

Please check the examination details below before entering your candidate information

Candidate surname <i>StemUp Model Solution</i>		Other names
Centre Number	Candidate Number	

Pearson Edexcel Level 3 GCE

Friday 16 June 2023

Morning (Time: 1 hour 45 minutes)

Paper reference **9BI0/02**

Biology B

Advanced

PAPER 2: Advanced Physiology, Evolution and Ecology

You must have:
Scientific calculator, HB pencil, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
– *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- In question(s) marked with an **asterisk (*)**, marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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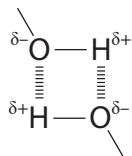

Pearson

Answer ALL questions. Write your answers in the spaces provided.

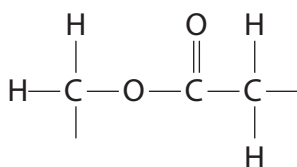
Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Carbohydrates and proteins are important biological molecules.

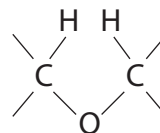
(a) The diagrams show some of the bonds found in biological molecules.



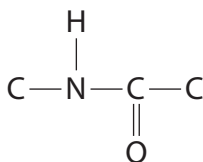
V



W



X



Y



Z

(i) Which one of the letters shows a bond that joins glucose molecules together in a disaccharide?

(1)

- ☐ A W
- ☒ B X
- ☐ C Y
- ☐ D Z



(ii) Which letters show bonds that hold together the tertiary structure of a protein?

(1)

- ☐ **A** V and X
- ☒ **B** V and Z
- ☐ **C** W and Y
- ☐ **D** W and Z

(iii) Which letter shows a bond that holds together cellulose molecules within a cellulose microfibril?

(1)

- ☒ **A** V
- ☐ **B** W
- ☐ **C** X
- ☐ **D** Y

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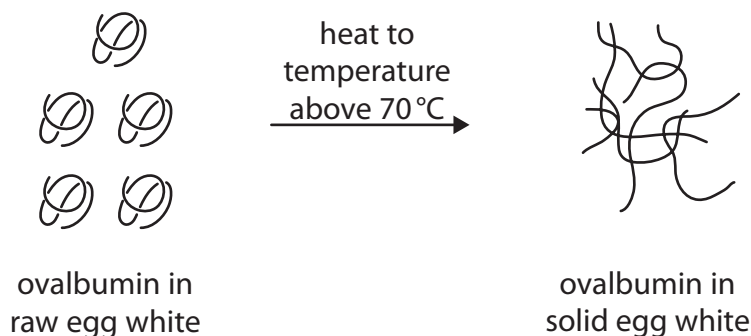


(b) Raw egg white is a liquid containing dissolved ovalbumin, a globular protein.

Ovalbumin has some amino acids with polar R-groups and some amino acids with non-polar R-groups.

If raw egg white is heated to a temperature above 70°C , it irreversibly changes into a solid.

The diagram shows how the structure of ovalbumin changes when heated.



Explain why heating ovalbumin to temperatures above 70°C causes egg white to change from a liquid into a solid.

(3)

In raw egg white ovalbumin is folded so that the polar (hydrophilic) R-groups are on the outside and the non-polar (hydrophobic) R-groups are on the inside.

The polar groups form hydrogen bonds with water molecules, so ovalbumin is soluble and the egg white is a liquid.

Heating above 70°C denatures the ovalbumin: the hydrogen bonds and ionic bonds holding the tertiary structure break, so the molecule unfolds.

This exposes the non-polar (hydrophobic) groups, and new bonds form between the hydrophobic groups of different ovalbumin molecules, so they join into a tangled network that forms a solid.

(Total for Question 1 = 6 marks)

2 Bromelain is a protease enzyme in pineapple juice.

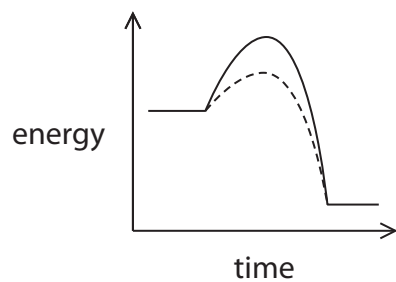
- (a) Which graph shows the energy changes that occur in a typical enzyme catalysed reaction?

(1)

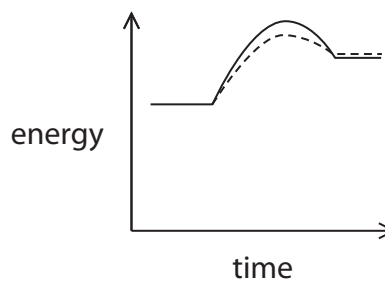
Key:

— without enzyme

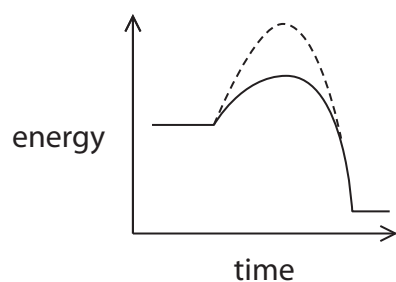
----- with enzyme



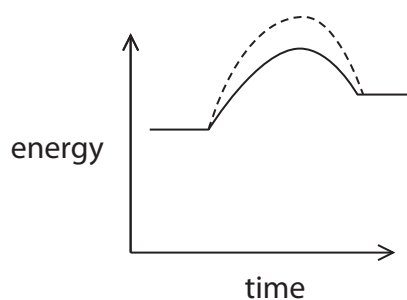
W



X



Y



Z

☒ **A** W

☐ **B** X

☐ **C** Y

☐ **D** Z



(b) A student investigated the digestion of gelatine protein by pineapple juice.

