SL Paper 2

a. The pumping of blood is a vital process. Explain the roles of the atria and ventricles in the pumping of blood. [4]

b. Explain how the structure of an artery allows it to carry out its function efficiently. [5]

c. Describe the inheritance of ABO blood groups. [9]

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a. Outline what is meant by homeostasis. [4]

b. Describe how body temperature is maintained in humans. [6]

c. Explain the need for a ventilation system and the mechanism of ventilation of the lungs in humans. [8]

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a. Define *pathogen*. [1]

b. Explain antibody production. [3]

c. Explain why antibiotics are effective against bacterial diseases but not against viral diseases. [2]

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a. All organisms take in and also release carbon compounds. Draw a labelled diagram of the carbon cycle. [5]

b. Describe how the rate of photosynthesis can be measured. [6]

c. Explain the mechanism of ventilation in humans. [7]

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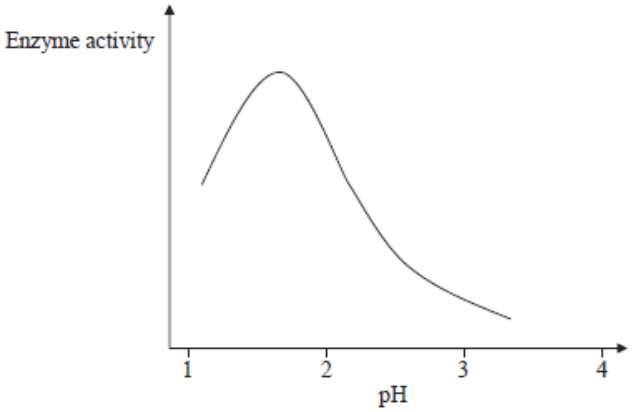
a. Draw a labelled diagram to show the human ventilation system. [4]

b. Outline anaerobic cell respiration in plant cells. [5]

c. Explain the concept of homeostasis, using the control of blood sugar as an example. [9]

Researchers extracted an enzyme from the human digestive system and tested its activity at different pH values on proteins extracted from the blood of cows. The results are shown in the graph below.



a. Deduce from where in the human digestive system this enzyme was extracted. [1]

b. Outline the need for enzymes in the digestive system. [2]

c. State **one** function of the large intestine. [1]

d. Explain how the structure of the villus is adapted for absorption. [3]

Distinguish between type I and type II diabetes.

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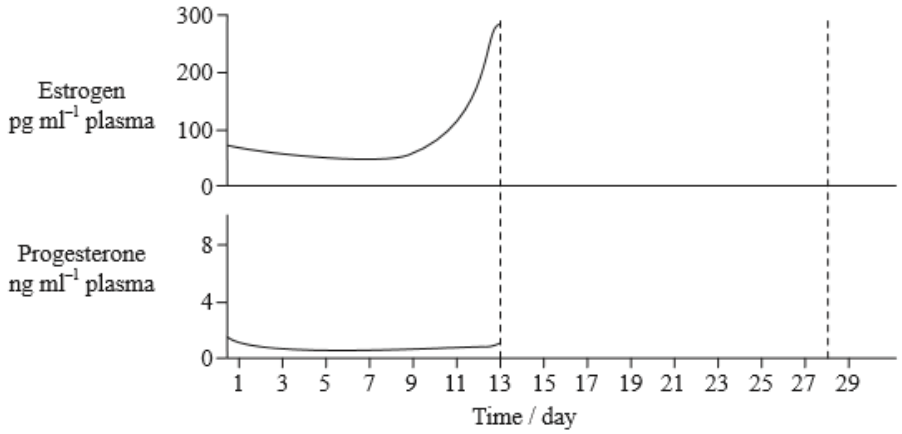
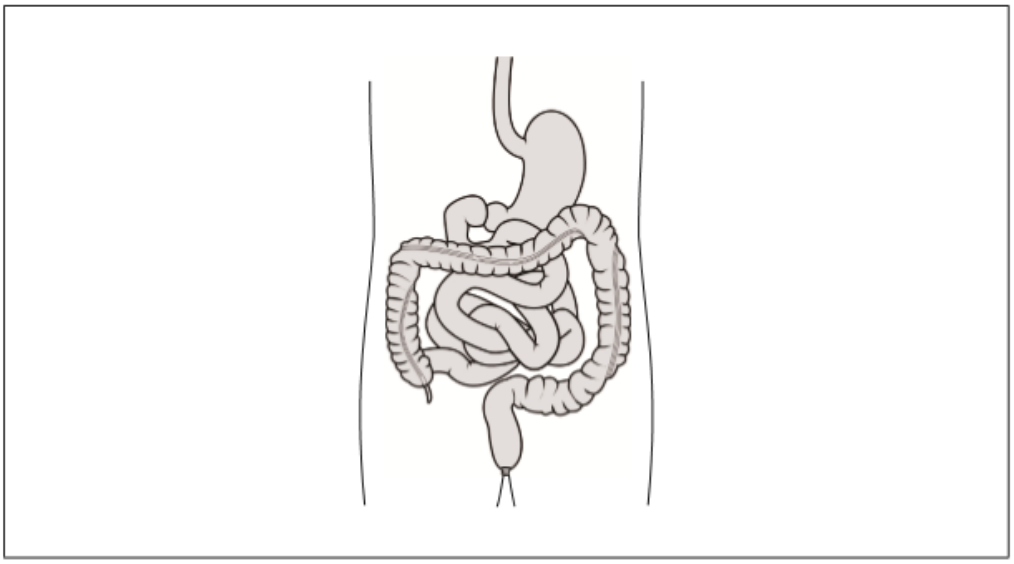
b. Describe the need for a ventilation system in humans. [2]

c. Sketch the hormone changes between days 13 and 28 on the graphs below for a woman in her normal menstrual cycle. [2]



[Source: adapted from www.mivf.com.au/ivf/infertility/images/cyclediagram.GIF]

The structure of part of the digestive system is shown in the diagram below.



[Source: http://commons.wikimedia.org/wiki/File:Intestinesall.svg
Created by Wikipedia user: Madhero88.]

a (i) Label the diagram to show the structure that is involved in digestion of proteins in acid conditions (using the letter A). [1]

a (ii) Label the diagram to show the structure where **most** absorption of water to prevent dehydration occurs (using the letter B). [1]

a (iii) Label the diagram to show the structure where **most** absorption of nutrients occurs (using the letter C). [1]

b (i) Explain how the structure of veins is adapted to their function. [2]

b (ii) Cells defend the body against pathogens. Outline how some of these cells ingest pathogens in the blood and in body tissues. [2]

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a. Draw a labelled diagram of the human heart showing the attached blood vessels. [6]

b. Describe the action of the heart in pumping blood. [5]

c. Nerves connecting the brain and heart contain neurons that control heart rate. Explain how a nerve message passes from one neuron to another neuron. [7]

Explain the propagation of electrical impulses along a neuron including the role of myelin.

