# HL Paper 2

a. Outline the structure of a ribosome. [4]

b. Distinguish between fibrous and globular proteins with reference to **one** example of each protein type. [6]

c. Auxin is a protein. Explain its role in phototropism. [8]

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

c. Explain the effect of light intensity and temperature on the rate of photosynthesis. [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. Define the *active site* of an enzyme. [1]

b. Explain how the active site promotes enzyme–substrate specificity. [2]

c. Outline possible effects of acids on enzyme activity. [2]

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a. Draw a labelled diagram showing **two** different complementary pairs of nucleotides in a molecule of DNA. [4]

b. Outline the structure of nucleosomes. [2]

c. Explain primary structures and tertiary structures of an enzyme. [3]

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a. Draw a labelled diagram of a prokaryotic cell. [4]

b. Outline transcription in prokaryotes. [6]

c. Some prokaryotes cause infectious disease in humans. Explain the principles of vaccination. [8]

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a. Describe how plants carry out gas exchange in the leaves. [5]

b. Outline the causes and consequences of the enhanced greenhouse effect. [5]

c. Explain the role of limiting factors in photosynthesis. [8]

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a. Outline the thermal, cohesive and solvent properties of water. [5]

c. Explain the role of the kidney in maintaining water balance in humans. [9]

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a. Outline the bonding between DNA nucleotides. [2]

b. Explain how chemical bonding between water molecules makes water a valuable coolant in living organisms. [2]

c. State a word equation for anaerobic cell respiration in humans. [1]

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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. State **four** functions of proteins, giving a **named** example of each. [4]

b. Outline the structure of ribosomes. [6]

c. Explain the process of transcription leading to the formation of mRNA. [8]

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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. Draw a labelled diagram of the digestive system. [4]

b. Many people cannot digest lactose and benefit from a diet containing no lactose. Outline the production of lactose-free milk. [6]

c. Explain how the kidney helps to retain useful substances in the blood and eliminate substances which the body does not need. [8]

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a. List the general functions of non-membrane proteins. [4]

b. Outline the digestion, absorption and assimilation of proteins in humans. [6]

c. Actin and myosin are two proteins found in muscles. Explain how skeletal muscle contracts, including the interaction of these proteins. [8]

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b. Explain how abiotic factors affect the rate of transpiration in terrestrial plants. [8]

c. Describe the importance of water to living organisms. [5]

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a. Outline the action of enzymes. [4]

b. Explain the roles of specific enzymes in prokaryote DNA replication. [7]

c. Many genetic diseases are due to recessive alleles of autosomal genes that code for an enzyme. Using a Punnett grid, explain how parents who do not show signs of such a disease can produce a child with the disease. [4]

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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. Water is essential to life on Earth. Outline **two** properties of water that are important for living organisms. [4]

c. Explain the roles of the structures in the kidney that maintain the water balance of the blood in humans. [8]

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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]

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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. Outline how **three** properties of water enhance its use by living organisms. [6]

b. Describe the role of ADH in osmoregulation. [4]

c. Explain how water is moved from roots to leaves in terrestrial plants. [8]

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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. 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]

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a. Draw a labelled diagram of the ultrastructure of a prokaryote. [4]

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

c. Outline how the structure of the ribosome is related to its function in translation. [6]

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a. Nitrogen is part of many important substances in living organisms. [3]

Draw labelled diagrams to show a condensation reaction between two amino acids.

b. Nitrogen is part of many important substances in living organisms. [4]

Distinguish between transcription and translation.

c. Nitrogen is part of many important substances in living organisms. [8]

Explain how insects excrete nitrogenous wastes.

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Defence occurs on the micro and macro levels.

a. Describe the functioning of immunoglobulins. [3]

b. Outline how antibiotics offer protection from certain forms of infectious disease. [4]

c. Coughing to clear the airways is accomplished by muscle contractions. Explain muscle contraction. [8]

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a. Draw a labelled diagram showing the ultra-structure of a liver cell. [4]

b. Distinguish between prokaryotic cells and eukaryotic cells. [6]

c. Explain prokaryotic DNA replication. [8]

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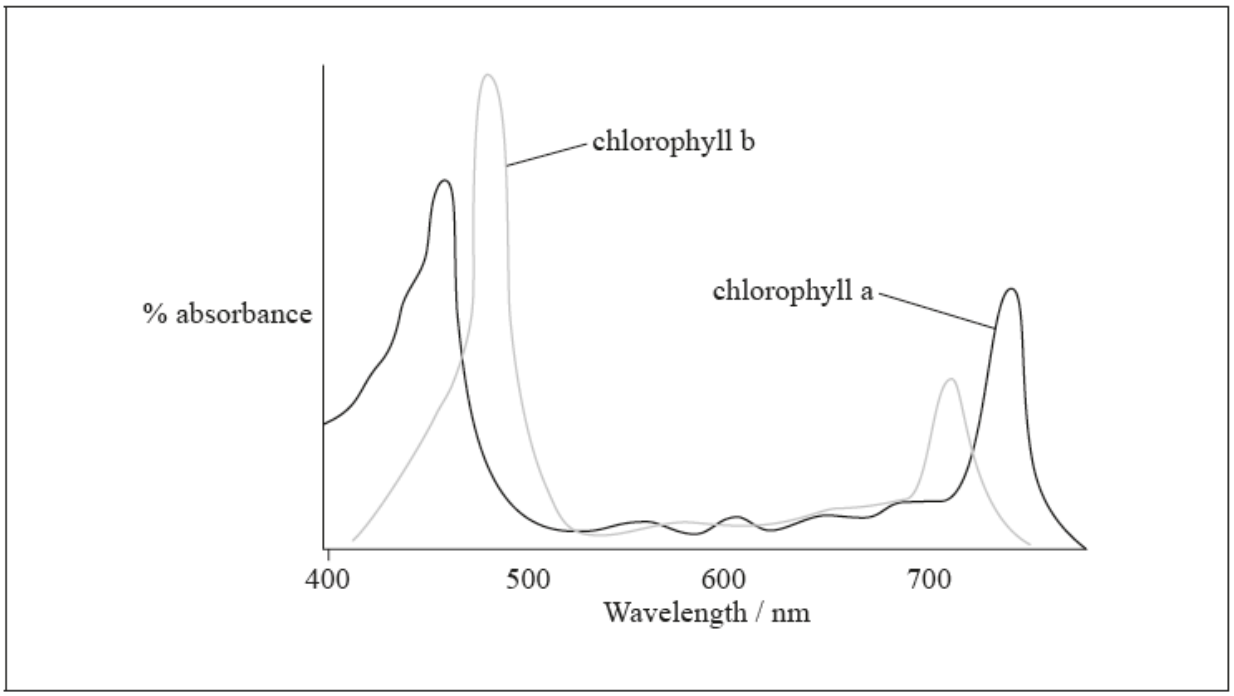
a. The graph shows the absorption spectrum for two types of chlorophyll. [3]




[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]

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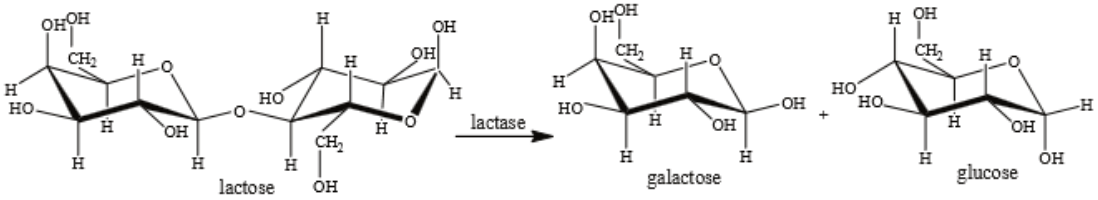
The equation below shows the production of glucose and galactose from lactose.




a. Glucose and galactose are examples of monosaccharides. State **one** other example of a monosaccharide. [1]

b (i) There are several different types of carbohydrate. State which type of carbohydrate lactose is. [1]

b (ii) State the type of chemical reaction that occurs when lactose is digested into glucose and galactose. [1]

d. Simple laboratory experiments show that when the enzyme lactase is mixed with lactose, the initial rate of reaction is highest at 48°C. In food processing, lactase is used at a much lower temperature, often at 5°C. Suggest reasons for using lactase at relatively low temperatures. [2]

a. Most of the DNA of a human cell is contained in the nucleus. Distinguish between unique and highly repetitive sequences in nuclear DNA. [5]

b. Draw a labelled diagram to show **four** DNA nucleotides, each with a different base, linked together in **two** strands. [5]

c. Explain the methods and aims of DNA profiling. [8]

