HL Paper 2

Oxygen is needed to complete aerobic cell respiration.

a. Explain how chemical energy for use in the cell is generated by electron transport and chemiosmosis. [8]

b. Outline **four** different functions of membrane proteins. [4]

c. Distinguish between anabolism, catabolism and metabolism. [3]

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a. Draw a labelled diagram of the structure of a chloroplast as seen with an electron microscope. [4]

b. Describe how water is carried by the transpiration stream. [7]

c. Explain how flowering is controlled in long-day and short-day plants. [7]

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b. Outline the metabolic processes that occur in starchy seeds during germination. [6]

c. Explain the light-independent processes of photosynthesis in plants. [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. Describe a model that accounts for the ability of enzymes to catalyse reactions. [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. State the role of **four named** minerals needed by living organisms. [4]

b. Explain the processes by which minerals are absorbed from the soil into the roots. [8]

c. In anaerobic conditions, plants release energy by glycolysis. Outline the process of glycolysis. [6]

a. Outline the role of condensation and hydrolysis in the relationship between amino acids and polypeptides. [4]

b. The protein hemoglobin transports oxygen to cells. Describe the processes that occur in the mitochondria of cells when oxygen is present. [8]

c. Sickle-cell anemia affects the ability of red blood cells to transport oxygen.Explain the consequence of the mutation causing sickle-cell anemia in relation to the processes of transcription and translation. [6]

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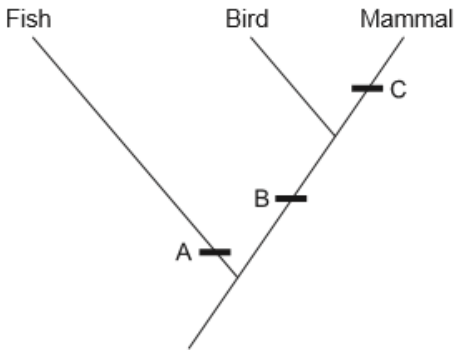
a. The image shows part of a cladogram. [3]



Using the cladogram, identify one diagnostic feature that characterizes the given groups of vertebrates at A, B and C.

A: .....
B: .....
C: .....

b. Starting from the concept of gene pool, explain briefly how populations of early vertebrates could have evolved into different groups. [3]

c. Mitochondria are thought to have evolved from prokaryotic cells. Describe **two** adaptations of the mitochondria, each related to its function. [2]

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

b. The light-dependent reactions in photosynthesis take place on the thylakoid membranes. Explain the light-dependent reactions. [8]

c. Outline two factors that affect the rate of photosynthesis. [5]

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a. Draw a labelled diagram of the ultrastructure of *Escherichia coli* as an example of a prokaryote. [4]

b. Describe the events that occur in the four phases of mitosis in animals. [6]

c. Explain the process of aerobic cell respiration after glycolysis has occurred. [8]

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a. Describe **four** properties of water that are due to hydrogen bonding and polarity. [4]

b. Describe how water is carried through a flowering plant. [6]

c. Some of the water carried to the leaves of a plant is used in photosynthesis. Explain the role of water in the light-dependent reactions of photosynthesis. [8]

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a. Draw a labelled diagram of a mitochondrion as seen in an electron micrograph. [4]

b. A supply of oxygen is needed for aerobic respiration in mitochondria. Describe the featuresofalveoliinhumanlungsthatadaptthemforefficient absorptionofoxygen. [6]

c. Explain the mechanism of ventilation of human lungs. [8]

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a. Distinguish between RNA and DNA. [3]

b. Explain the process of DNA replication. [8]

c. Outline how enzymes catalyse reactions. [7]

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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 effect of inhibitors on the activity of enzymes. [8]

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a. Outline the process of glycolysis. [5]

b. Describe how pancreatic cells directly affect blood glucose levels. [5]

c. Explain why diabetes could be detected through the analysis of urine. [8]

Describe the process of photolysis in photosynthesis.

Photosynthesis and transpiration occur in leaves. Explain how temperature affects these processes.

b. Outline the light-dependent reactions of photosynthesis. [6]

c. Explain the effect of light intensity and temperature on the rate of photosynthesis. [8]

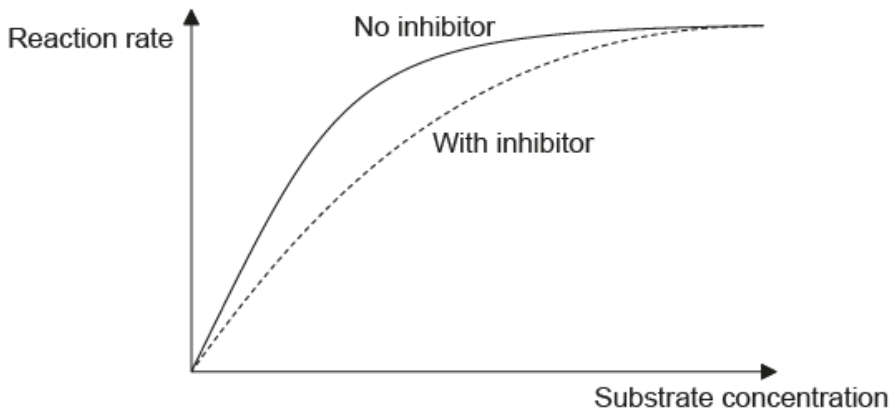
a. Outline the effect of temperature and substrate concentration on the activity of enzymes. [4]

b. Distinguish between competitive and non-competitive enzyme inhibition of chemical reactions, giving an example of each. [5]

c. Explain the light-independent reactions of photosynthesis. [9]

The enzyme ATP synthase has an essential role in aerobic cell respiration.

a. The sketch shows the relationship between the reaction rate and substrate concentration in the presence and the absence of a competitive inhibitor. [2]



Explain the effect of the competitive inhibitor on the reaction rate.

b.i. Describe its location. [1]

b.ii. Describe its function. [2]

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a. Identify the following processes as **either** anabolism **or** catabolism by placing a tick (√) in the correct box. [2]

Process	Anabolism	Catabolism
Light-independent reactions of photosynthesis	☐	☐
Glycolysis	☐	☐

b. Outline the importance of enzymes to metabolic processes. [4]

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a. Explain chemiosmosis as it occurs in photophosphorylation. [8]

b. Draw an annotated graph of the effects of light intensity on the rate of photosynthesis. [4]

c. Using a **named** example of a genetically modified crop, discuss the specific ethical issues of its use. [6]

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a. Describe the relationship between genes, polypeptides and enzymes. [4]

b. Outline control of metabolic pathways. [6]