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a. Distinguish between ventilation, gas exchange and cell respiration. [4]

b. Outline the process of aerobic respiration. [6]

c. Respiration and other processes in cells involve enzymes. Explain the factors that can affect enzymes. [8]

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a. State **four** molecules transported by the blood. [4]

b. Outline the control of the heartbeat. [6]

c. Discuss the cause, transmission and social implications of AIDS. [8]

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b. Describe the relationship between the structure and function of blood vessels. [6]

c. Explain the mechanisms involved in the ventilation of the lungs. [8]

The human circulatory system is structured to serve the organs and tissues of the body efficiently.

a. Outline the exchange of materials between capillaries and tissues. [3]

b. Explain the structures and functions of arteries and veins. [8]

c. Describe what happens in alveoli. [4]

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b. Outline the control of the heartbeat by the nervous and endocrine systems. [6]

c. Explain the principles of synaptic transmission. [8]

Blood transports molecules throughout the body. State where the blood absorbs oxygen.

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a. List **two** functions of membrane proteins. [2]

b. Explain why digestion of large food molecules is essential. [1]

c. Outline why antibiotics are effective against bacteria but not against viruses. [2]

d. Outline the use of polymerase chain reaction (PCR) to copy and amplify minute quantities of DNA. [2]

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a. State **one** disaccharide and the **two** monomers from which it can be synthesized. [2]

Disaccharide:

1:

Monomers:

1:

and 2:

b. Discuss the roles of the enzymes secreted by the pancreas during digestion. [3]

c. Compare and contrast cis-fatty acids and trans-fatty acids. [2]

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a. Outline the role of hydrolysis in the relationships between monosaccharides, disaccharides and polysaccharides. [4]

b. Describe the use of biotechnology in the production of lactose-free milk. [6]

c. Explain the importance of enzymes to human digestion. [8]

a. Describe the properties of water that make it a useful component of blood. [4]

b. Explain the relationship between structure and function of arteries, capillaries and veins. [8]

c. Outline how leucocytes defend the body against pathogens. [6]

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b. Ecologists sometimes display data from an ecosystem using a diagram called a pyramid of energy. Describe what is shown in pyramids of energy. [6]

c. Explain the control of body temperature in humans. [8]

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a. Draw a labelled diagram of the adult male reproductive system. [5]

b. Describe the role of sex chromosomes in the control of gender and inheritance of hemophilia. [7]

c. Discuss the ethical issues associated with IVF. [6]

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a. State the source, substrate, products and optimal pH condition for lipase in the human digestive system. [4]

b. Outline the use of **named** enzymes in gene transfer using plasmids. [6]

c. Explain the effect of changes of pH, substrate concentration and temperature on enzyme activity. [8]

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a. Draw a labelled diagram to show the molecular structure of a membrane. [4]

b. Some proteins in membranes act as enzymes. Outline enzyme-substrate specificity. [6]

c. Membranes of pre-synaptic and post-synaptic neurons play an important role in transmission of nerve impulses. Explain the principles of synaptic transmission. [8]

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a. Plants are a diverse group of eukaryotic organisms. Describe the different characteristics of the bryophyta, filicinophyta, coniferophyta and angiospermophyta. [9]

b. Plants store carbohydrate in the form of starch. Explain the reasons for starch being digested by the human digestive system. [4]

c. Compare the structure of prokaryotic and eukaryotic cells. [5]

James Beard, a famous chef, once said “Food is our common ground, a universal experience.”

a. Explain how the small intestine moves, digests and absorbs food. [8]

b. Distinguish between the structures of the different types of fatty acids in food. [4]

c. Outline how leptin controls appetite. [3]

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a. Draw a molecular diagram of an amino acid to show its general structure. [3]

b. Outline the role of ribosomes in translation. [4]

c. Some blood proteins are involved in defence against infectious disease. Explain the roles of **named** types of blood proteins in different defence mechanisms. [8]

Reproduction in eukaryotes can be sexual or asexual.

a. Describe the origin of eukaryotic cells according to the endosymbiotic theory. [4]

b. Explain how hormones are used to control the human menstrual cycle. [8]

c. Outline natural methods of cloning in some eukaryotes. [3]

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a. Outline, with examples, the types of carbohydrate found in living organisms. [4]

b. Describe the importance of hydrolysis in digestion. [6]

c. Explain the flow of energy between trophic levels in ecosystems. [8]

a. Draw a labelled diagram of a prokaryotic cell. [5]

b. Bacteria are prokaryotes that sometimes act as pathogens. Describe how the body can defend itself against pathogens. [7]

c. Explain the evolution of antibiotic resistance in bacteria. [6]

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a. Outline the role of condensation and hydrolysis in metabolic reactions involving carbohydrates. [4]

b. Metabolic reactions are catalysed by enzymes. Explain how enzymes catalyse reactions and how a change in pH could affect this. [8]

c. Describe the digestion of food in the human digestive system. [6]

Outline how nerve impulses are transmitted along a nerve fibre.

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a. Draw a labelled diagram to show the structure of a membrane. [5]

b. Outline how vesicles are used to transport materials secreted by a cell. [6]

c. Explain how the structure of a villus in the small intestine is related to its function. [7]

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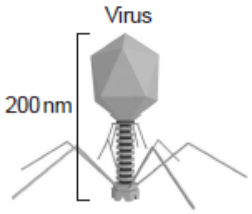
a. State the functions of the following organelles of a eukaryotic animal cell: lysosome, Golgi apparatus, free ribosomes, plasma membrane, rough endoplasmic reticulum. [5]

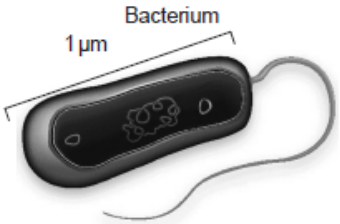
b. Distinguish between anaerobic and aerobic cell respiration in eukaryotes. [4]

c. Explain the mechanism of ventilation in the lungs in order to promote gas exchange for cell respiration. [9]

The diagrams show a virus and a bacterium.



[Source: adapted from http://cronodon.com]



[Source: adapted from www.microbiologyonline.org.uk]

a. Calculate the magnification of the bacterium. [1]

b. State the method that bacteria use to divide. [1]

c. Outline the effectiveness of antibiotics against viruses and bacteria. [1]

d(i) Saprotrophic organisms, such as *Mucor* species, are abundant in soils. [1]

Define *saprotrophic organisms*.

d(ii) State **one** role of saprotrophic organisms in the ecosystem. [1]

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a. Draw a labelled diagram showing the **interconnections** between the liver, gall bladder, pancreas and small intestine. [2]

b. Outline the role of glucagon in homeostasis of glucose. [2]

c. List **two** examples of polysaccharides. [1]

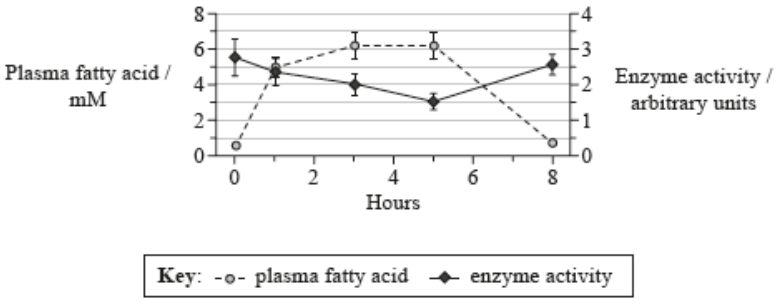
a. Compare simple diffusion with facilitated diffusion as mechanisms to transport solutes across membranes. [5]

b. Describe the process of endocytosis. [5]

c. Explain how an impulse passes along the membrane of a neuron. [8]