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a. Draw molecular diagrams to show the condensation reaction between two amino acids to form a dipeptide. [4]

b. Outline the roles of the different binding sites for tRNA on ribosomes during translation. [4]

c. Explain the production of antibodies. [7]

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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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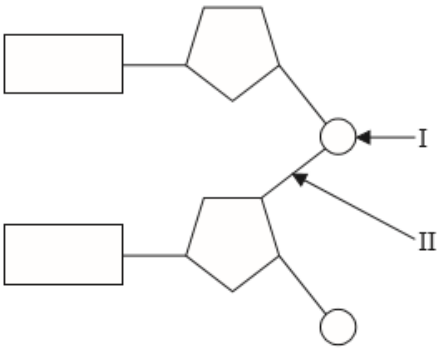
The diagram below shows two nucleotides linked together to form a dinucleotide.




a (i). Identify the chemical group labelled I. [1]

a (ii). State the type of bond labelled II. [1]

b. Distinguish between the sense and antisense strands of DNA during transcription. [1]

c. Compare the DNA found in prokaryotic cells and eukaryotic cells. [2]

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Cells in the alveolus wall produce a surfactant. Its function is to prevent alveoli collapse at the end of expiration. Surfactants are used in the treatment of respiratory system disease in premature babies.

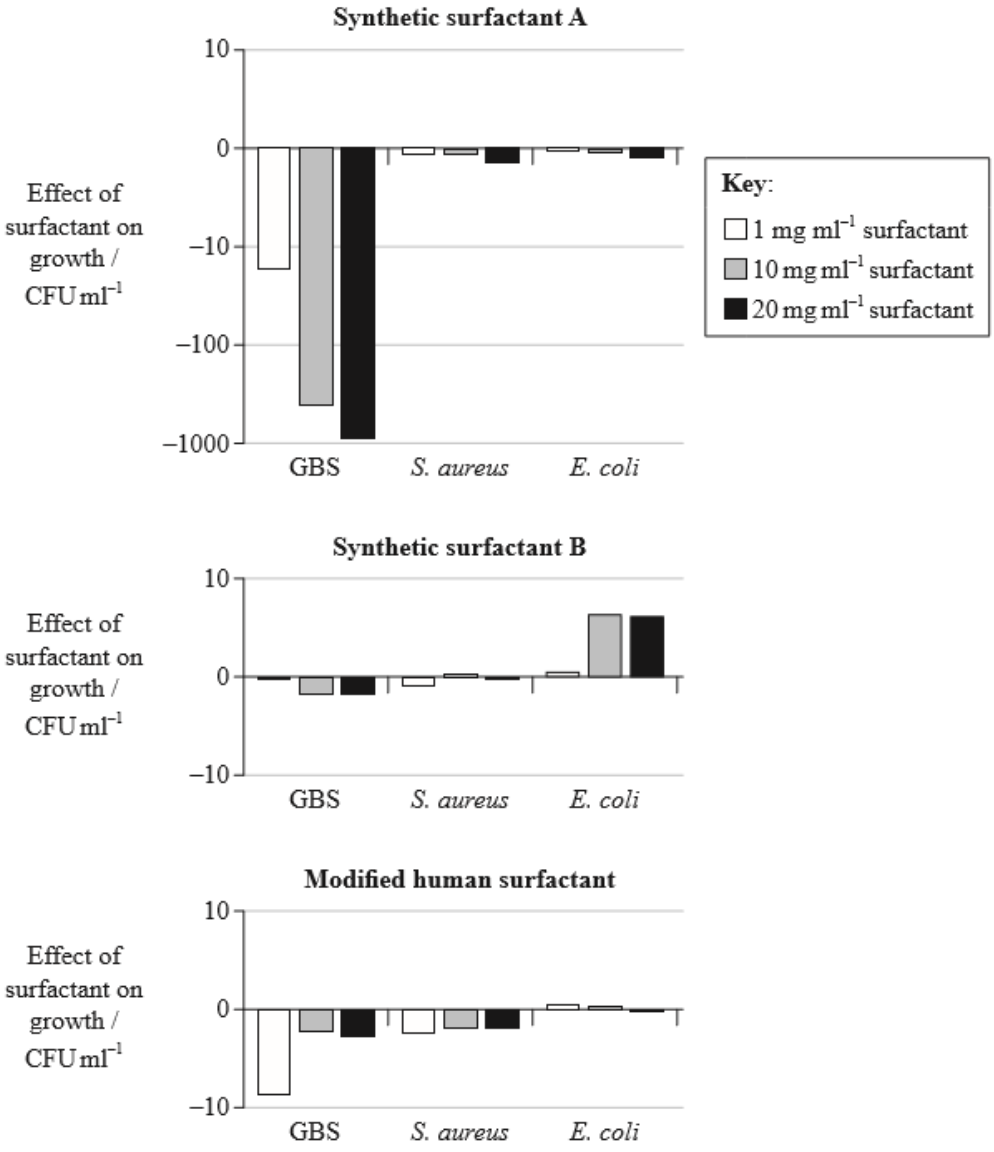
The table shows some of the components of different surfactant preparations.

| | Percentage composition by mass | | | |
|---|---|---|---|---|
| **Component** | **Synthetic surfactant A** | **Synthetic surfactant B** | **Natural human surfactant** | **Modified human surfactant** |
| Phospholipids | 99 | 84 | 81 | 100 |
| Cholesterol | 0 | not stated | 5 to 10 | 0 |
| Fatty acids | <0.5 | 6 | 1.5 | 0 |
| Proteins | 1 | 0.5 to 1 | 5 to 10 | 0 |

[Source: *Clinical and Diagnostic Laboratory Immunology*, 2000, 7(5), pp. 817–822, 2012, January 9, 2013]

The effect of three different surfactants on the growth of three types of bacteria was assessed. Group B streptococci (GBS), *Staphylococcus aureus*, and *Escherichia coli* were incubated with three different concentrations of surfactant (1, 10 and 20 mg $ml^{-1}$).

The bar charts show whether each concentration of surfactant increased or decreased bacterial growth, compared with the growth without surfactant. The difference in growth is shown as colony forming units (CFU) per millilitre.




[Source: *Clinical and Diagnostic Laboratory Immunology*, 2000, 7(5), pp. 817–822, 2012, January 9, 2013]

a. State the surfactant that contains the least amount of phospholipids. [1]

b. Compare the composition of natural human surfactant with synthetic surfactants. [2]

c. Phospholipids found in the surfactants form a surface film on the moist lining of the alveoli. Outline how the hydrophilic and hydrophobic parts of the phospholipids in the surfactants are aligned on the alveolar surface. [1]

d. Identify the effect of increasing the concentration of synthetic surfactant A on the growth of GBS. [1]

e. Compare the effect of the three surfactants, synthetic surfactants A and B and the modified human surfactant, on the growth of the different bacteria at a concentration of 20 mg $ml^{-1}$. [3]

f. Using all the data provided, evaluate the hypothesis that the presence of proteins in surfactants can decrease bacterial growth. [3]