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a. Draw the absorption spectrum of chlorophyll. [4]

b. Explain the process of photophosphorylation in chloroplasts. [8]

c. Outline how the glucose produced as a result of photosynthesis is transported and stored in plants. [6]

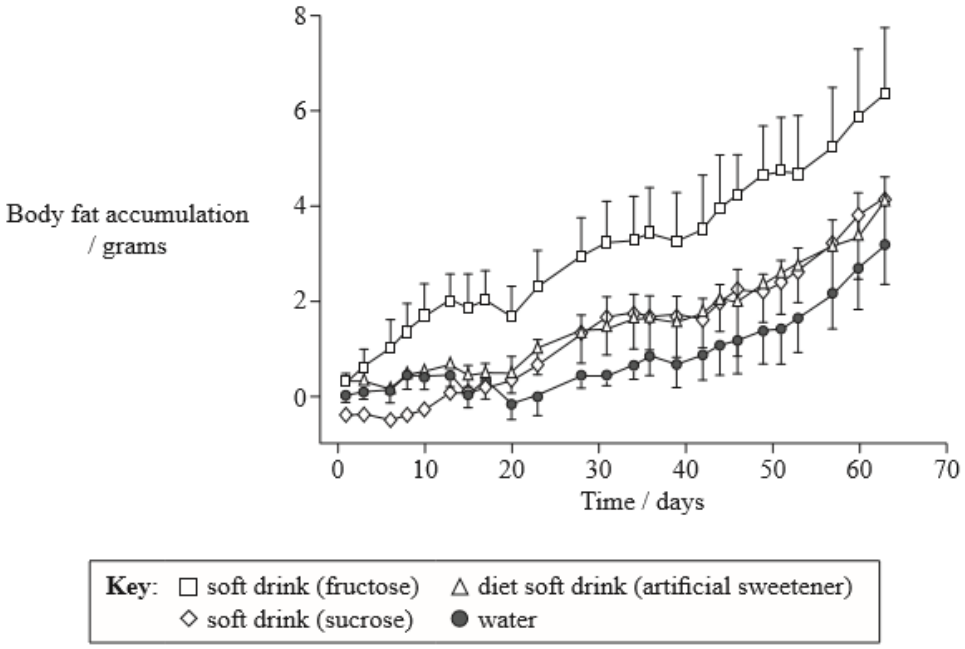
In ecosystems, energy is used to convert inorganic compounds into organic matter. Energy enters ecosystems through producers.

a. Explain the processes by which light energy is converted into chemical energy. [8]

c. Describe how energy flows through and is used by organisms in ecosystems. [4]

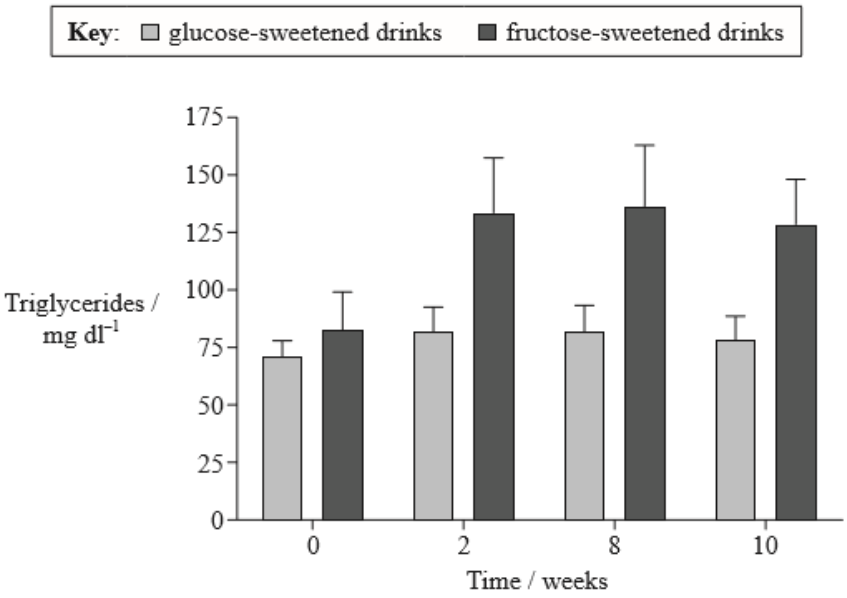
Obesity (excessive weight) is recognized as a global health problem and has been correlated with a large number of health issues, diseases and deaths. The increased consumption of fructose, now widely used as a sweetener, has been associated with the increase in obesity.

In a study, mice were divided into four groups. Each group was given the same amount of food and either a soft drink with a different sweetener or water.



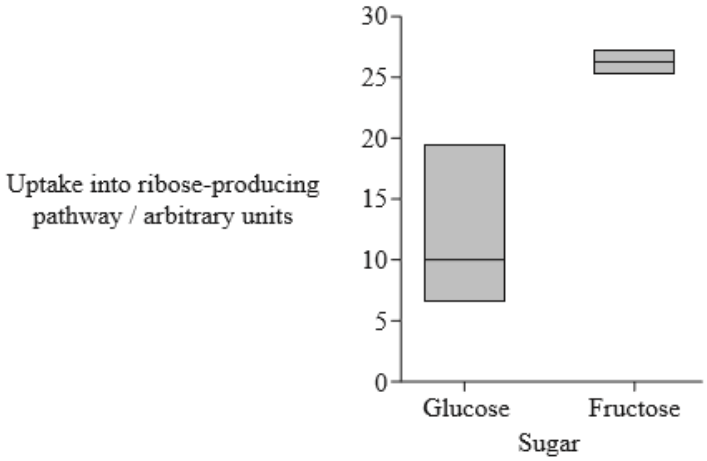
[Source: H. Jürgens et al. (2005) "Consuming fructose-sweetened beverages increases body adiposity in mice", *Obesity Research*, 13 (7), pages 1146–1156.]

As it has been shown that high triglyceride levels correlate to obesity, another study was undertaken with humans. Over a ten-week period, one group was given glucose-sweetened drinks and the other fructose-sweetened drinks. Triglyceride levels in blood were measured throughout the study.



[Source: Adapted from Stanhope KL, Schwarz JM, Keim NL, Griffen SC, Bremer AA, Graham JL, Hatcher B, Cox CL, Dyachenko A, Zhang W, McGahan JP, Seibert A, Krauss RM, Chiu S, Schaefer EJ, Ai M, Otokozawa S, Nakajima K, Nakano T, Beysen C, Hellerstein MK, Berglund L, Havel PJ. Consuming fructose-sweetened, not glucose-sweetened, beverages increases visceral adiposity and lipids and decreases insulin sensitivity in overweight/obese humans. *The Journal of Clinical Investigation*, 119 (5), pages 1322–1334.]