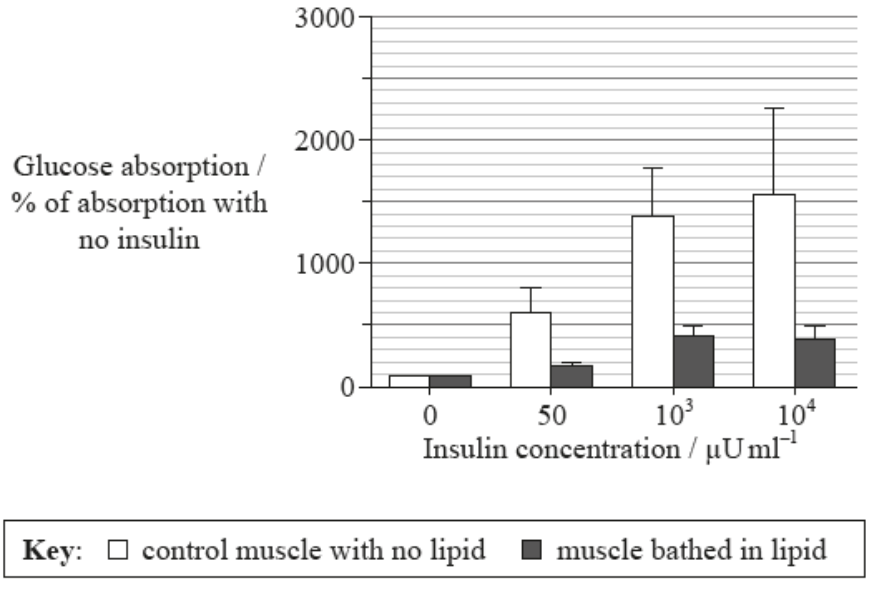
Skeletal muscle fibres normally respond to insulin by absorbing glucose. Failure of skeletal muscle to respond to insulin is a major factor in the development of type II diabetes.

A study was undertaken to investigate the effect of plasma lipids on the process of glucose absorption in response to insulin by muscle fibers. Muscle was bathed in a lipid solution for 5 hours. The lipid was then washed out over the next 3 hours. The graph shows the level of plasma fatty acids and the activity of an enzyme involved in glucose absorption in response to insulin over the period of the study. (Values are means ± standard error)



[Source: Chunli Yu, *et al.* (2002), *The Journal of Biological Chemistry*, **277**, pages 50 230–50 236]

A further study was undertaken to look at the effect of increasing the concentration of insulin on glucose absorption in muscle bathed in lipids. A wide range of insulin concentrations were used in the same type of muscle. Glucose absorption was then measured after 5 hours.



[Source: Chunli Yu, *et al.* (2002), *The Journal of Biological Chemistry*, **277**, pages 50 230–50 236]

a. Distinguish between type I and type II diabetes. [2]

b. State the relationship between plasma fatty acid level and enzyme activity. [1]

c. Calculate the percentage change of enzyme activity after 5 hours exposure to lipids. [1]

d. Discuss, using the data, whether the effect of lipids on this enzyme is reversible. [2]

e. Calculate the increase in glucose absorption when insulin is increased from 0 to 10^3 μU ml^{-1} for the muscle bathed in lipid. [1]

_____% of absorption with no insulin

f. Comment on the effect of increased insulin concentration on glucose absorption in the muscle bathed in lipid. [2]

g. Some investigators suggest that there is a strong relationship between high lipid diet and the body's response to insulin. Using the data provided, evaluate this hypothesis. [2]

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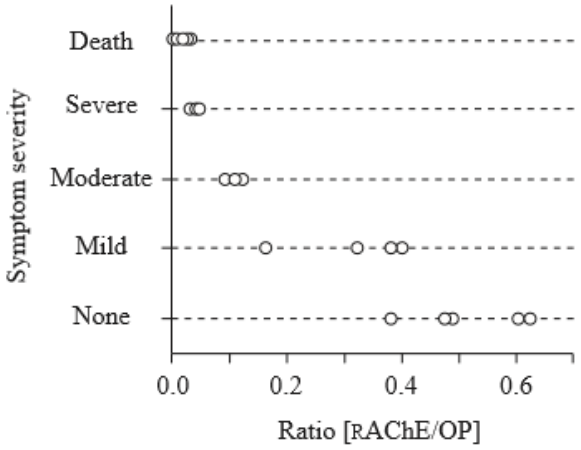
a. Reproduction can cause populations to increase rapidly. Draw a labelled graph showing a sigmoid population growth curve. [4]

b. Explain the various possible consequences of overproduction of offspring. [6]

c. Outline the role of hormones in the menstrual cycle. [8]

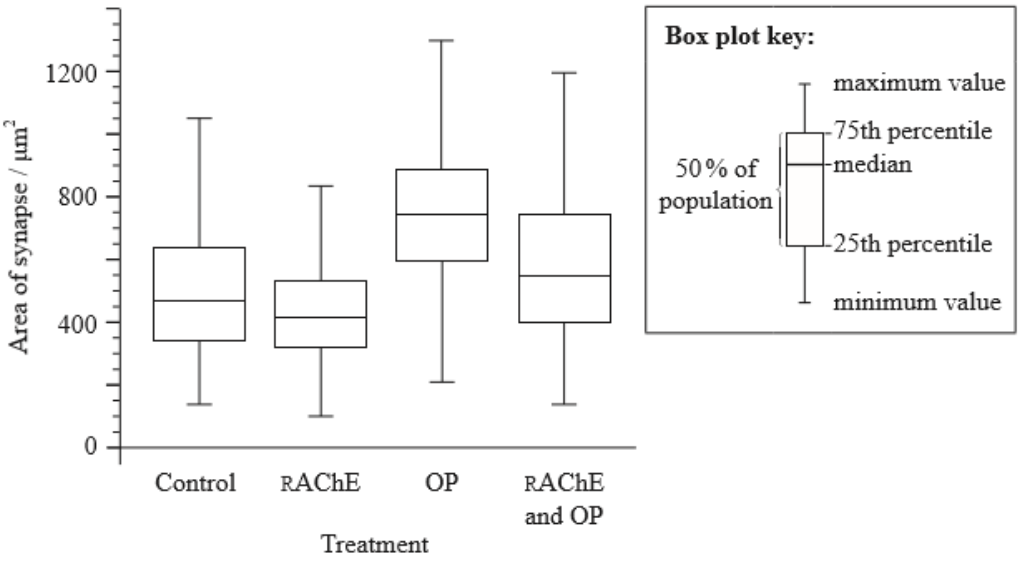
Exposure to organophosphorus pesticides (OP) is a cause of serious nerve damage. It disrupts synaptic transmission by inhibiting the enzyme acetylcholinesterase, causing death due to cardiovascular and respiratory failure.

Recombinant human acetylcholinesterase (rAChE) was obtained by genetic engineering and produced in *Nicotiana benthamiana* plants. It was tested as a new therapeutic treatment in mice that were exposed to OP. The following graph shows the severity of the symptoms shown by each mouse at different ratios of rAChE to OP.



[Source: T. Evron *et al.* (2007), "Plant-derived human acetylcholinesterase-R provides protection from lethal organophosphate poisoning and its chronic aftermath", *FASEB Journal*, 21 (11), pages 2961–2969: Figure 4a. Reprinted with permission.]