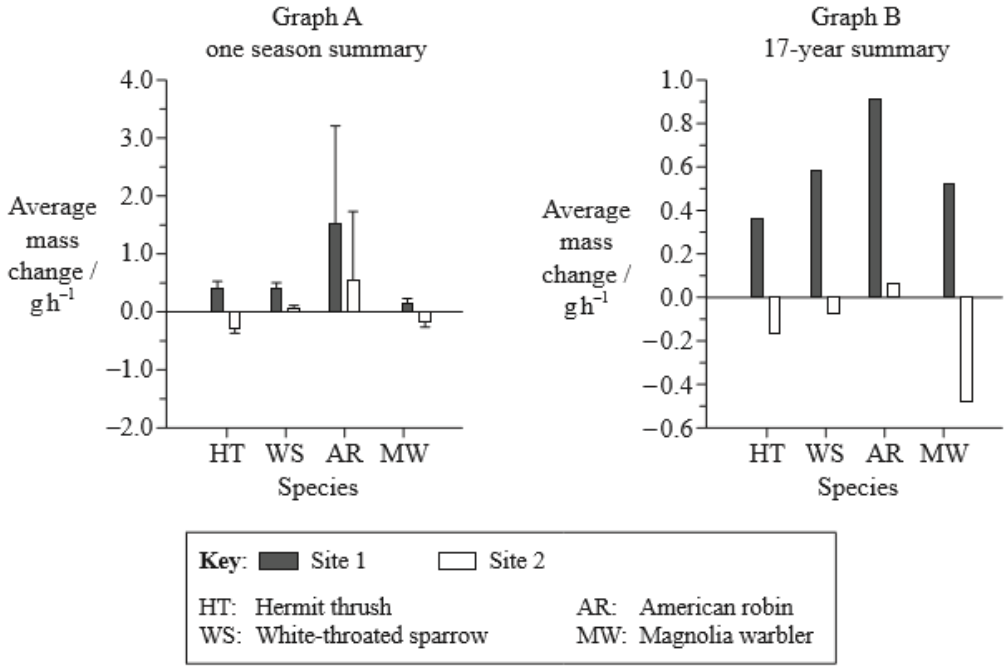
Migrating birds must refuel along the way in order to continue flying. A field study was conducted among four different species of migrating birds known to stop at high quality and low quality food sites. Two techniques were used to assess food quality in the stopover sites. Birds were captured and weighed at the two sites. Blood samples were taken from the birds to determine nutrient levels in their blood. The two techniques were compared for their effectiveness.

The table below shows data collected from the two sites during one season.

| Species | Site 1 | | Site 2 | |
|---|---|---|---|---|
| | *N* (number captured) | Mean bird mass / g | *N* (number captured) | Mean bird mass / g |
| Hermit thrush | 46 | 29.8 | 28 | 28.3 |
| White-throated sparrow | 47 | 27.9 | 48 | 27.2 |
| American robin | 8 | 78.3 | 10 | 77.6 |
| Magnolia warbler | 30 | 8.4 | 10 | 8.2 |

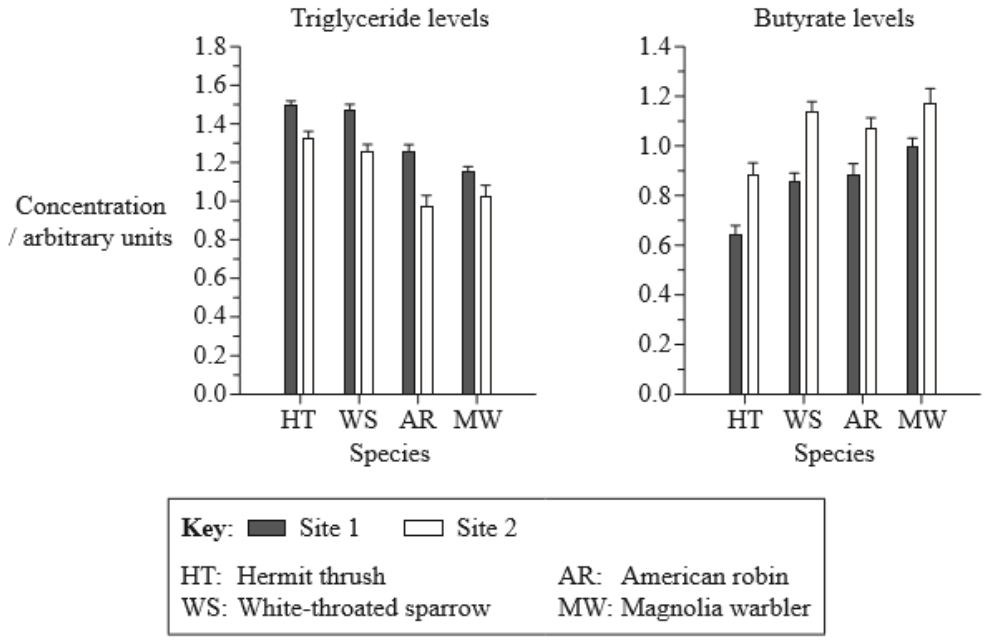
[Source: adapted from C Guglielmo, *et al.*, (2005), *Physiological and Biochemical Zoology*, **78**(1), pages 116–125]

A method was used to determine the average mass change in grams per hour ($gh^{-1}$) during the study. Graph A represents a summary of data collected during one season whereas Graph B represents a summary of data collected over 17 years.




[Source: adapted from C Guglielmo, *et al.*, (2005), *Physiological and Biochemical Zoology*, **78**(1), pages 116–125]

Among birds, high triglyceride concentration in blood plasma indicates fat deposition whereas high butyrate concentration in blood plasma indicates fat utilization and fasting. The following data summarizes triglyceride levels and butyrate levels measured for the same groups of birds.




[Source: adapted from C Guglielmo, *et al.*, (2005), *Physiological and Biochemical Zoology*, **78**(1), pages 116–125]

a. Considering all the birds sampled, identify which species was sampled the most and which was sampled the least. [1]

Most:

Least:

b. Using the data from the table, calculate the percentage difference in mean bird mass for the hermit thrushes refueling at Site 1 compared to those refueling at Site 2. [1]

c. Compare the 17-year summary data for the hermit thrush and the magnolia warbler. [2]

d. Evaluate the one season data for the hermit thrush and the American robin with regard to average mass change per hour at Site 1. [2]

e. Describe, using the triglyceride levels graph, the results at Site 1 and Site 2 for all of the birds. [2]

f. Explain the differences in the triglyceride level and butyrate level for the hermit thrush at Site 1 and Site 2. [2]

g. Scientists have hypothesized that the food quality is better at Site 1 than at Site 2. Evaluate this hypothesis using the data provided. [2]

h. Suggest **one** advantage and **one** disadvantage for blood sampling rather than weighing birds to assess food quality at stopover sites. [1]

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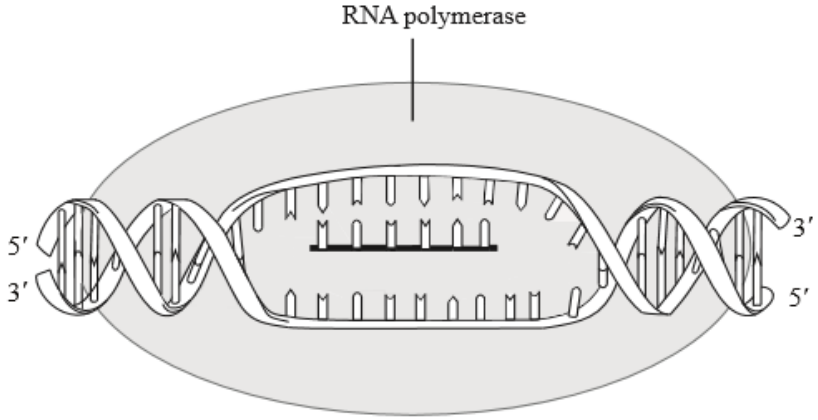
The diagram below shows the process of transcription.




a. DNA replication involves a number of enzymes including DNA polymerase. Identify **one** other enzyme involved in DNA replication. [1]

b. Explain the role of Okazaki fragments in DNA replication. [2]

c (i) Label the sense and antisense strands. [1]

c (ii) Draw an arrow on the diagram to show where the next nucleotide will be added to the growing mRNA strand. [1]

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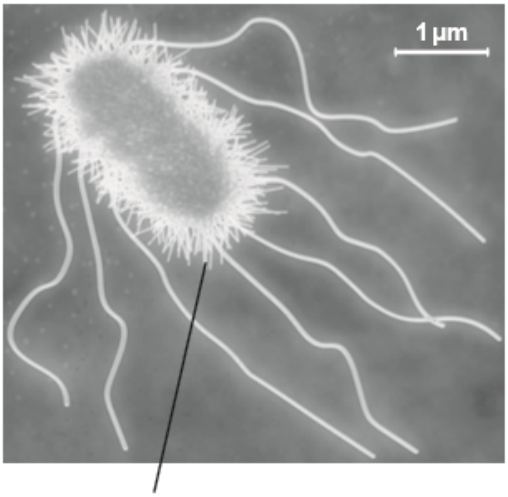


. . . . . .

a. Outline the cell theory. [2]

b (i) Annotate the electron micrograph of the *Escherichia coli* cell with the function of the indicated structure. [1]

b (ii) Calculate the magnification of the electron micrograph. [1]

c (i) Explain the role of the following enzymes in DNA replication. [1]

Helicase

c (iv) Explain the role of the following enzymes in DNA replication. [1]

DNA ligase

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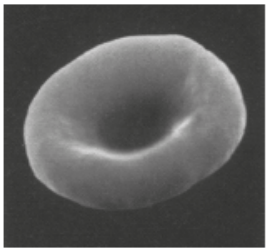
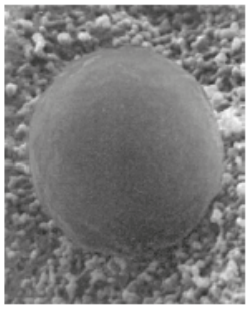
This image shows a normal red blood cell.