Studies investigated the role of glucose and fructose in the development of pancreatic cancer cells. Pancreatic cancer cells were grown in equal concentrations of each sugar and the uptake of each into ribose-producing pathways was measured. The graph shows the range of uptake of sugars and the mean value.



[Source: H. Liu et al.(2010) *Cancer Research*, 70 (15), pages 6368–6376.]

a. Describe the overall trend in body fat accumulation for the four groups of mice. [1]

b. Compare the body fat accumulation between the four groups. [2]

c. Distinguish between the results for the two groups. [2]

d. This study also showed a significant reduction in insulin sensitivity when participants were given fructose-sweetened drinks, but not when they were given glucose-sweetened drinks. [2]

Describe possible effects of the reduction of insulin sensitivity.

e. Discuss whether the results provide clear evidence of a difference in uptake. [2]

f. Determine which sugar is **primarily** used in the production of ribose. [1]

h. Using all of the data, evaluate the evidence that suggests the consumption of large amounts of fructose poses a risk to human health. [3]

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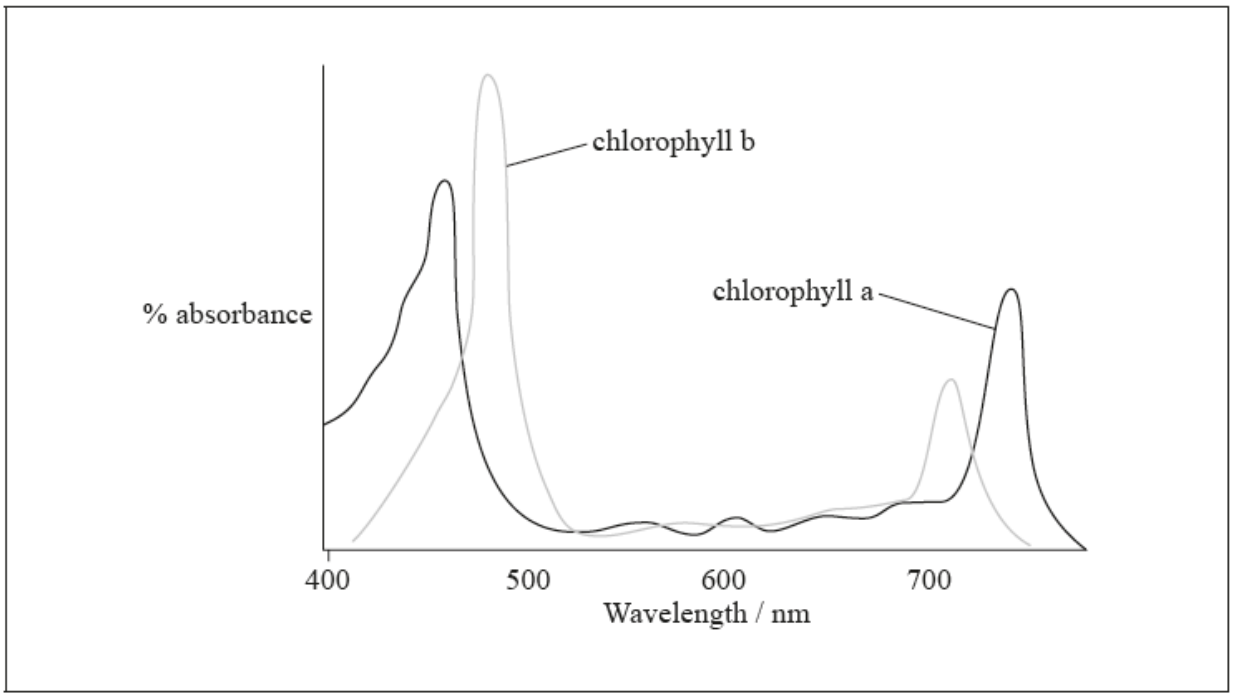
a. The graph shows the absorption spectrum for two types of chlorophyll. [3]



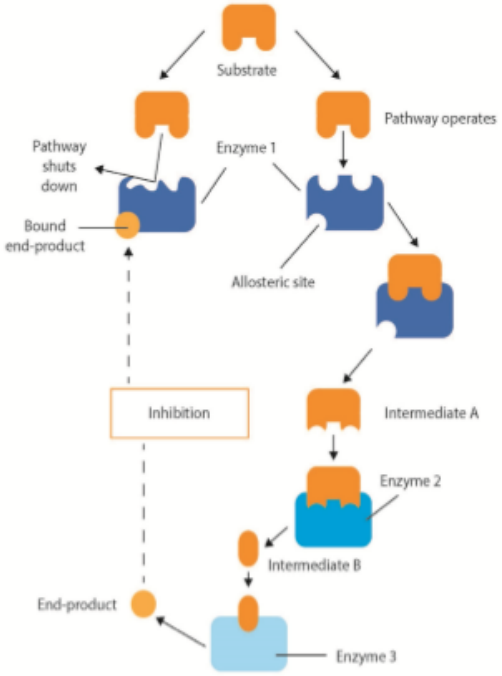
[Source: © International Baccalaureate Organization 2014]

(i) Sketch on the graph, the action spectrum of photosynthesis.

(ii) Explain the relationship between the absorption spectrum for chlorophyll and action spectrum of photosynthesis for green plants.

b. Outline photoactivation of photosystem II in the light-dependent reaction of photosynthesis. [2]

The following diagram shows the synthesis and regulation of some amino acids.

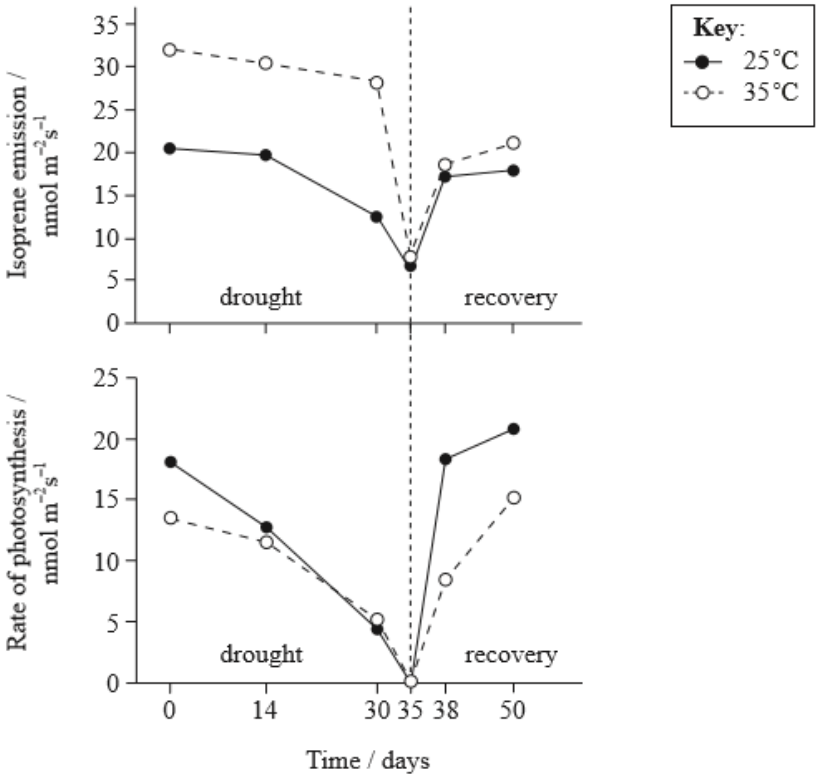


[Source: © International Baccalaureate Organization 2013]

a. State the type of inhibition shown in this diagram. [1]