To test the effect of OP damage on synapses, mice were treated with rAChE, OP or both. Their diaphragms were dissected 10 days after treatment. The area of the synapse between axons and the diaphragm was measured. When the synapses are damaged by OP there is a greater area. The box plot shows the effect of different treatments on the area of the synapse.



[Source: Tama Evron, Brian C. Geyer, Irene Cherni, Mrinalini Muralidharan, Jacquelyn Kilbourne, Samuel P. Fletcher, Hermona Soreq and Tsafrir S. Mor (2007), "Plant-derived human acetylcholinesterase-R provides protection from lethal organophosphate poisoning and its chronic aftermath", *FASEB Journal*, 21 (11), pages 2961–2969: Figure 5b. Reprinted with permission.]

a. State the minimum ratio at which some mice showed no symptoms. [1]

b. Analyse the effect of increasing the ratio of rAChE to OP on the symptoms in mice. [3]

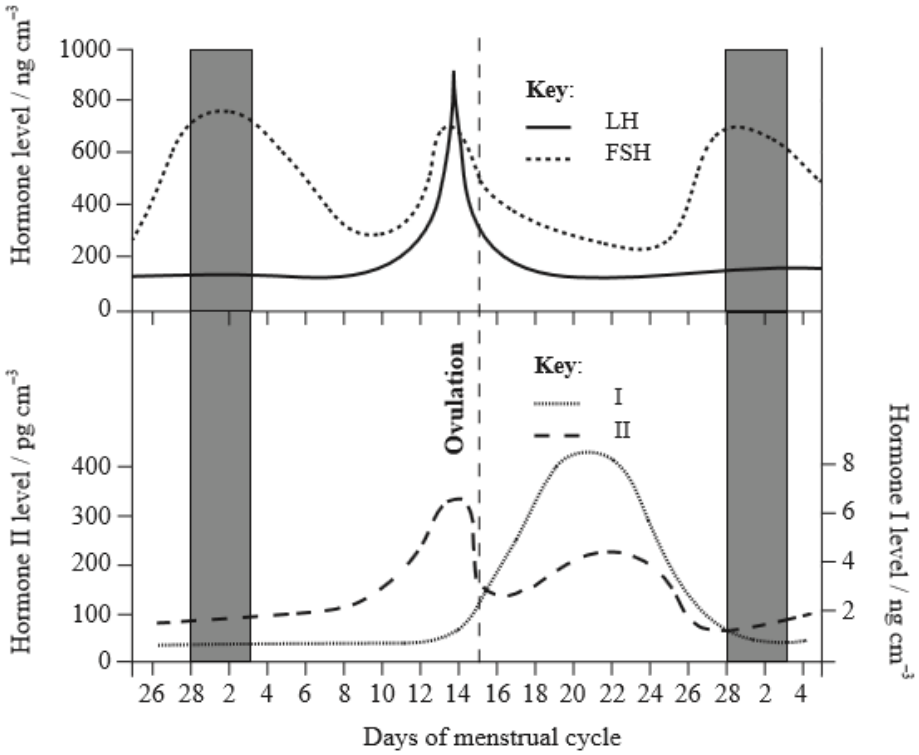
c. Predict what would happen if a mouse received 300 mg of rAChE and 600 mg of OP. [2]

d. Calculate the difference in median area of synapse between the control mice and mice treated with rAChE and OP, giving the units. [1]

e. Describe the evidence for damage to synapses by OP provided by data in the box plot. [2]

f. Using the data from **both** graphs, evaluate the hypothesis that plant-produced rAChE could be used to protect humans or other mammals from damage caused by exposure to OP. [2]

The graph below shows the levels of hormones during the menstrual cycle.



a. Identify hormones I and II. [2]

I: .....

II: .....

b. Outline the roles of FSH in the menstrual cycle. [2]

c. FSH is secreted by the pituitary gland. During pregnancy, FSH secretion is inhibited. Suggest how FSH secretion could be inhibited during pregnancy. [1]

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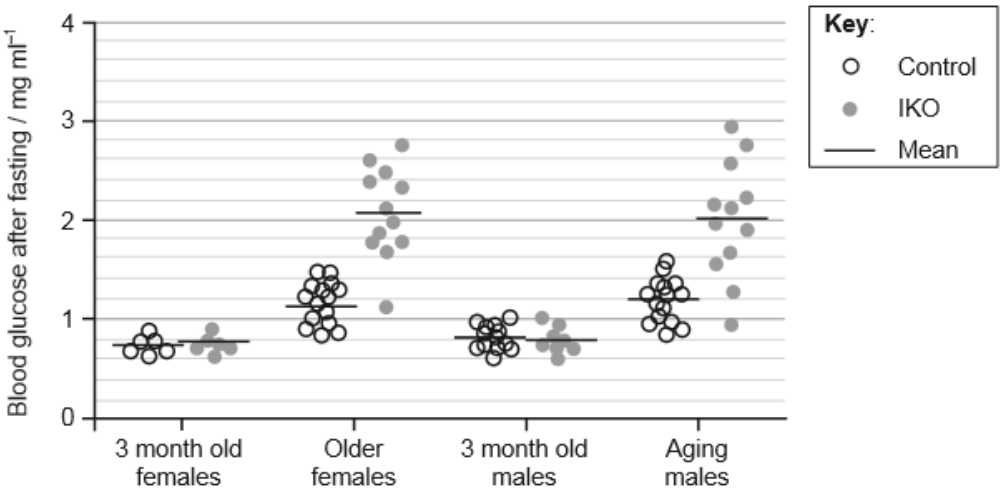
a. Draw a labelled diagram of a motor neuron. [5]

b. Explain how an impulse passes along the membrane of a neuron. [8]

c. Describe the process of endocytosis. [5]

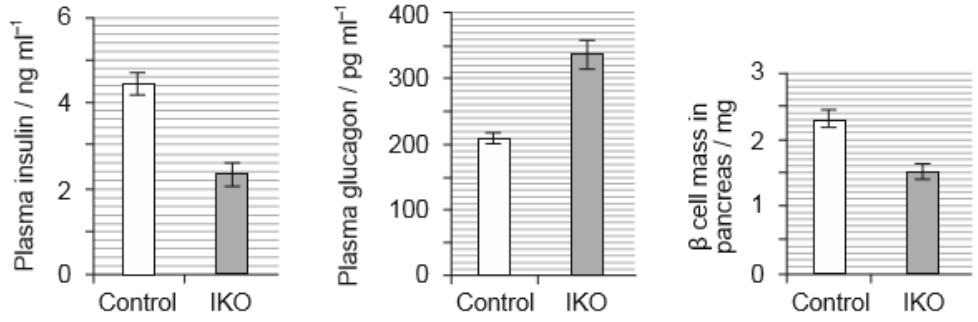
Diabetes is often associated with the failure of the β (beta) cells in the pancreas, but it is unclear what actually causes this failure. FoxO1 is a protein which acts as a transcription factor to regulate the expression of genes involved in cell growth. FoxO1 also regulates increase in number and differentiation in cells such as pancreatic β cells.

A study was conducted using mice lacking the gene for FoxO1 in β cells (IKO) as well as normal (control) mice. Blood glucose levels after fasting were compared for four groups of mice: young (3 months old) male mice, young (3 months old) female mice, older females (who have had several pregnancies) and aging males (16–20 months).