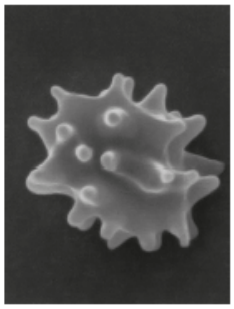


These images show two red blood cells that have been placed in solutions with different concentrations of solutes.

Red blood cell 1



Red blood cell 2



[Source: adapted from www.acbrown.com]

a. Outline the properties of water molecules that permit them to move upwards in plants. [2]

b. Define osmolarity. [1]

c. Deduce, with a reason, which red blood cell has been placed in a hypertonic solution. [1]

d. State what change there has been in the cell surface area to volume ratio in red blood cell 1. [1]

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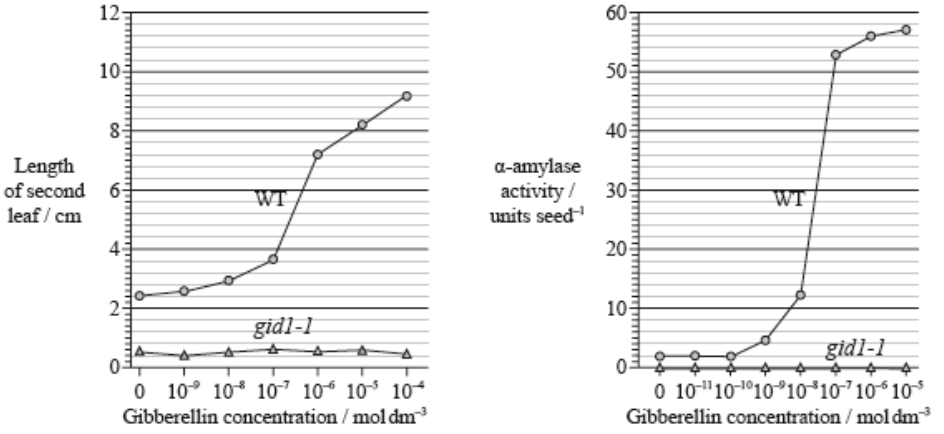
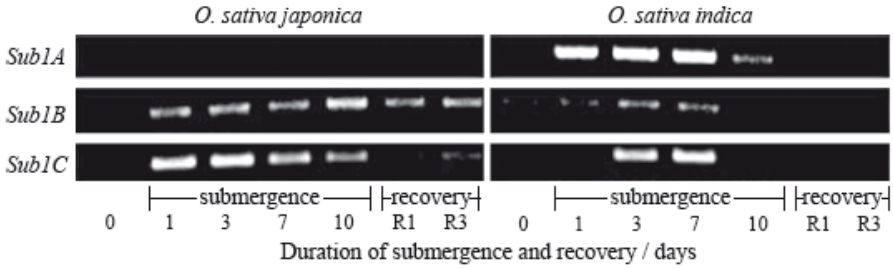
Gibberellin promotes both seed germination and plant growth. Researchers hypothesize that the gene *GID1* in rice (*Oryza sativa*) codes for the production of a cell receptor for gibberellin. The mutant variety *gid1-1* for that gene leads to rice plants with a severe dwarf phenotype and infertile flowers when homozygous recessive. It is suspected that homozygous recessive *gid1-1* plants fail to degrade the protein SLR1 which, when present, inhibits the action of gibberellin. The graphs show the action of gibberellin on the leaves and α-amylase activity of wild-type rice plants (WT) and their *gid1-1* mutants.




[Source: adapted from M. Ueguchi-Tanaka et al. (2005) 'Gibberellin-insensitive dwarf1 encodes a soluble receptor for gibberellin'. Nature, 437, pp. 693—698. Adapted by permission from Macmillan Publishers Ltd (c) 2005.]

Most rice varieties are intolerant to sustained submergence under water and will usually die within a week. Researchers have hypothesized that the capacity to survive when submerged is related to the presence of three genes very close to each other on rice chromosome number 9; these genes were named *Sub1A*, *Sub1B* and *Sub1C*. The photograph below of part of a gel shows relative amounts of messenger RNA produced from these three genes by the submergence-intolerant variety, *O. sativa japonica*, and by the submergence-tolerant variety, *O. sativa indica*, at different times of a submergence period, followed by a recovery period out of water.

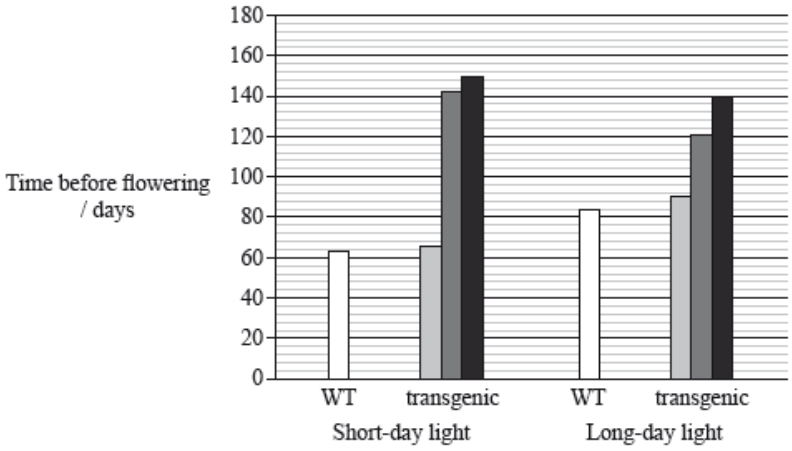



[Source: Adapted from "Sub1A is an ethylene-response-factor-like gene that confers submergence tolerance to rice" (2006) Kenong Xu, Xia Xu, Takeshi Fukao, Patrick Canlas, Reycel Maghirang-Rodriguez et al. Nature, 442, pp. 705—708. Adapted by permission from Macmillan Publishers Ltd (c) 2006.]

The *OsGI* gene causes long-day flowering and the effect of its overexpression has been observed in a transgenic variety of rice. Some wild-type rice (WT) and transgenic plants were exposed to long days (14 hours of light per day) and others to short days (9 hours of light per day).

The shades of grey represent the genotypes of the transgenic plants, where:

- –/– do not have the overexpressed *OsGI* gene
- +/– are heterozygous for the overexpressed *OsGI* gene
- +/+ are homozygous for the overexpressed *OsGI* gene.




[Source: adapted from R. Hayama, S. Yokoi, S. Tamaki, M. Yano and K. Shimamoto (2003) 'Adaptation of photoperiodic control pathways produces short-day flowering in rice.' Nature, 422, pp. 719—722. Adapted by permission from Macmillan Publishers Ltd (c) 2003.]

a(i). State which variety of rice fails to respond to gibberellin treatment. [1]

a(ii). The activity of α-amylase was tested at successive concentrations of gibberellin. Determine the increment in gibberellin concentration that produces the greatest change in α-amylase activity in wild-type rice plants (WT). [1]

b. Discuss the consequence of crossing *gid1-1* heterozygous rice plants amongst themselves for food production. [3]

c(i). Determine which gene produced the most mRNA on the first day of the submergence period for variety *O. sativa japonica*. [1]

c(ii). Outline the difference in mRNA production for the three genes during the submergence period for variety *O. sativa indica*. [2]

d. Using only this data, deduce which gene confers submersion resistance to rice plants. [2]

e(i). State the overall effect of overexpression of the *OsGI* gene in plants treated with short-day light. [1]

e(ii). Compare the results between the plants treated with short-day light and the plants treated with long-day light. [2]

e(iii). State, giving **one** reason taken from the data opposite, if unmodified rice is a short-day plant **or** a long-day plant. [1]

g. Evaluate, using all the data, how modified varieties of rice could be used to overcome food shortages in some countries. [2]

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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]