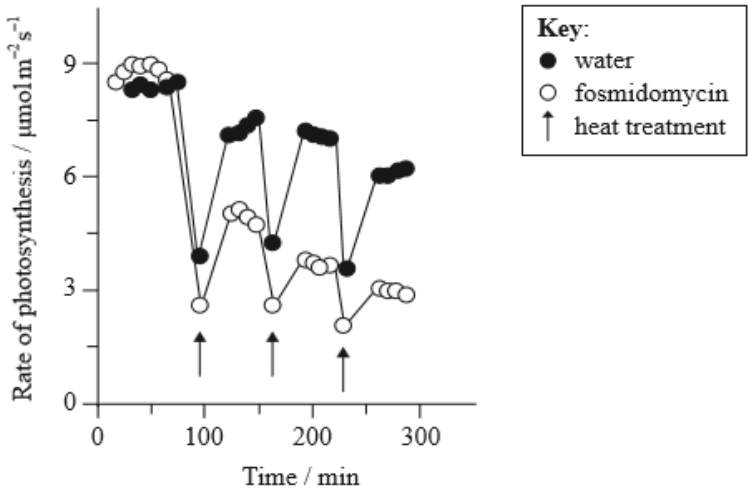
b. Explain how this type of regulation could affect the synthesis of an amino acid. [2]

Isoprene is a chemical synthesized and emitted in large amounts by some plant species, especially oak (*Quercus sp.*) and poplar (*Populus sp.*) trees. It has been suggested that isoprene increases the tolerance of plants to high temperatures, which can cause a decrease in photosynthesis rates. Black poplar (*Populus nigra*) plants were subjected to two raised temperatures and to drought. Measurements of photosynthesis and isoprene emission were made during a 35-day-long drought stress (drought period) and 3 and 15 days after re-watering stressed plants (recovery period). The rate of photosynthesis was recorded as the carbon dioxide taken up per unit of leaf area per second.



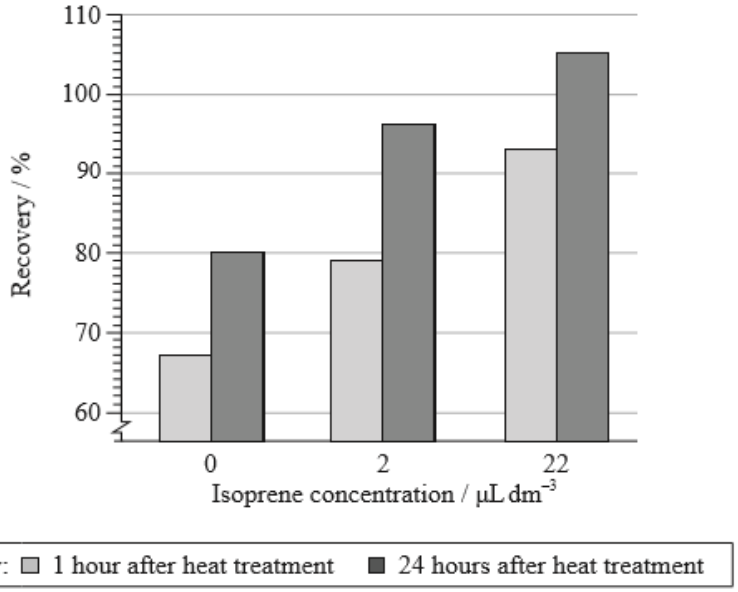
[Source: A. Fortunati et al. (2008) "Isoprene emission is not temperature-dependent during and after severe drought-stress: a physiological and biochemical analysis", *The Plant Journal*, 55, pages 687–697]

The effect of isoprene on photosynthesis was assessed in detached oak leaves that were supplied either water (control) or fosmidomycin dissolved in water. Fosmidomycin inhibits the emission of isoprene without affecting photosynthesis. The measurements were taken at 30°C, but at three points in the experiment the leaves were subjected to heat treatment of 46°C (indicated on the graph by the arrows). The rate of photosynthesis was measured as uptake of CO_2 in $\mu molm^{-2}\ s^{-1}$



[Source: Sharkey, T.D., X.Y. Chen, and S. Yeh. Isoprene increases thermotolerance of fosmidomycin-fed leaves. *Plant Physiology*, April 2001, vol. 125, no. 4, 2001–2006. www.plantphysiol.org © American Society of Plant Biologists.]

To test the effect of isoprene on a plant that does not normally produce it, leaves of common beans (*Phaseolus vulgaris*) were treated with heat stress at 46°C and were supplied with isoprene in the airstream. The percentage recovery compares the rate of photosynthesis before and after heat treatment. The data show the recovery of photosynthesis at different isoprene concentrations 1 hour and 24 hours after the heat treatment.



[Source: Sharkey, T.D., X.Y. Chen, and S. Yeh. Isoprene increases thermotolerance of fosmidomycin-fed leaves. *Plant Physiology* April 2001, vol. 125, no. 4, 2001–2006. www.plantphysiol.org © American Society of Plant Biologists.]

a. Suggest **one** method other than measuring CO_2 uptake by which the rate of photosynthesis could have been measured in these experiments. [1]

b. Suggest why heat treatment may reduce photosynthesis rates. [2]

c. Outline the effect of drought and of re-watering on the rate of photosynthesis. [1]

d. Describe the isoprene emissions during the drought and recovery periods at 25°C. [2]

e. Compare the effect of the two temperatures on the emission of isoprene. [2]

f. State the effect of heat treatment on the rate of photosynthesis. [1]

g. Using the results in the graph, deduce the effect of the presence of fosmidomycin on the rate of photosynthesis in the leaves. [2]