[Source: Chutima Talchai, Shouhong Xuan, Hua V. Lin, Lori Sussel, Domenico Accili, "Pancreatic β Cell Dedifferentiation as a Mechanism of Diabetic β Cell Failure", *Cell*, Volume 150, Issue 6, 14 September 2012, Pages 1223–1234.]

The levels of pancreatic hormones and β cell mass in older female control mice and older female IKO mice lacking FoxO1 were then investigated.



[Source: Chutima Talchai, Shouhong Xuan, Hua V. Lin, Lori Sussel, Domenico Accili, "Pancreatic β Cell Dedifferentiation as a Mechanism of Diabetic β Cell Failure", *Cell*, Volume 150, Issue 6, 14 September 2012, Pages 1223–1234]

a. Compare blood glucose levels after fasting in young control mice and young IKO mice without FoxO1. [2]

b (i) Estimate the difference between mean blood glucose levels in control and IKO older female mice. [1]

.....mg ml^{-1}

b (ii) Aging and having pregnancies are considered to be physiological stresses. Deduce the effect of stress on blood glucose levels. [2]

c. Outline the relationship between blood glucose levels after fasting and lack of FoxO1 in the mice studied. [2]

d. Calculate the percentage difference in β cell mass of the IKO mice compared to the control mice. [2]

e. State the correlation between lack of FoxO1 and pancreatic hormones in mice. [1]

f. Referring to the functions of insulin and glucagon, suggest how the differences in hormone levels help to explain the blood glucose levels. [3]

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 ± 0.68	2.6 ± 0.60	2.0 ± 0.46	1.3 ± 0.24

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

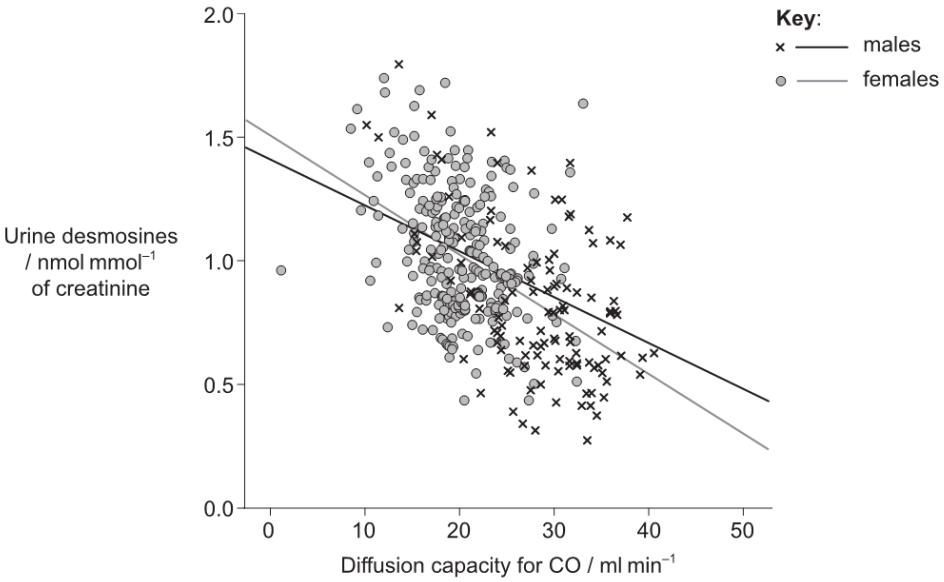
The elasticity and resilience of the lungs are mainly provided by the protein elastin. Degradation of elastin produces peptides called desmosines.

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.

	Urine desmosines / nmol $mmol^{-1}$ of creatinine	Plasma desmosines / nmol L^{-1}
	Median	Median
Disease severity		
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]

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]

a. State the level of COPD that has the lowest FEV. [1]

b. Explain how a low FEV can be used to indicate emphysema. [2]

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

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

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

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

g. 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]

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

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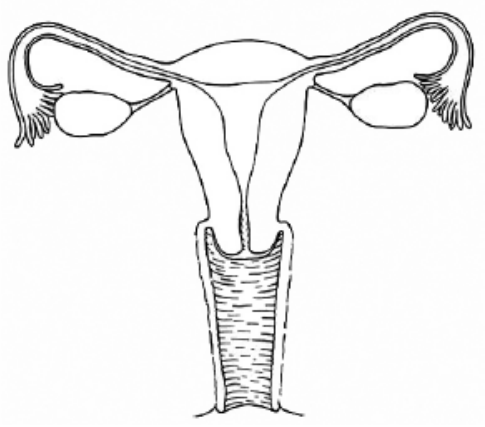
a. The diagram below shows the female reproductive system. [1]



Label the diagram above with the letter U to show the uterus.

b. Outline the role of luteinizing hormone (LH) **after** ovulation. [1]

c. Explain how sexual reproduction can lead to variation in a species. [3]

Male Lepidoptera (butterflies and moths) commonly drink from pools of water or from moist soil. This behaviour, called puddling, was investigated in an undisturbed area where male tiger swallowtails, *Papilio glaucus*, had been seen puddling.

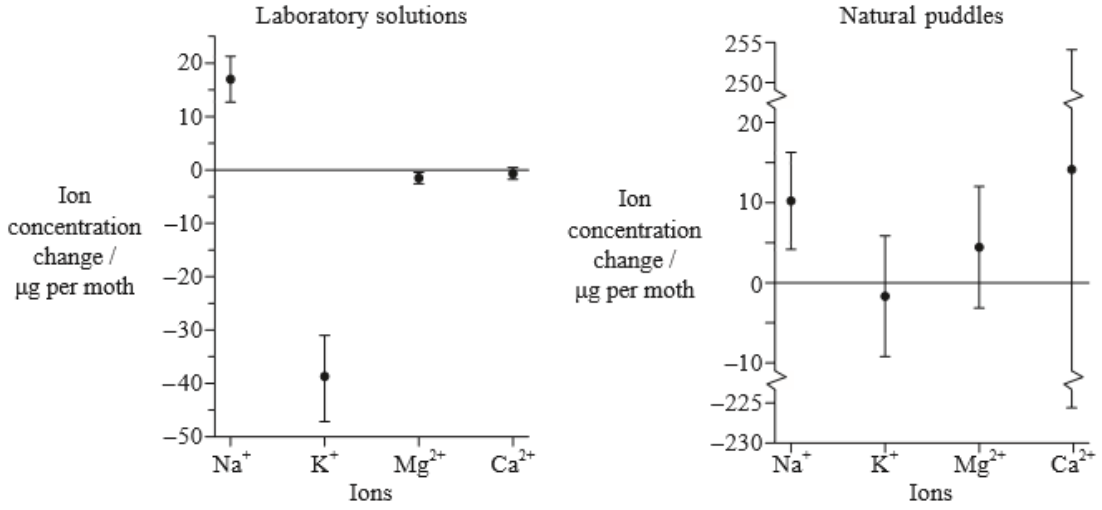
Four successive sets of experiments were performed under similar conditions of temperature and humidity. In each set, equal samples of sand were spread out evenly on trays and then treated differently. Except for one dry sample (in the first set), all others were saturated with a different liquid. Results of the observations are given in the table below.