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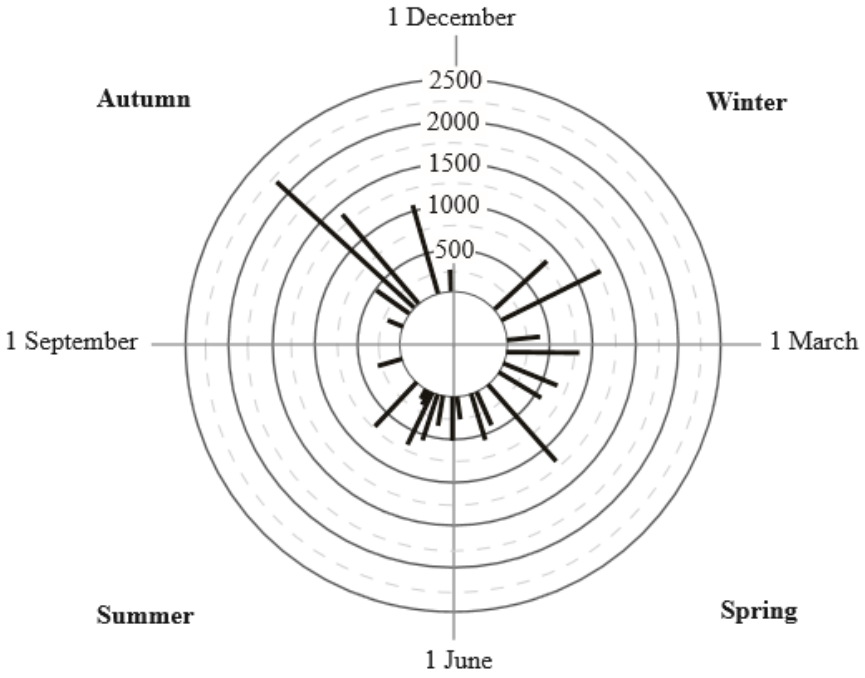
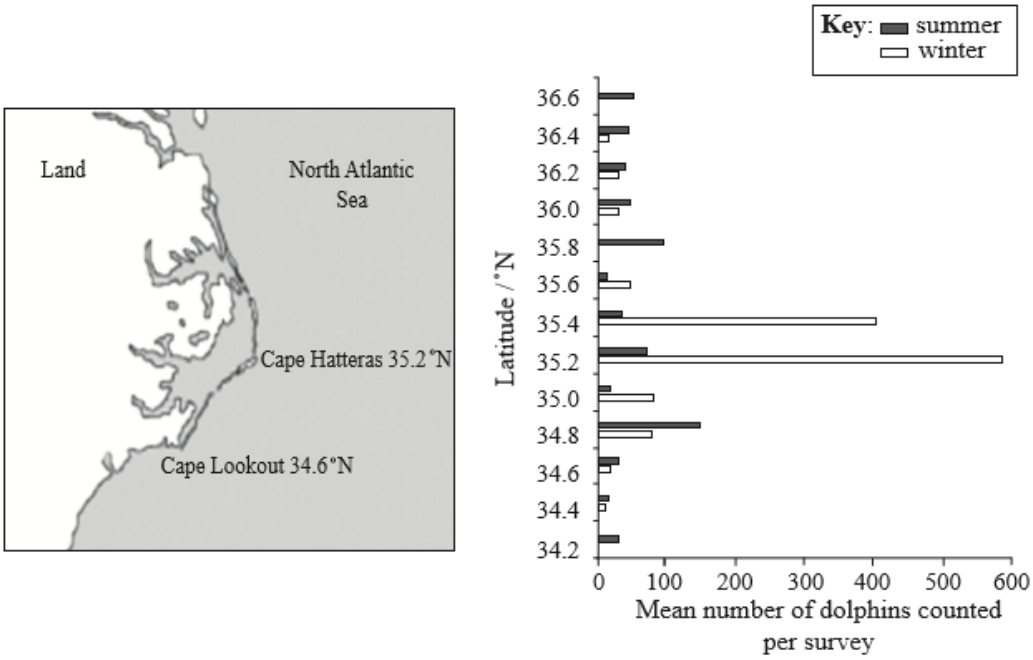
Bottlenose dolphins (*Tursiops truncatus*) inhabit almost all tropical and temperate oceans between 45°N and 45°S. Over a two-year period, aerial surveys were carried out to investigate the seasonal distribution of these animals along the mid-Atlantic and eastern coastal waters of the USA. Sightings were recorded using a global positioning system (GPS) while flying in a regular pattern within approximately 65 km of the shore. A total of 12 760 dolphins were sighted over the two-year period and the data are summarized in the chart below.

Each bar corresponds to a single survey and the length of the bar corresponds to the total number of bottlenose dolphins counted in that survey. The circles with numbers indicate numbers of dolphins.




[Source: adapted from Leigh G. Torres, William A. McLellan, Erin Meagher and D. Ann Pabst (2005) 'Seasonal distribution and relative abundance of bottlenosedolphins, *Tursiops truncatus*, along the US mid-Atlantic Coast.' *Journal of Cetacean Research and Management*, 7 (2), pp. 153–161.]

As part of the same study, coastal aerial surveys were carried out over the same time period by flying parallel to the coast approximately 500 m offshore. The diagram below shows a map of the section of coast surveyed. The bar graph shows the seasonal data for summer and winter at the corresponding latitudes (°N). A total of 5431 bottlenose dolphins were sighted during these surveys.



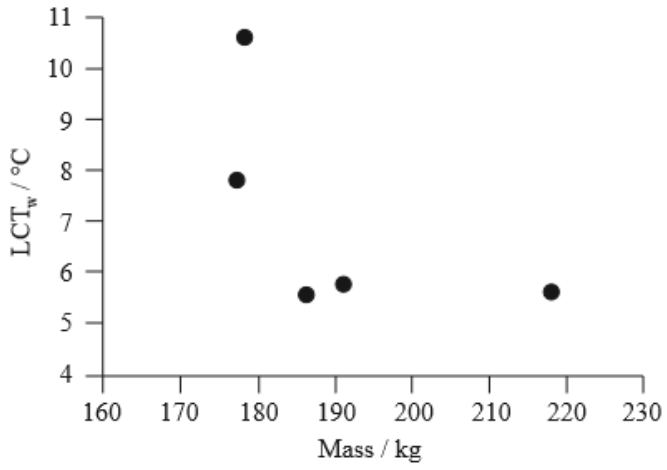

[Source: adapted from Leigh G. Torres, William A. McLellan, Erin Meagher and D. Ann Pabst (2005) 'Seasonal distribution and relative abundance of bottlenosedolphins, *Tursiops truncatus*, along the US mid-Atlantic Coast.' *Journal of Cetacean Research and Management*, 7 (2), pp. 153–161.]

In a different study, researchers investigated the role of water temperature as a possible factor in the distribution of bottlenose dolphins. The rate of metabolism (measured as the rate of oxygen uptake per unit mass) of five captive adults was measured under a range of water temperatures. The rate of metabolism was found to increase significantly when the water temperature fell below a certain value known as the lowest critical water temperature ($LCT_w$). Below this temperature the body uses more energy to combat the cooling effect of the surrounding water. The data for these animals are summarized below.

| Animal | Sex | Age / years | Mass / kg | $LCT_w$ / °C |
|---|---|---|---|---|
| 1 | male | 27 | 177.3 | 7.8 |
| 2 | male | 24 | 191.4 | 5.7 |
| 3 | male | 26 | 219.7 | 5.6 |
| 4 | male | 14 | 187.0 | 5.5 |
| 5 | female | 33 | 178.2 | 10.6 |

Adapted with permission from L.C. Yeates and D.S. Houser (2008) 'Thermal tolerance in bottlenose dolphins (*Tursiops truncatus*).' *Journal of Experimental Biology*, 211, pp. 3249–3257, Table 1. doi:10.1242/jeb.020610: The Journal of Experimental Biology: jeb.biologists.org

The graph below summarizes the relationship between $LCT_w$ and body mass.