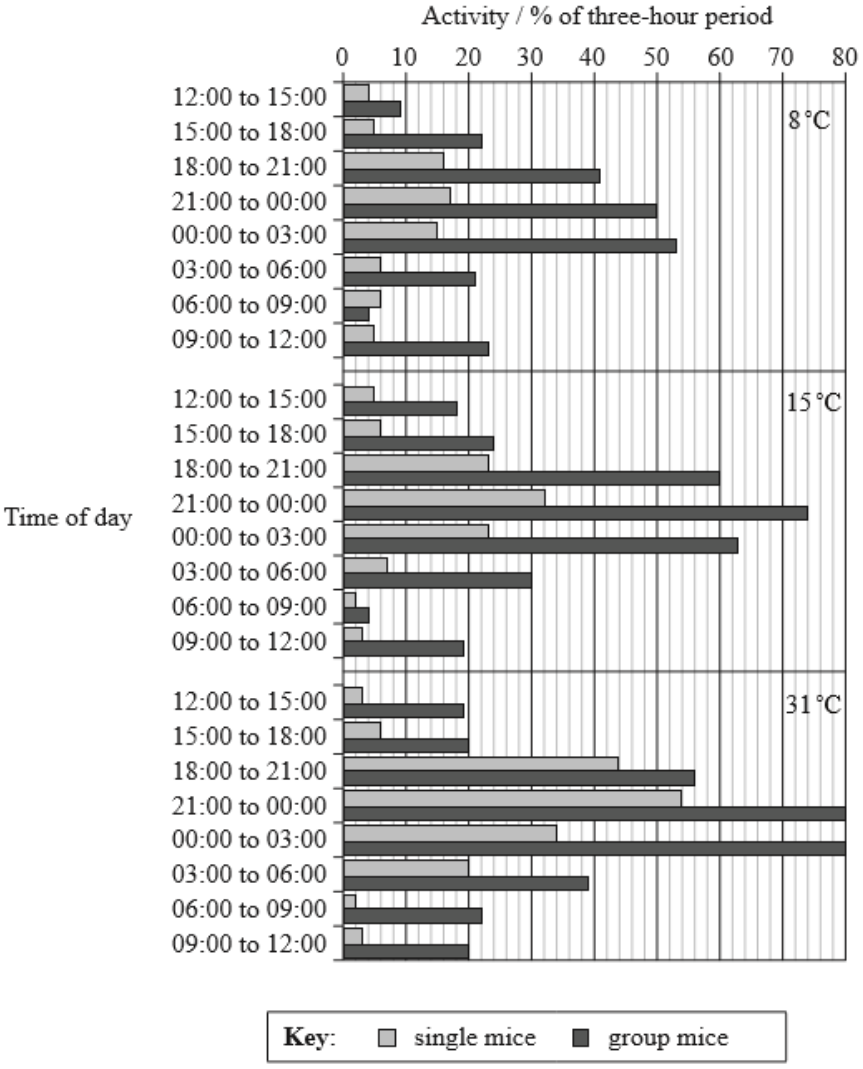
h. Suggest possible conclusions for this experiment. [2]

i. State the difference in percentage recovery of photosynthesis 1 hour after heat treatment between the 22 μLdm^{-3} isoprene treatment and the 0 μLdm^{-3} isoprene treatment. [1]

j. Explain the evidence provided by the data in the bar chart for the hypothesis that isoprene improves plants' tolerance to high temperatures. [2]

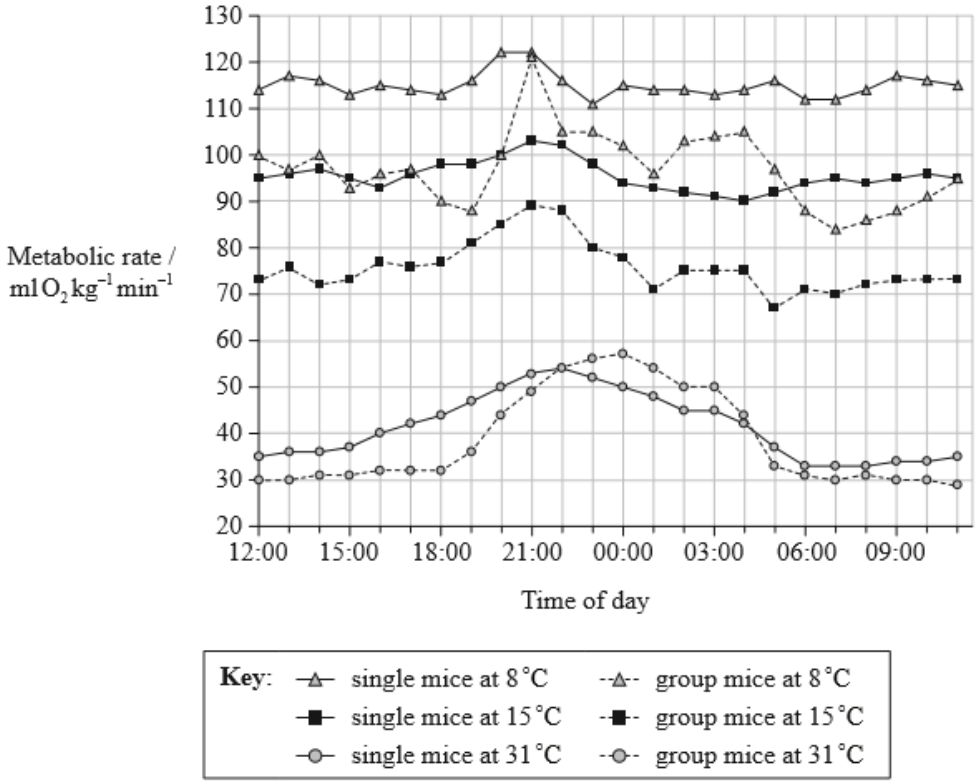
k. Suggest **two** reasons for some plant species synthesizing and emitting isoprene, but not other plant species such as common beans. [2]

Investigators carried out experiments to find the relationship between the energy used by mice (the metabolic rate) and their activity. They found that the amount of time mice are active depends on the time of day, whether they are single or in groups and on the temperature of their surroundings. The bar chart below shows the percentage of time mice were active during three-hour periods at three different temperatures.



L. E. Mount and J. V. Willmott (1967) Journal of Physiology, 190, pages 371–380. Published by Wiley-Blackwell. Used with permission.

The investigators also found that the metabolic rate of the mice changed at different times of the day. Mice were kept at one of the three constant temperatures for 24 hours and their oxygen consumption was measured. The graph below shows the results for single mice and the mean values for group mice.