Numbers of visits (V) and time in minutes (T) spent puddling by male *Papilio glaucus* adults on sand treated in different ways.

Experiments	Visits and times on sand plus substance:									
	V	T	V	T	V	T	V	T	V	T
1	*Dry sand alone*		*Distilled H_2O*		*Casein hydrolyzate*		*5% Sucrose*		*NaCl (0.17 M)*	
	26	0	47	0.5	27	205.5	60	0.5	74	320.5
2	*KCl (0.1 M)*		*$MgCl_2$ (0.1 M)*		*$CaCl_2$ (0.1 M)*		*Na_3PO_4 (0.1 M)*		*NaCl (0.1 M)*	
	33	0	36	0	48	1.5	43	79.5	65	362.0
3	*NH_4Cl (0.1 M)*		*KNO_3 (0.1 M)*		*K_3PO_4 (0.1 M)*		*Na_3PO_4 (0.1 M)*		*$NaNO_3$ (0.1 M)*	
	9	0	6	0	6	0	3	0.5	86	279.5
4	*Distilled H_2O*		*NaCl (10^{-5} M)*		*NaCl (10^{-4} M)*		*NaCl (10^{-3} M)*		*NaCl (10^{-2} M)*	
	2	0	7	1.5	16	27.5	32	172.5	22	195.5

[Source: adapted from K Arms, *et al.*, (1974), *Science*, **185**, pages 372–374]

Study of the male moth *Gluphisia septentrionis* revealed that their puddling behaviour can last for hours. Though drinking results in the uptake of hundreds of gut-loads of fluid, this fluid becomes rapidly expelled from the digestive system through frequent anal ejections. In this experiment, the ion concentration change was calculated by subtracting ions ejected from ions taken in. The following data was collected from males drinking laboratory solutions and from natural puddles.



[Source: adapted from SR Smedley and T Eisner, (1995), *Science*, **270**, pages 1816–1818]

a. Identify the dissolved element always present in the three samples with most puddling time. [1]

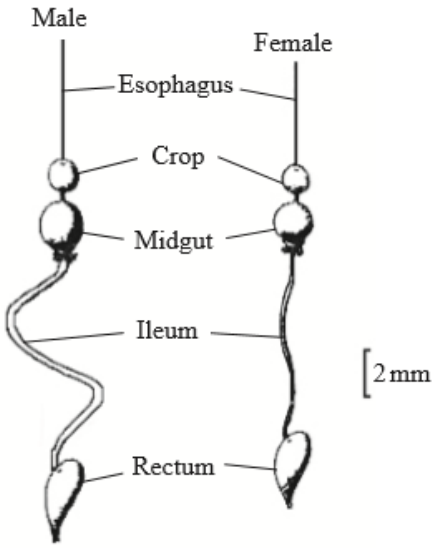
b. Discuss the relationship between sampling visits (V) and puddling time (T) in experiments 1, 2 and 3. [2]

c. Analyse the results for experiment 4. [2]

d (i). Identify which ion the moths are retaining in their body from the laboratory solutions. [1]

d (ii). Compare the gain and loss of ions in the male moths which have drunk from laboratory solutions with the changes in those that have drunk from natural puddles. [3]

e. The diagram below shows the digestive system anatomy of the male and female moth. [2]



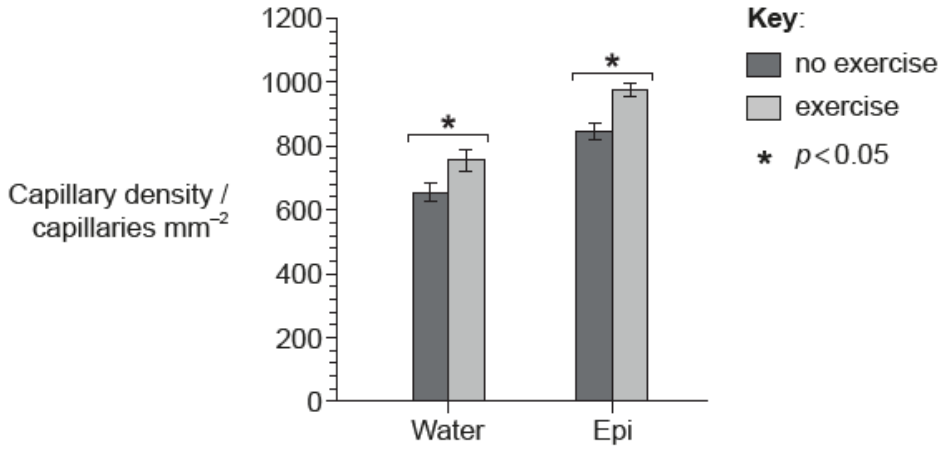
[Source: adapted from S R Smedley and T Eisner, (1995), *Science*, **270**, pages 1816–1818]

Using the diagram above, evaluate the hypothesis that male moths are better adapted than female moths to benefit from puddling behaviour.

Consumption of dark chocolate has been shown to have health benefits. A study was undertaken to see the effects of epicatechin (Epi), a substance in dark chocolate, on the aerobic capacity of leg muscles of mice.

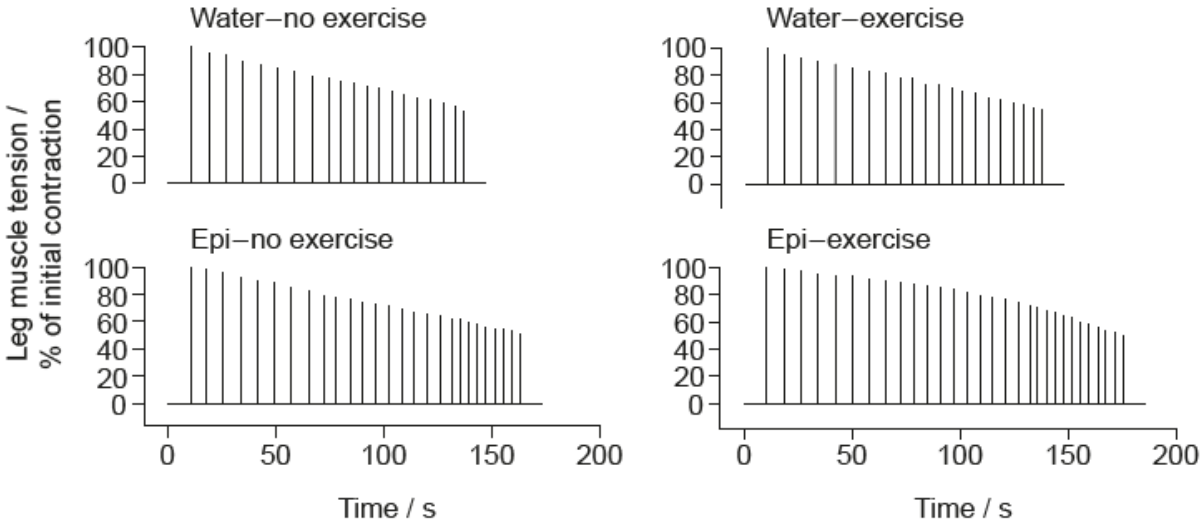
A group of adult mice was used to measure the effects of a low dose of Epi given over 15 days. The mice were divided into four groups and given either water or Epi and were either kept idle (no exercise) or made to exercise on a treadmill.

