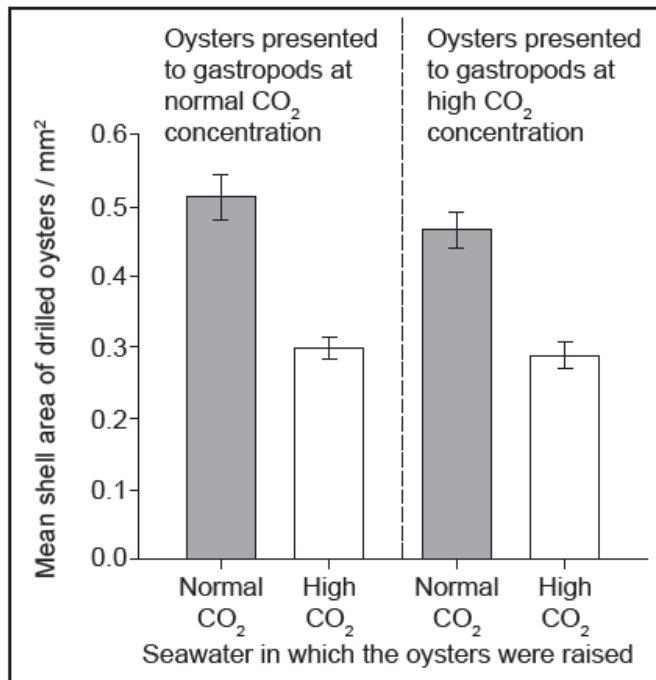
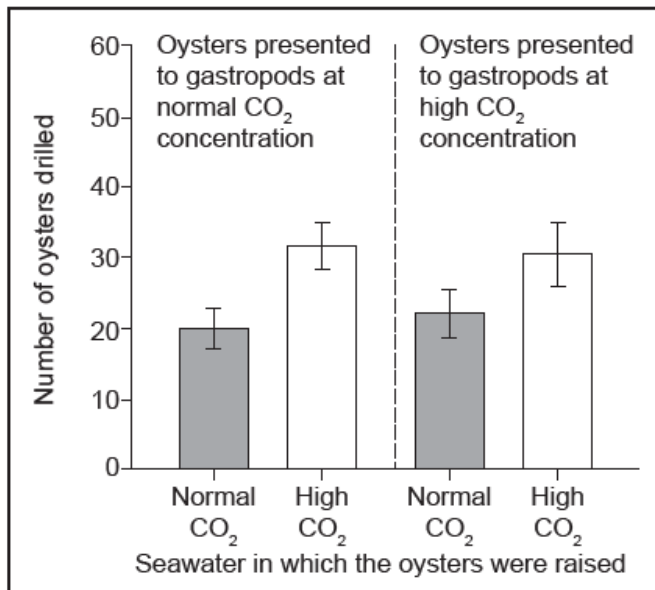
.....

.....

.....

.....

Equal numbers of oysters raised in seawater with a normal  $\text{CO}_2$  concentration and in seawater with a high  $\text{CO}_2$  concentration were then presented together to the gastropod predators in seawater with a normal  $\text{CO}_2$  concentration. The same numbers of oysters from the two groups were also presented together to the gastropods in seawater with a high  $\text{CO}_2$  concentration. The bar charts show how many of the oysters were drilled by the gastropods and the mean size of drilled oysters.



[Source: © International Baccalaureate Organization 2017]

11c. Estimate how much smaller drilled oysters raised in seawater at a high CO<sub>2</sub> concentration were than drilled oysters raised in seawater at a normal CO<sub>2</sub> concentration. [1 mark]

.....

.....

.....

11d. Deduce from the data in the bar charts which factors were and were not[2 marks] correlated significantly with the number of oysters drilled by the gastropods.

11e. Suggest reasons for the differences in the numbers of oysters drilled, as[2 marks] shown in the bar charts.



11f. The radula in a gastropod is hard but not made of calcium carbonate. [2 marks]  
Outline how this statement is supported by the drilling success of the gastropods in seawater with normal or high CO<sub>2</sub> concentrations.

11g. Using all the data, evaluate how CO<sub>2</sub> concentrations affect the development of oysters and their predation by gastropods. [2 marks]