L. E. Mount and J. V. Willmott (1967) *Journal of Physiology*, 190, pages 371–380. Published by Wiley-Blackwell. Used with permission.

a. Calculate how many minutes the group mice are active between 21:00 and 00:00 at 8°C. [1]

b. Outline the relationship between activity and temperature from 21:00 to 03:00 in all of the mice. [1]

c. Animals which are active at night are nocturnal. Suggest **one** advantage for mice being nocturnal. [1]

d. State the relationship between temperature and metabolic rate. [1]

e. Compare the results for the single mice at 15°C with those for the group mice at 15°C. [2]

f. Suggest **one** reason why the results differ for single mice and group mice. [1]

g. Explain why oxygen consumption is used as a measure of metabolic rate. [2]

h. Using the data from both graphs, evaluate the hypothesis that increased activity causes an increase in metabolic rate in mice. [2]

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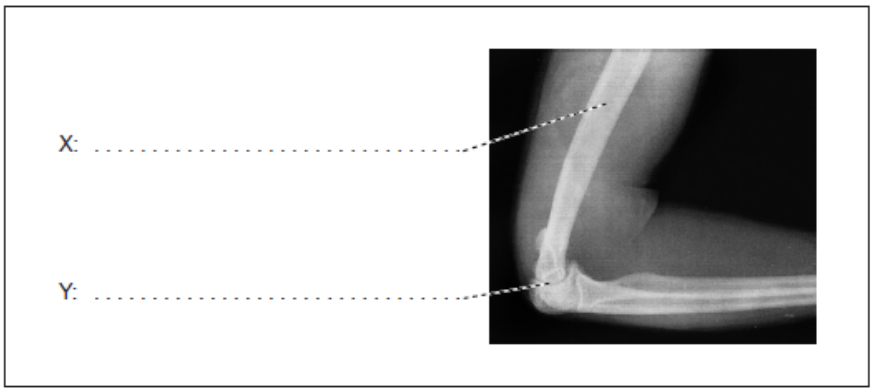
a. Draw a labelled diagram to show the ultrastructure of *Escherichia coli*. [5]

b. Distinguish between active and passive movements of materials across plasma membranes, using **named** examples. [4]

c. Explain how chemiosmosis assists in ATP production during oxidative phosphorylation. [9]

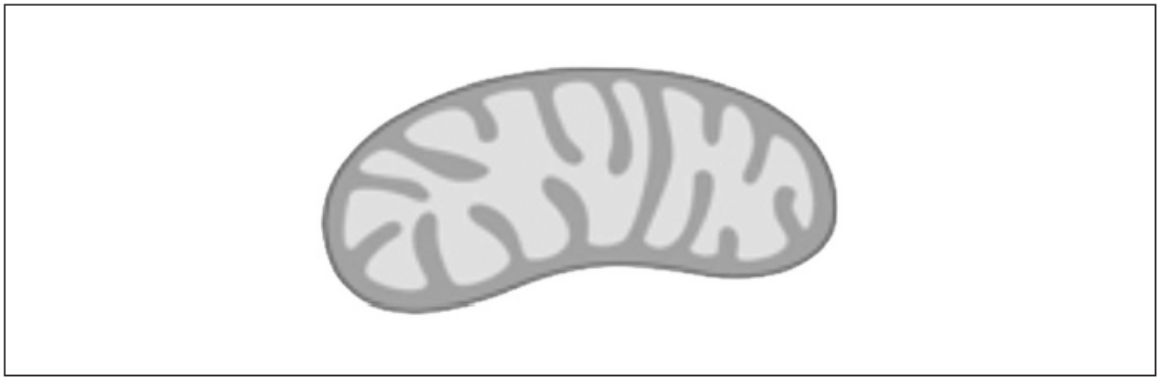
a(i) Label the structures indicated on the X-ray of a human elbow. [2]



b. Explain the role of calcium in muscle contraction. [3]

c(i) One of the stages of aerobic respiration is called the link reaction. [1]

Label the diagram to indicate where the link reaction occurs.



c(ii) Outline the role of coenzyme A in aerobic respiration. [2]

The diagram below shows the structure of lactase

[Source: Kindly provided by RL Miesfeld, The University of Arizona, Tucson, AZ USA]

a (i) A study of 600 adolescents in Sweden showed that milk consumption has a positive effect on height which shows continuous variation. [1]

However, milk contains lactose which some people can digest but some cannot.

State the pattern of inheritance that contributes to continuous variation.

a (ii) Explain the production of lactose-free milk. [3]

b (i) Identify the protein structures indicated by I and II. [1]

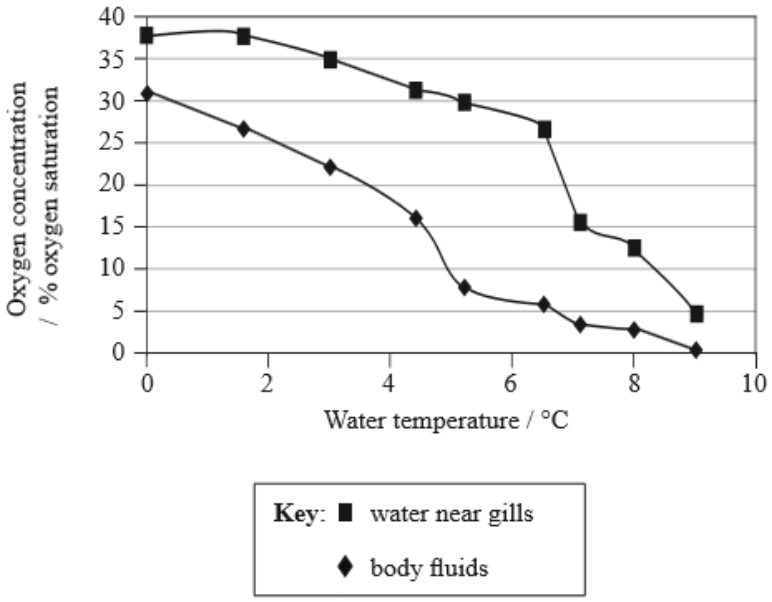
I: .....
II: .....

b (ii) Describe how structure I is held together. [2]

b (iii) This protein is described as a globular protein. Distinguish between globular and fibrous proteins. [2]