After 15 days, the results were analysed. The blood capillary density in leg muscle was measured under the light microscope.



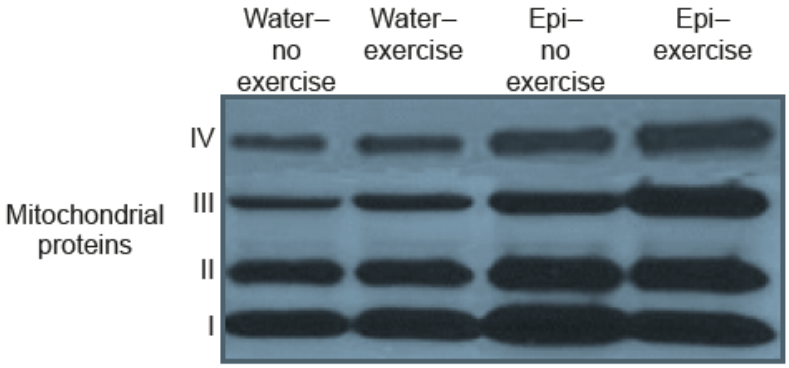
[Source: adapted from L Nogueira, *et al.*, (2011), *The Journal of Physiology*, **589** (part 18), Wiley, pages 4615–4631]

Leg muscle tension was measured over time during a treadmill exercise in all four groups. The muscle is considered to reach a point of fatigue when there is a decrease in tension to 50 % of the initial tension.



[Source: adapted from L Nogueira, *et al*., (2011), *The Journal of Physiology*, **589** (part 18), Wiley, pages 4615–4631]

The scientists tested the expression of four different mitochondrial proteins. The protein samples were taken from leg muscles. The technique that was used to quantify the amount of protein expressed was Western blotting. In this procedure the thickness of the band is an indicator of the amount of protein.



[Source: adapted from L Nogueira, *et al*., (2011), *The Journal of Physiology*, **589** (part 18), Wiley, pages 4615–4631]

a.i. State the significance of the statement: $p<0.05$. [1]

a.ii. Outline the trends in capillary density in the results of this experiment. [2]

b. Describe how increased capillary density could affect the aerobic capacity of muscle. [2]

c.i. State the time when the point of fatigue occurred in the Epi–exercise group. [1]

c.ii. Compare and contrast the results for the water–no exercise group and the Epi–no exercise group. [3]

d. Discuss the effect of exercise on the results of the experiment. [2]

e. Analyse the effect of exercise on the presence of the mitochondrial proteins in the leg muscle. [2]

f. Mitochondria are essential for aerobic respiration. Suggest **one** possible role of the proteins that were studied. [1]

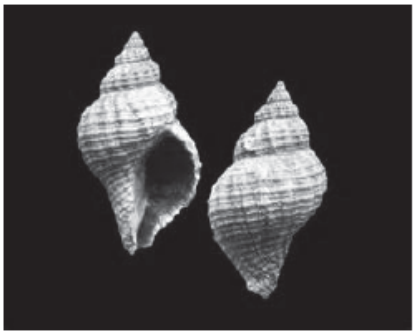
g. The scientists concluded that Epi significantly increased aerobic capacity in leg muscle. [3]

Evaluate the strength of the evidence provided by all of the data for dark chocolate improving the aerobic capacity of athletes.

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]



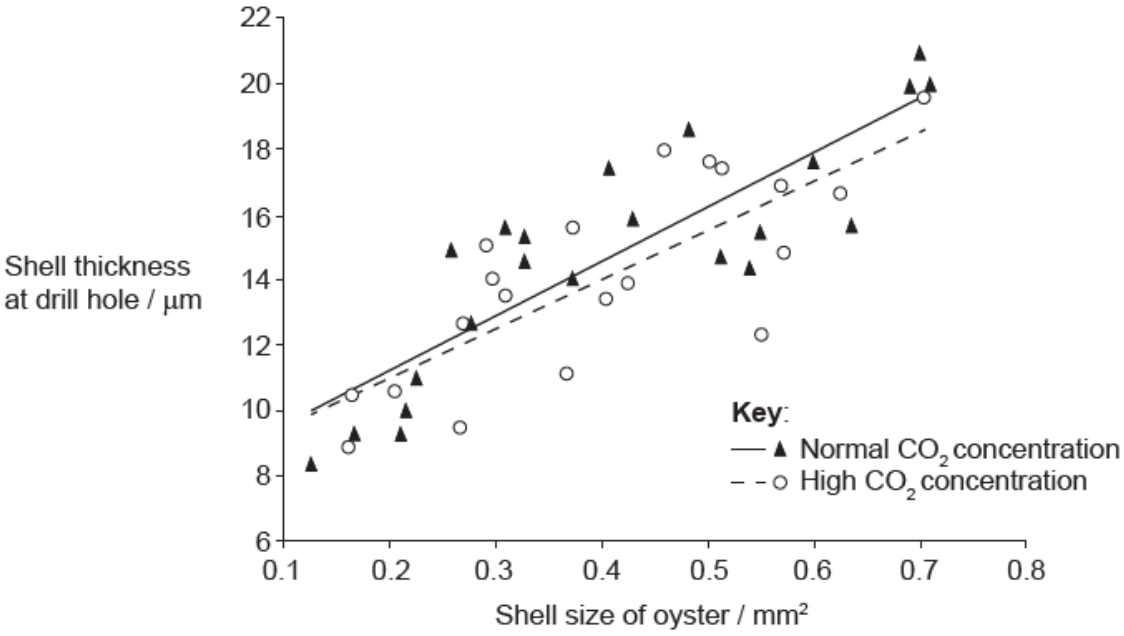
Adult gastropod shell, *Urosalpinx cinerea*

[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.

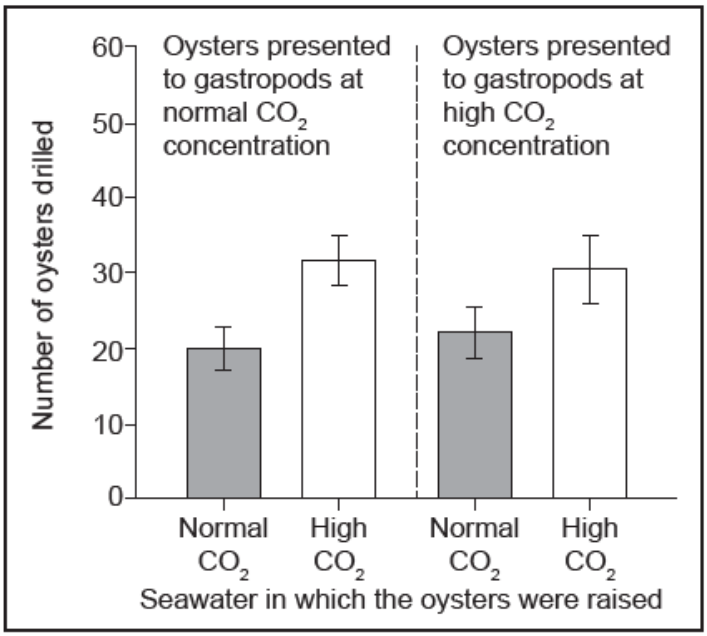
The first step was to raise oysters in two different mesocosms. One had seawater at a normal concentration of CO_2 and the other had sea water with a high concentration of CO_2. Gastropods were raised in two further mesocosms with normal and high CO_2 concentrations respectively.