[Adapted with permission from L.C. Yeates and D.S. Houser (2008) 'Thermal tolerance in bottlenose dolphins (*Tursiops truncatus*).' *Journal of Experimental Biology*, 211, pp. 3249–3257, Figure 4. doi:10.1242/jeb.020610: The Journal of Experimental Biology: jeb.biologists.org.]

a. State the largest number of dolphins counted in a single survey. [1]

b. Calculate the mean number of dolphins counted per survey for the winter season. [1]

c. Compare the data for the dolphin populations in winter and summer. [2]

d (i) Compare the distribution of dolphins in summer and winter. [2]

d (ii) Suggest **one** reason for the differences in distribution. [1]

e. Outline the relationship between body mass and $LCT_w$ for male dolphins. [2]

f. Suggest **one** reason for the high $LCT_w$ measured for the female dolphin. [2]

g. Evaluate the hypothesis that water temperature determines the range and distribution of bottlenose dolphins in the wild. [2]

h. Explain how an increase in water temperature due to global warming could affect the distribution of bottlenose dolphins along the eastern coast of the USA. [2]

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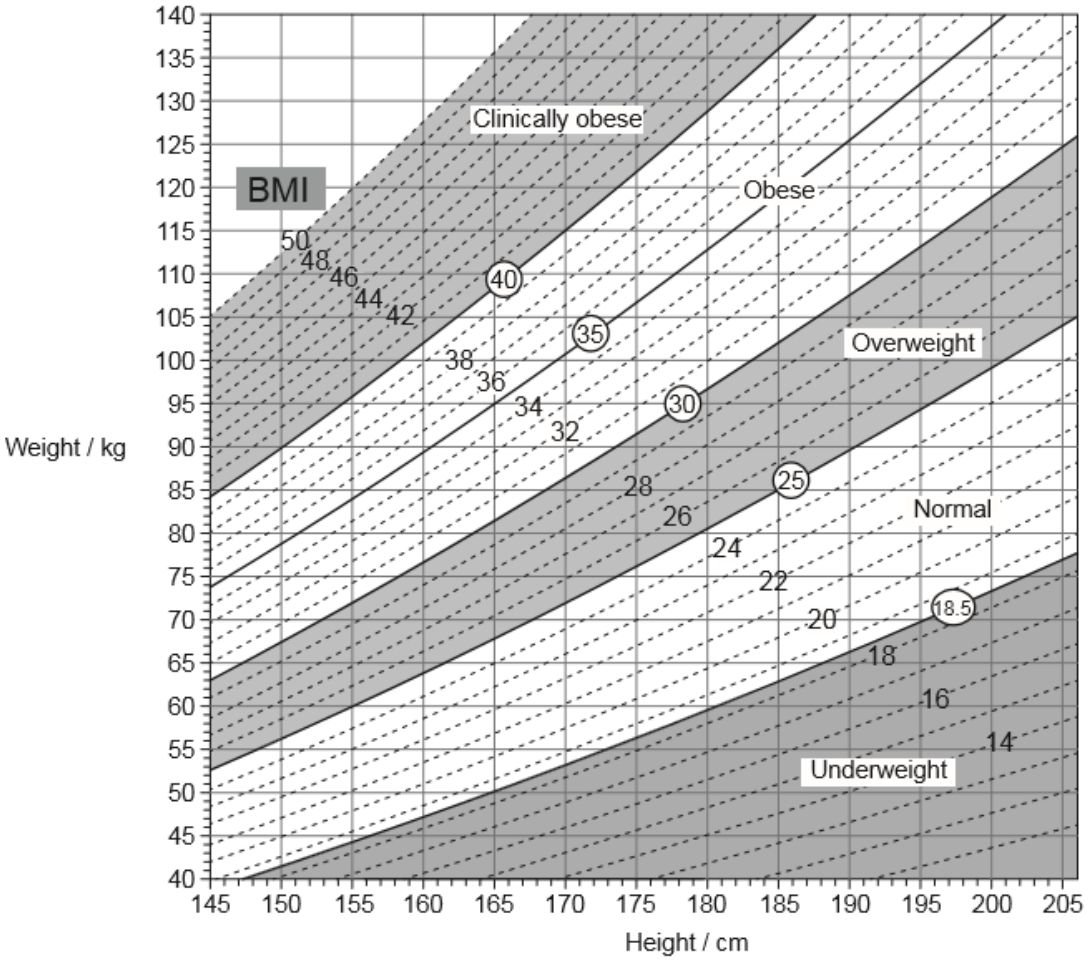
The image shows a nomogram.






a. (i) Using the nomogram, state the lower weight limit for a woman with the height of 155 cm who is classified as overweight, giving the units. [2]

Lower weight limit: .....

(ii) State a major health problem of the circulatory system that is correlated with obesity.

b. Draw the structure of a saturated fatty acid. [2]

c. Describe how the hormone leptin helps to prevent obesity. [3]

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The Chinese soft-shelled turtle, *Pelodiscus sinensis*, lives in salt water marshes. The turtle can live under water and out of water.

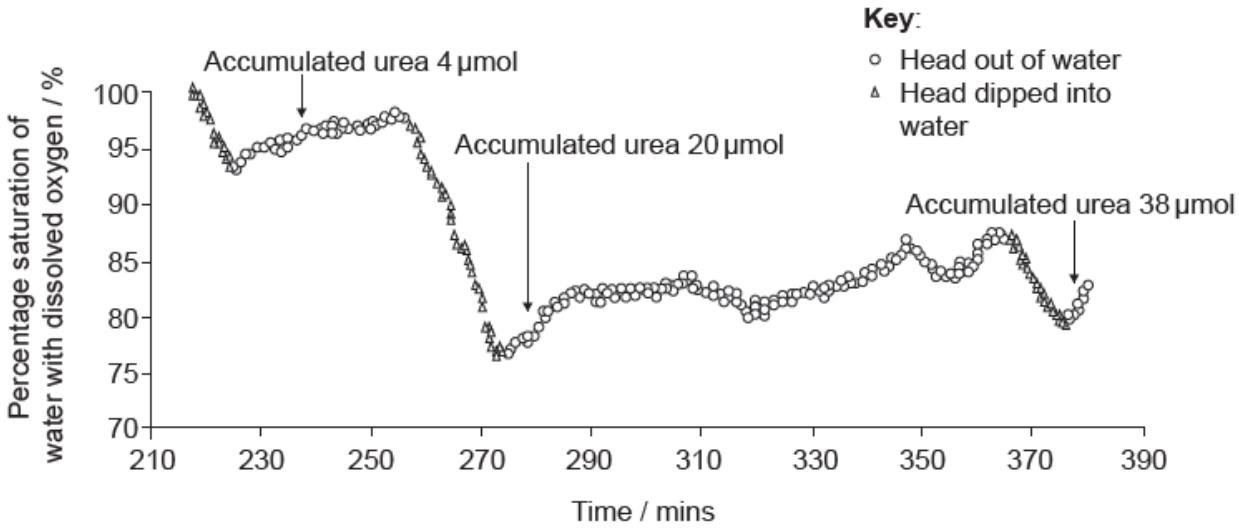
These turtles have fully developed lungs and kidneys, however, many microvilli have been discovered in the mouth of *P. sinensis*. A study was undertaken to test the hypothesis that oxygen uptake and urea excretion can simultaneously occur in the mouth.

Initial experiments involved collecting nitrogen excretion data from *P. sinensis*. The turtle urinates both in water and out of water. When in water it allows waste products to be washed out of its mouth. When out of water it regularly dips its head into shallow water to wash its mouth. The table shows the mean rates of ammonia and urea excretion from the mouth and kidney over six days.

| | Excretion of nitrogen by the mouth / μmol $day^{-1}$ $g^{-1}$ turtle | | Excretion of nitrogen by the kidney / μmol $day^{-1}$ $g^{-1}$ turtle | |
|---|---|---|---|---|
| | Turtle submerged in water | Turtle out of water | Turtle submerged in water | Turtle out of water |
| **Ammonia** | 0.29 | 0.30 | 0.63 | 0.54 |
| **Urea** | 0.90 | 1.56 | 0.07 | 0.73 |