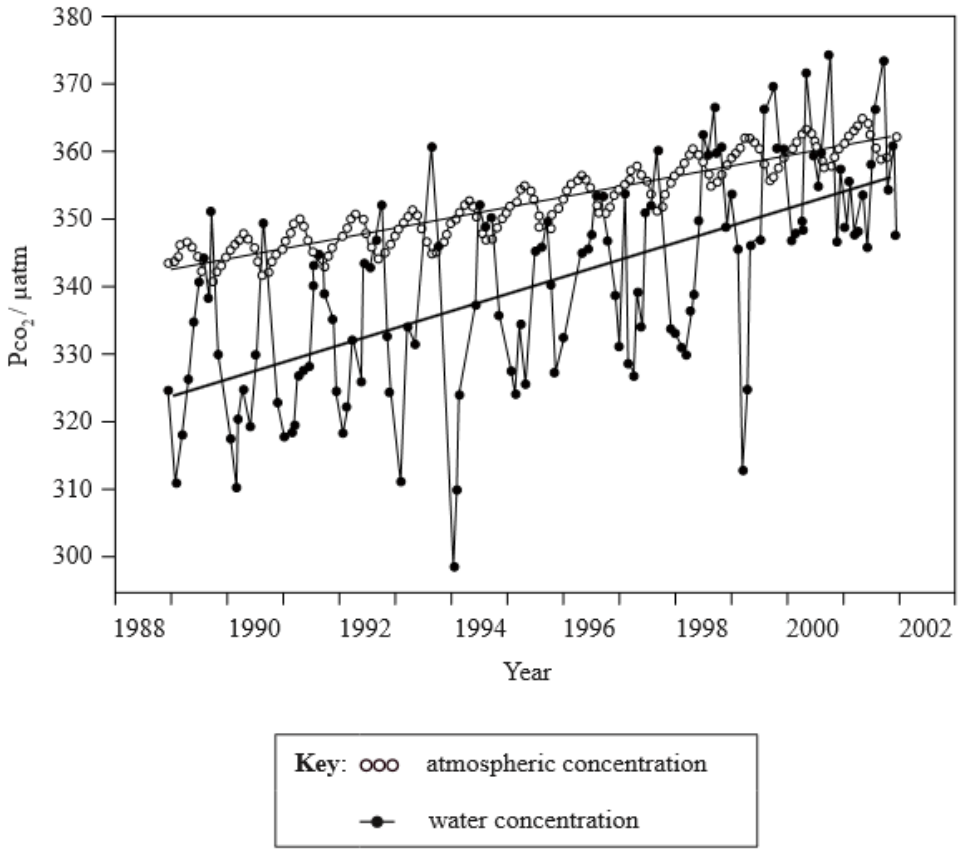
During aerobic cell respiration, oxygen is consumed and carbon dioxide is produced inside cells. This generates concentration gradients between respiring cells and the environment, which cause diffusion of oxygen and carbon dioxide. Both oxygen and carbon dioxide are soluble in water. As the temperature rises, water becomes saturated at a lower concentration of the gas.

Laternula elliptica is a mollusc that lives on the sea bed in Antarctica. Its body temperature is always similar to that of the environment around it. To investigate the effect of temperature on *Laternula elliptica*, specimens were kept in temperature-controlled aquaria. The oxygen concentrations of water near the gills and in the body fluids were measured, at a range of temperatures from 0°C to 9°C. The graph below shows the mean results.



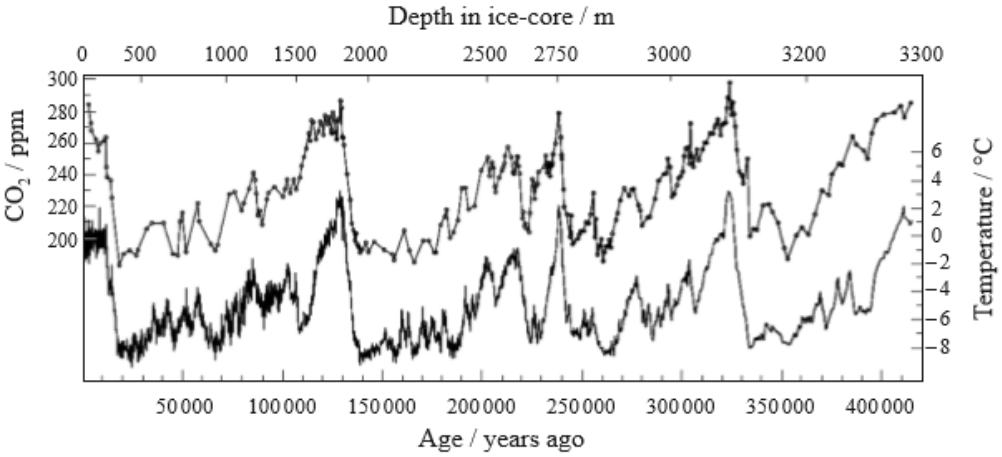
[Source: HO Pörtner, *et al.*, (2006), *Polar Biology*, **29** (8), pages 688–693]

The world's oceans can absorb large amounts of carbon dioxide. This process has been studied in the Pacific Ocean near Hawaii, by measuring carbon dioxide concentrations in the atmosphere and in surface water every month, from October 1988 onwards. The graph below shows the carbon dioxide concentration expressed as partial pressures (Pco_2).



[Source: JE Dore, *et al.*, (2003), *Nature*, **424**, pages 754–756]

The concentration of carbon dioxide in the atmosphere is currently 385 ppm (parts per million). Variations in the concentration of carbon dioxide in the atmosphere can be studied using ice-cores. An ice-core record covering the last 400 000 years has been obtained from Vostok in the Antarctic. The graph below shows the carbon dioxide concentrations that were measured at different depths in the ice. Atmospheric temperatures are also shown on the graph. These were deduced from ratios of oxygen isotopes. The upper line on the graph shows CO_2 concentrations and the lower line shows temperature.



[Source: LR Kump, (2002), *Nature*, **419**, pages 188–190]

a (i) Outline the relationship between temperature and oxygen concentration in the body fluids in *Laternula elliptica*. [2]

a (ii) Suggest **two** reasons for the relationship. [2]

b. In its natural environment, *Laternula elliptica* buries itself in the mud on the sea bed. In this investigation, it was found that above 6°C it is unable to bury itself. Suggest a reason for this. [1]

c (i) Describe the trends in atmospheric carbon dioxide concentration, shown in the graph. [2]

c (ii) Suggest **two** reasons for the trends that you have described. [2]

d (i) Diffusion of carbon dioxide only occurs when there is a concentration gradient. Deduce the pattern of carbon dioxide diffusion, between water and atmosphere, from 1988 to 2002. [2]

d (ii) The graph provides evidence for the hypothesis that there will be no net diffusion of carbon dioxide between water and atmosphere by 2020. Explain this evidence. [1]

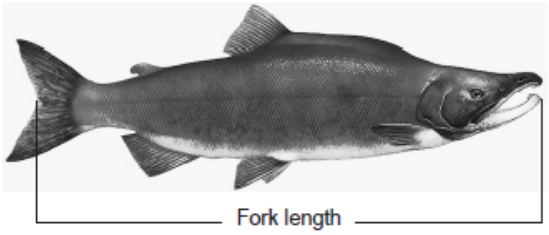
e (i) State the highest carbon dioxide concentration shown on the graph. [1]

e (ii) State the highest temperature shown on the graph. [1]

f. Using the data in the graph, deduce the relationship between atmospheric carbon dioxide concentration and temperature. [1]