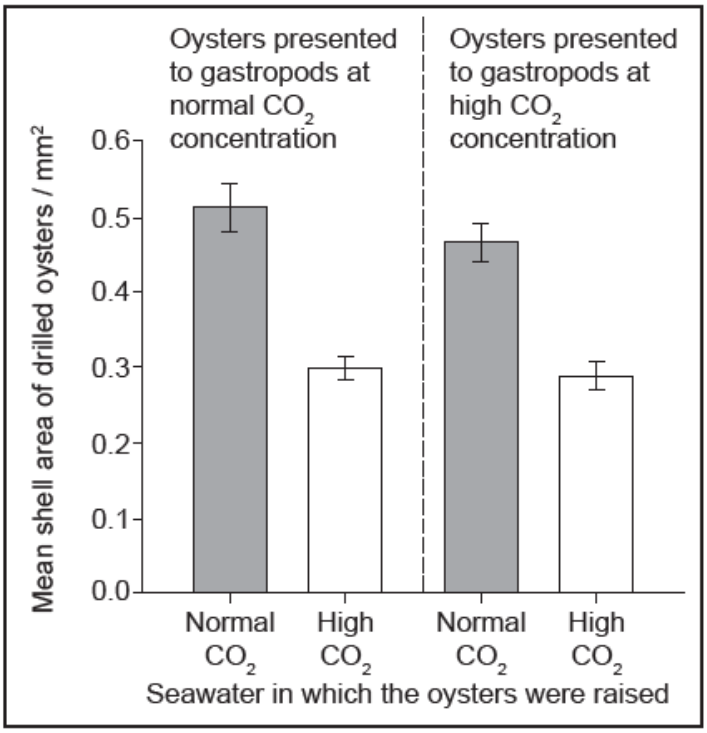
A juvenile gastropod will attack a juvenile oyster by using its tongue-like structure (radula) to drill a hole through the oyster shell. Once the hole has been drilled, the gastropod sucks out the soft flesh. Researchers investigated the shell thickness at the site of the drill hole in relation to the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

Equal numbers of oysters raised in seawater with a normal CO_2 concentration and in seawater with a high CO_2 concentration were then presented together to the gastropod predators in seawater with a normal CO_2 concentration. The same numbers of oysters from the two groups were also presented together to the gastropods in seawater with a high 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]

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

b. Outline the trends shown in the data in the graph. [2]

c. Estimate how much smaller drilled oysters raised in seawater at a high CO_2 concentration were than drilled oysters raised in seawater at a normal CO_2 concentration. [1]

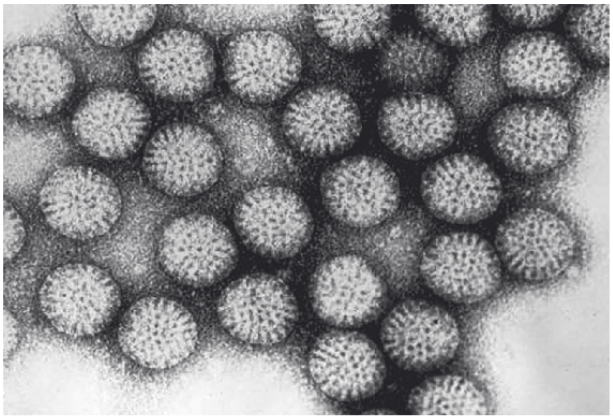
d.i. Deduce from the data in the bar charts which factors were and were not correlated significantly with the number of oysters drilled by the gastropods. [2]

d.ii. Suggest reasons for the differences in the numbers of oysters drilled, as shown in the bar charts. [2]

d.iii. The radula in a gastropod is hard but not made of calcium carbonate. Outline how this statement is supported by the drilling success of the gastropods in seawater with normal or high CO_2 concentrations. [2]

e. Using all the data, evaluate how CO_2 concentrations affect the development of oysters and their predation by gastropods. [2]

The figure shows a transmission electron micrograph of rotavirus particles. Each rotavirus is about 70 nanometres in diameter.



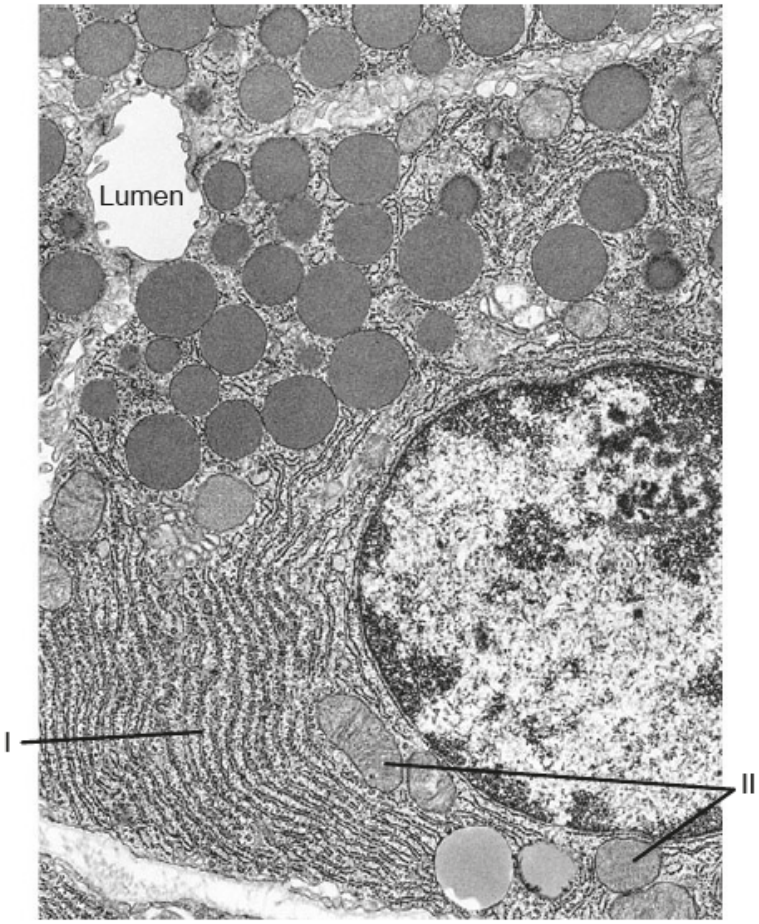
[Source: CDC / Dr. Erskine L. Palmer]

a. State a reason for using an electron microscope to view this virus rather than a light microscope. [1]

b. Rotavirus causes diarrhea and vomiting. Explain why viral diseases cannot be treated using antibiotics. [2]

c. State an application of plasmids in biotechnology. [1]

The electron micrograph shows the structures in an exocrine gland cell of the pancreas.



[Source: Meschner AL, *Junqueira's Basic Histology: Text and Atlas*, 12th edition. Copyright McGrawHill Education.]

a. Glands are organs that secrete and release particular chemical substances. Melatonin is an important hormone secreted in the pineal gland in the brain. Describe its role in mammals. [2]

b.i. State the principal product of this cell. [1]

b.ii. Using the table, identify the organelles labelled I and II on the electron micrograph with their principal role. [2]

Organelle	Name	Principal role
I		
II		