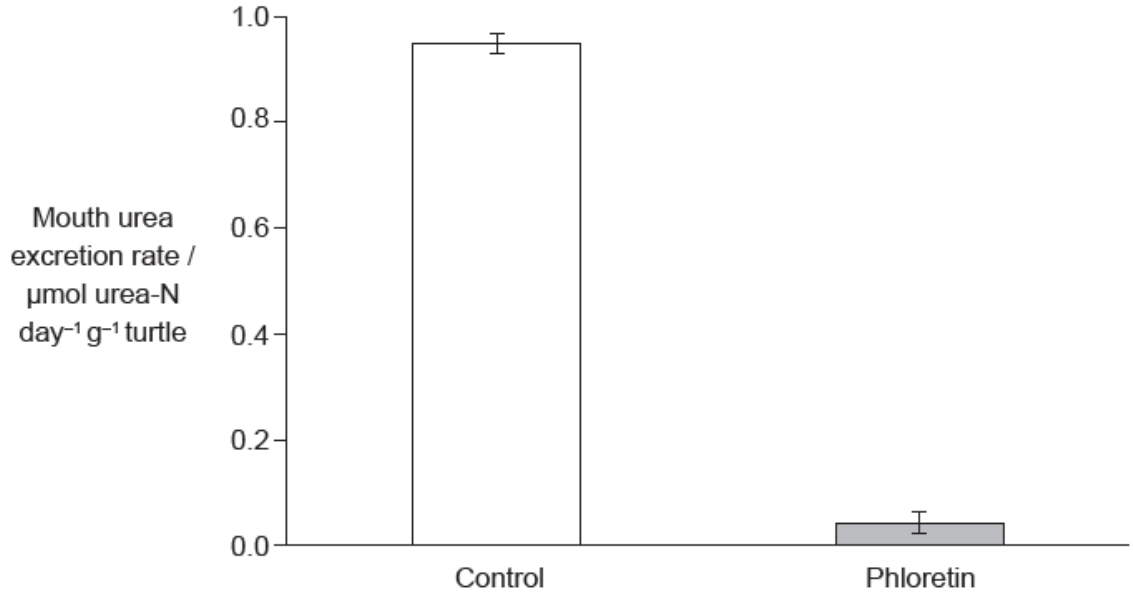
[Source: Reproduced with permission, Y. Ip *et al*. (2012) *The Journal of Experimental Biology*, 215, pages 3723—3733. jeb.biologists.org. doi: 10.1242/jeb.068916]

It was noted that during long periods out of water, turtles rhythmically moved their mouths to take in water from a shallow source and then discharge it. Changes in the dissolved oxygen and the quantity of accumulated urea in the rinse water discharged by the turtles were monitored over time as shown in this graph.



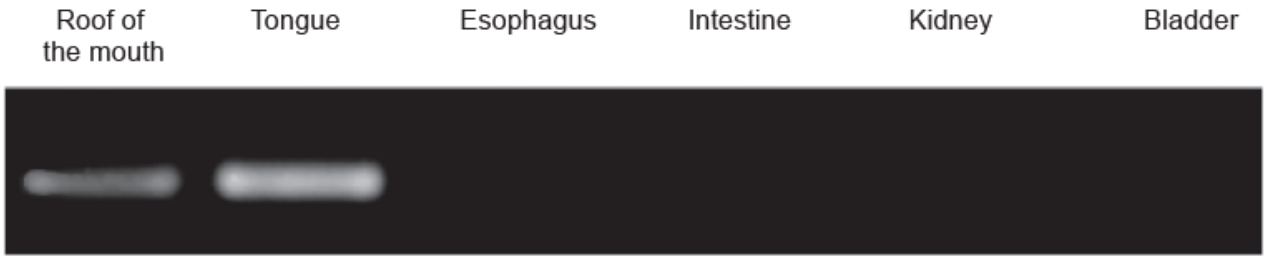

[Source: adapted with permission from Y. Ip *et al*. (2012) *The Journal of Experimental Biology*, 215, pages 3723–3733.]

In order to test whether a urea transporter was present in the mouth tissues of the turtles, phloretin (a known inhibitor of membrane proteins that transport urea) was added to the water in which a further set of turtles submerged their heads. The results of that treatment are shown.



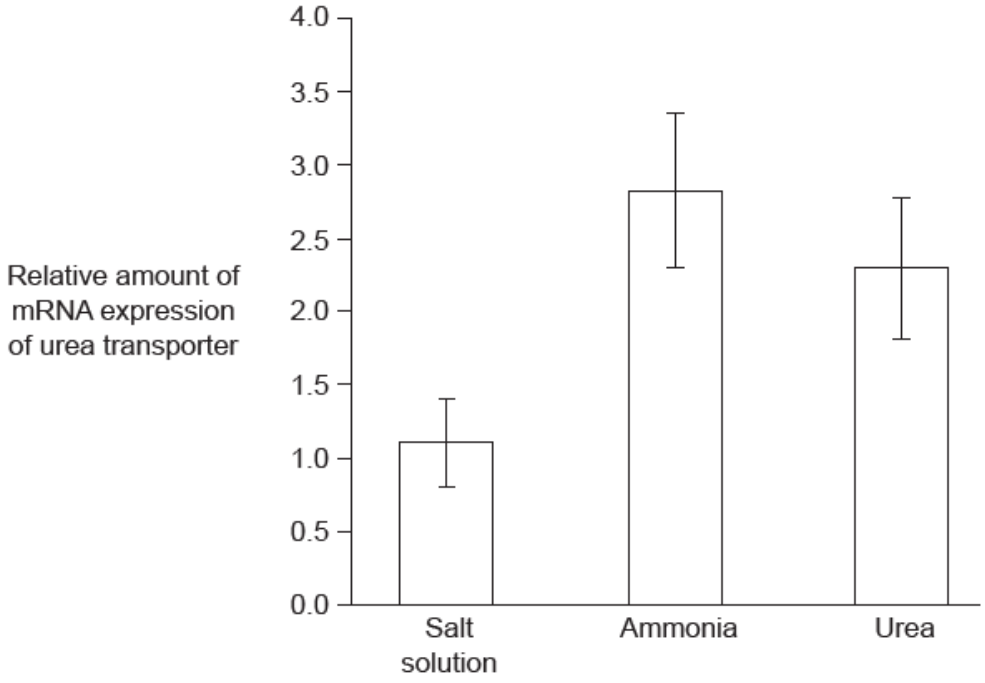

[Source: Reproduced with permission from Y. Ip *et al*. (2012) *The Journal of Experimental Biology*, 215, pages 3723–3733. jeb.biologists.org.]

Further research was conducted to determine where mRNA expression of a urea transporter gene might be occurring in *P. sinensis*. Gel electrophoresis was used to analyse different tissue samples for mRNA activity.




[Source: Reproduced with permission from Y. Ip *et al*. (2012) *The Journal of Experimental Biology*, 215, pages 3723–3733. jeb.biologists.org.]

Expression of the urea transporter gene by cells in the turtle's mouth was assessed by measuring mRNA activity. Turtles were kept out of water for 24 hours and then injected with either a salt solution that matched the salt concentration of the turtle, dissolved ammonia or urea, followed by another 24 hours out of water.




[Source: © International Baccalaureate Organization 2017]

a. Deduce whether the excretion of ammonia or urea changes more when a turtle emerges from water. [2]

b. Compare and contrast the changes in urea excretion in the mouth with the changes in urea excretion in the kidney when a turtle emerges from the water. [3]

c.i. Describe the trends shown by the graph for dissolved oxygen in water discharged from the mouth. [1]

c.ii. Suggest reasons for these trends in dissolved oxygen. [2]

d. Deduce with a reason whether a urea transporter is present in the mouth of *P. sinensis*. [2]

e. Outline the additional evidence provided by the gel electrophoresis results shown above. [2]

f.i. Identify which of these turtle groups represent the control, giving a reason for your answer. [1]

f.ii. Suggest a reason for the greater expression of the gene for the urea transporter after an injection with dissolved ammonia than an injection of urea. [2]

g. The salt marshes where these turtles live periodically dry up to small pools. Discuss the problems that this will cause for nitrogen excretion in the turtles and how their behaviour might overcome the problems. [3]