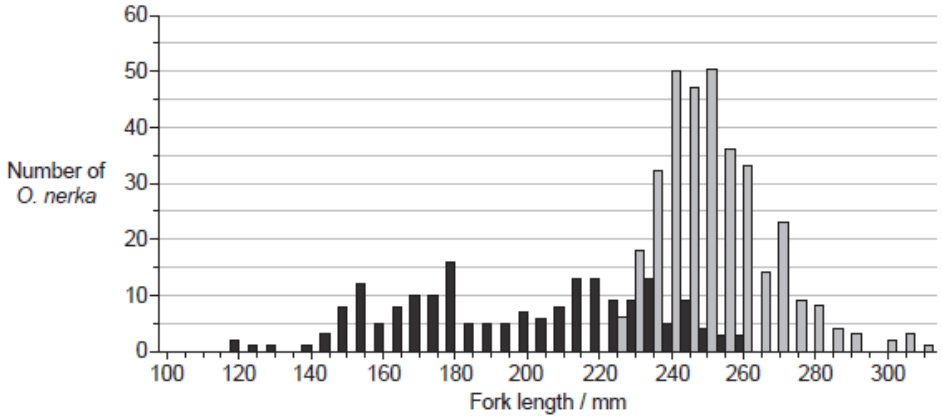
g. Using the data in this question, explain reasons for concern about the long-term survival of Antarctic species, such as *Laternula elliptica*. [3]

Sockeye salmon (*Oncorhynchus nerka*) spend the first years of their lives in the freshwater lakes of Alaska before migrating to marine waters. Their first months in marine waters are spent foraging and growing near the shore line. They then move to offshore regions of the North Pacific Ocean for 2 to 3 years.



[Source: adapted from http://pnwfolklore.org]

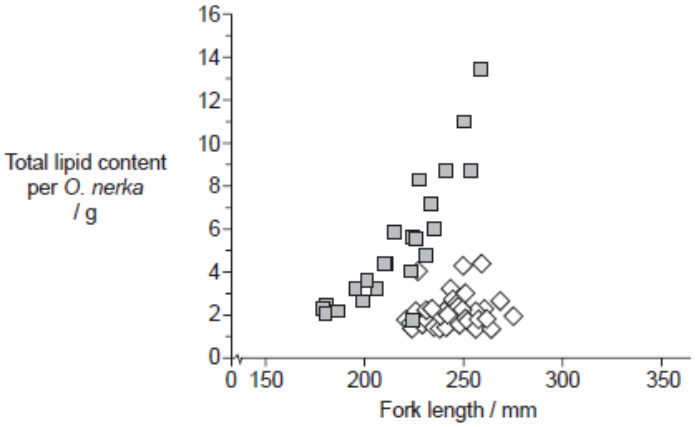
The graph shows fork length frequency of juvenile *O. nerka* caught during their first months in marine waters in autumn 2008 and ocean age one *O. nerka* caught 15 months later during winter 2009 in the North Pacific Ocean.



Key: ■ autumn 2008 (juvenile *O. nerka*) ■ winter 2009 (ocean age one *O. nerka*)

[Source: adapted from EV Farley, *et al.*, (2011), *ICES Journal of Marine Science*, **68** (6), pages 1138–1146]

Lipid in *O. nerka* was measured to evaluate possible differences in energy status during their first 15 months at sea. The graph shows the relationship between fork length and lipid content for *O. nerka* caught during autumn 2008 and winter 2009.

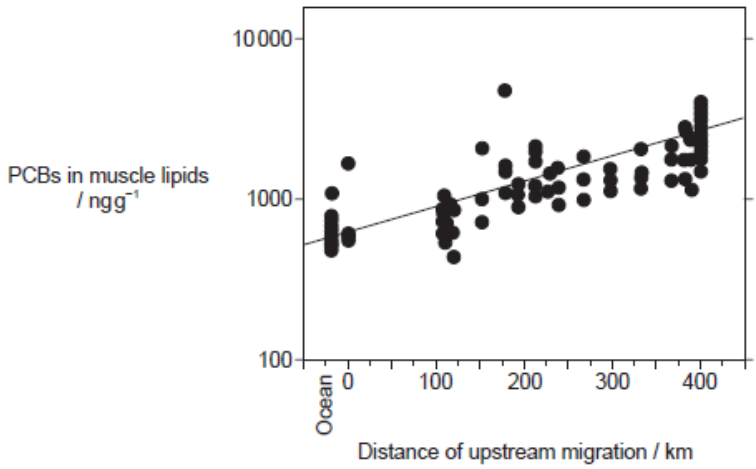


Key: ■ autumn 2008 (juvenile *O. nerka*) ◇ winter 2009 (ocean age one *O. nerka*)

[Source: adapted from EV Farley, *et al.*, (2011), *ICES Journal of Marine Science*, **68** (6), pages 1138–1146]

Persistent organic pollutants, such as polychlorinated biphenyls (PCBs), have been shown to reach unpolluted arctic areas by air currents. Another method of transport of these pollutants into these ecosystems is provided by migrating *O. nerka*.

Pollutant transport was studied in a population of *O. nerka* in the Copper River (Alaska). The graph shows concentration of PCBs in muscle lipids of *O. nerka* in relation to the distance of upstream migration.



[Source: adapted from G Ewald, *et al.*, (1998), *Arctic*, **51** (1), pages 40–47]

a. Identify the **total** number of *O. nerka* with fork length from 240 to 245 mm caught in autumn 2008 and winter 2009. [1]

b. Compare the data in the graph for autumn 2008 and winter 2009. [3]

c. Suggest **two** factors that could affect the distribution of *O. nerka* in the North Pacific Ocean. [2]

d. State the range of lipid content measured in *O. nerka* caught during autumn 2008. [1]

.....g

e. Outline any correlation between total lipid content and fork length in autumn 2008 and in winter 2009. [2]

Autumn 2008:

Winter 2009:

f. Suggest reasons for the differences in lipid content. [2]

g. Describe the relationship between the distance of upstream migration and the concentration of PCBs in *O. nerka*. [1]

h. State the concentration of PCBs in muscle lipids at 125 km from the ocean estimated by the correlation line. [1]

i. As the *O. nerka* migrate upstream they no longer feed. Suggest a reason for the relationship of distance of upstream migration and concentration of PCBs in muscle lipids. [1]