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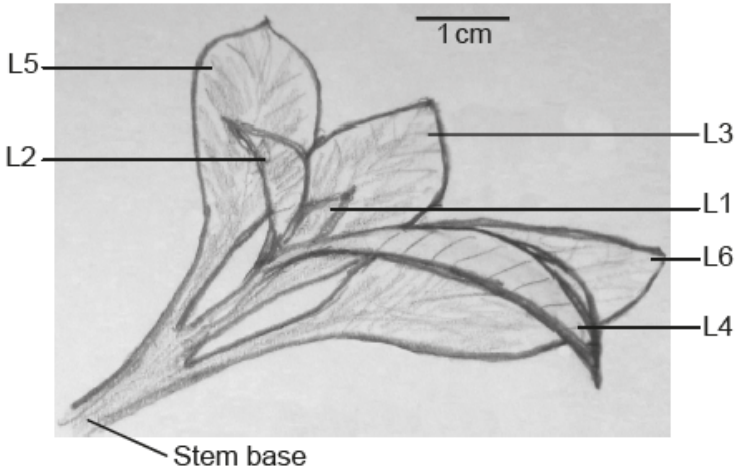
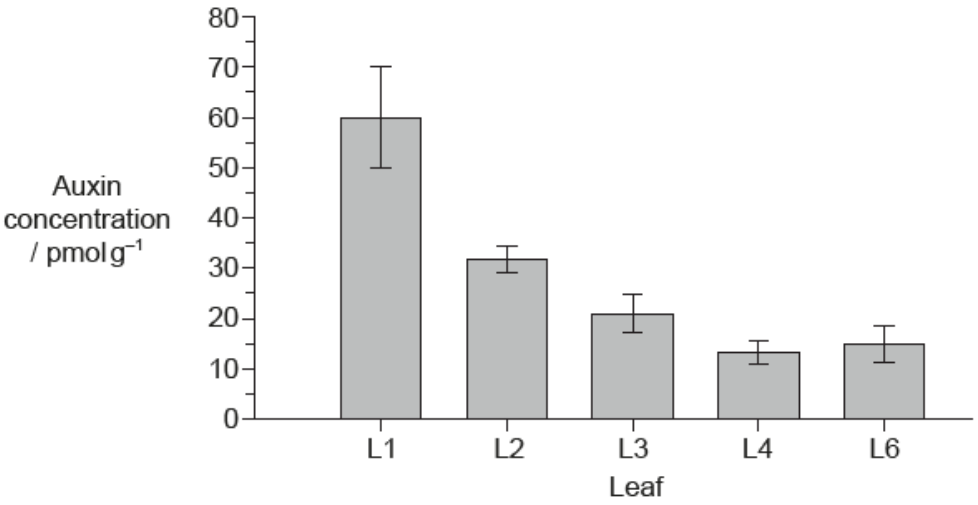
Auxin can be used to promote the development of roots from stem and leafy cuttings in some plants. In a study into the distribution of auxin in the development of these roots, scientists measured the amount of auxin in different leaves of a shoot tip of *Petunia hybrida*.

The figure indicates the numbering of leaves on the shoot, from L1 as the youngest and smallest to L6 as the largest and oldest leaf. The developmental stage of L5 and L6 was very similar, so L5 was not analysed. The stem base is the lowest part of the cutting where roots may form.




[Source: A. Ahkami *et al.* (2013) *Planta*, 238, pages 499–517]

The graph shows the auxin concentration in the different leaves.




[Source: A. Ahkami *et al.* (2013) *Planta*, 238, pages 499–517]

N-1-naphthylphthalamic acid (NPA) is an inhibitor used to block auxin transport. NPA was sprayed onto the leaves of a set of cuttings for 14 days.

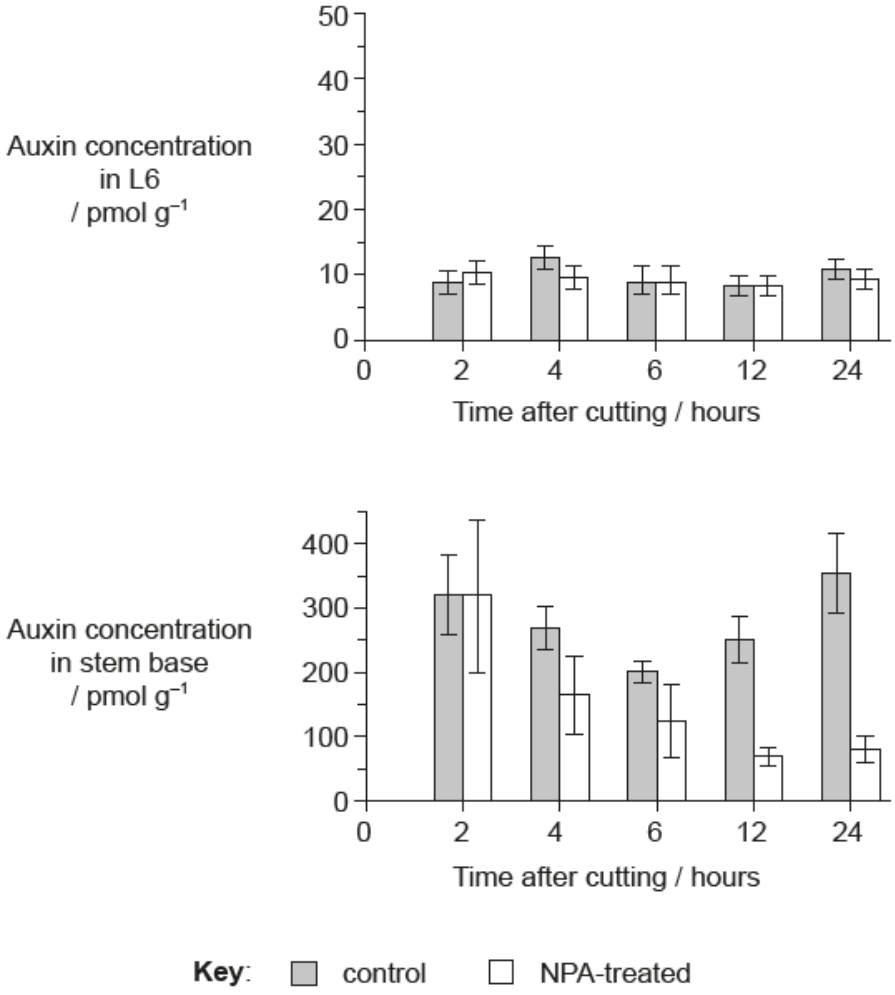
Development of the roots in control (non-treated) and NPA-treated cuttings was measured 14 days after taking the cuttings.

The table shows the influence of NPA on rooting.

| | **Mean number of roots per cutting** | **Mean root length / cm** | **Mean total root length per cutting / cm** |
|---|---|---|---|
| **Control** | 53.2 | 1.4 | 47.7 |
| **NPA-treated** | 8.0 | 0.6 | 1.0 |

[Source: adapted from A Ahkami, *et al.*, (2013), *Planta*, **238**, pages 499–517]

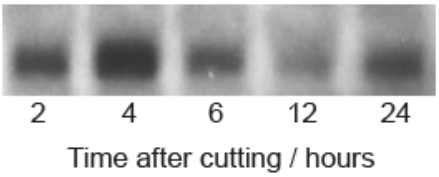
The scientists also measured the changes in auxin concentration in L6 and the stem base during the early period of root formation. They recorded the concentration in the control and NPA-treated cuttings for 24 hours after taking the cuttings.




[Source: adapted from A Ahkami, *et al*., (2013), *Planta*, **238**, pages 499–517]

The scientists wanted to know whether the accumulation of auxin over time in the stem base of the controls affected expression of the *GH3* gene, known to have a role in growth regulation in different plants. The technique that was used to quantify the level of transcription of the *GH3* gene was Northern blotting. In this procedure the darkness

and thickness of the band is an indicator of the level of transcription of a particular gene. The image shows the result of the Northern blot from 2 hours to 24 hours after cutting.




[Source: adapted from A Ahkami, *et al*., (2013), *Planta*, **238**, pages 499–517]

a. Calculate the difference in the concentration of auxin found in L1 and L6. [1]

. . . . . pmol $g^{-1}$

b. Identify the relationship between the concentration of auxin and the age of the different leaves. [2]

c. Analyse the effect of NPA on the formation of roots. [2]

d.i. Compare and contrast the changes in auxin concentration in the stem base over time for the control and NPA-treated cuttings. [2]

d.ii. Deduce the effect of NPA on auxin transport between L6 and the stem base. [2]

e. Based on all the data presented and your knowledge of auxin, discuss the pattern of auxin production and distribution in the leaves and the possible relationship to root formation in leafy cuttings of *Petunia hybrida*. [3]

f.i. State the name of the molecule which is produced by transcription. [1]

f.ii. Compare the pattern of *GH3* transcription with the pattern of auxin concentration in the stem base control cuttings. You may use the table provided to help you to record the patterns before you compare them. (Please note: a simple comparison in the table will not gain marks) [2]

| | 2–4 hours | 4–6 hours | 6–12 hours | 12–24 hours |
|---|---|---|---|---|
| **Auxin concentration** | | | | |
| ***GH3* bands** | | | | |

f.iii. The scientists concluded that auxin activates the transcription of the *GH3* gene. Using the information on the auxin concentration in the stem base in the graph and the Northern blot, evaluate whether this conclusion is supported. [2]