This is the method used.

Step 1: Make a solid disc of gelatine protein, with a depth of 1 cm, in a Petri dish.

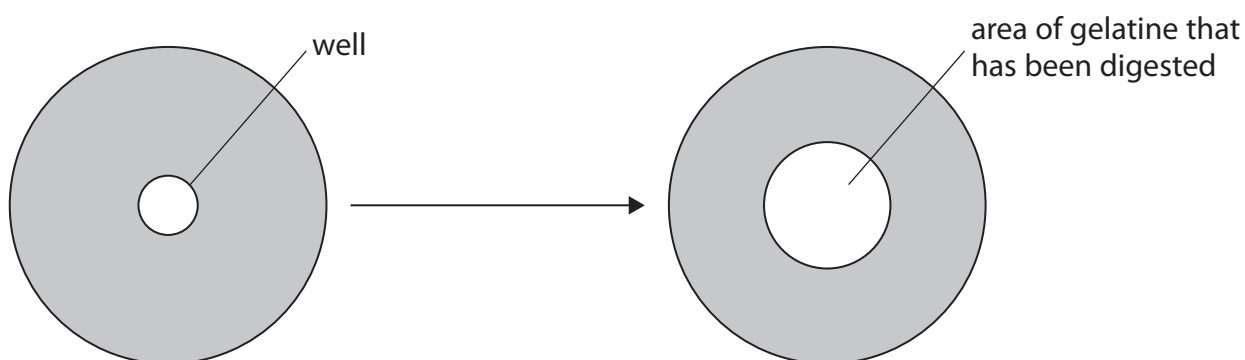
Step 2: Cut out a circular well with a diameter of 2 cm in the centre of the disc.

Step 3: Fill the well with pineapple juice.

Step 4: Incubate the dish for one hour at 37 °C.

Step 5: Measure the diameter of the area that has been digested by the bromelain enzyme.

The diagram shows a gelatine disc before and after incubation with the pineapple juice.



The diameter of the circular area that had been digested after one hour was 6 cm.

Calculate the volume of gelatine that had been digested.

Give your answer, in mm^3 , to two significant figures.

Volume of a cylinder = $\pi r^2 l$

$\pi = 3.14$

(3)

r (digested area) = 30 mm, r (well) = 10 mm, l = 10 mm

$V = (3.14 \times 30^2 \times 10) - (3.14 \times 10^2 \times 10)$

$V = 28\,260 - 3140 = 25\,120 \text{ mm}^3$

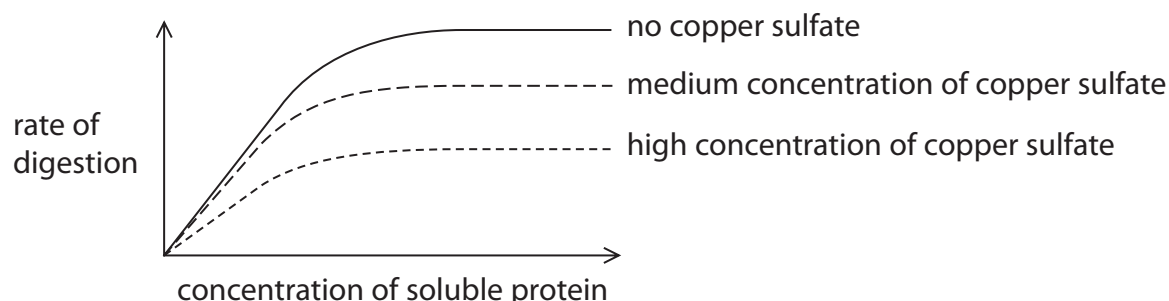
Answer 25 000 mm^3



- (c) Bromelain also digests other proteins.

The student also investigated the effects of changing the concentration of a soluble protein, and the addition of copper sulfate on the rate of digestion of this soluble protein by bromelain.

The results are shown in the graph.



- (i) Explain the effect of increasing substrate concentration on the rate of digestion of the soluble protein.

(2)

As substrate concentration increases the rate of digestion increases, then levels off.

At low concentrations substrate is the limiting factor: there are unoccupied active sites, so more substrate gives a higher chance of enzyme-substrate collisions and more enzyme-substrate complexes form.

The rate levels off when all the active sites are occupied, so enzyme concentration is limiting.

- (ii) Explain the effect of copper sulfate on the rate of digestion of the soluble protein.

(2)

Copper sulfate lowers the rate of digestion, and the higher its concentration the lower the maximum rate, because it is a non-competitive inhibitor.

Copper ions bind to the enzyme away from the active site (an allosteric site) and change its tertiary structure, so the shape of the active site changes.

The substrate can no longer bind, so fewer enzyme-substrate complexes form, even at high substrate concentration.

(Total for Question 2 = 8 marks)



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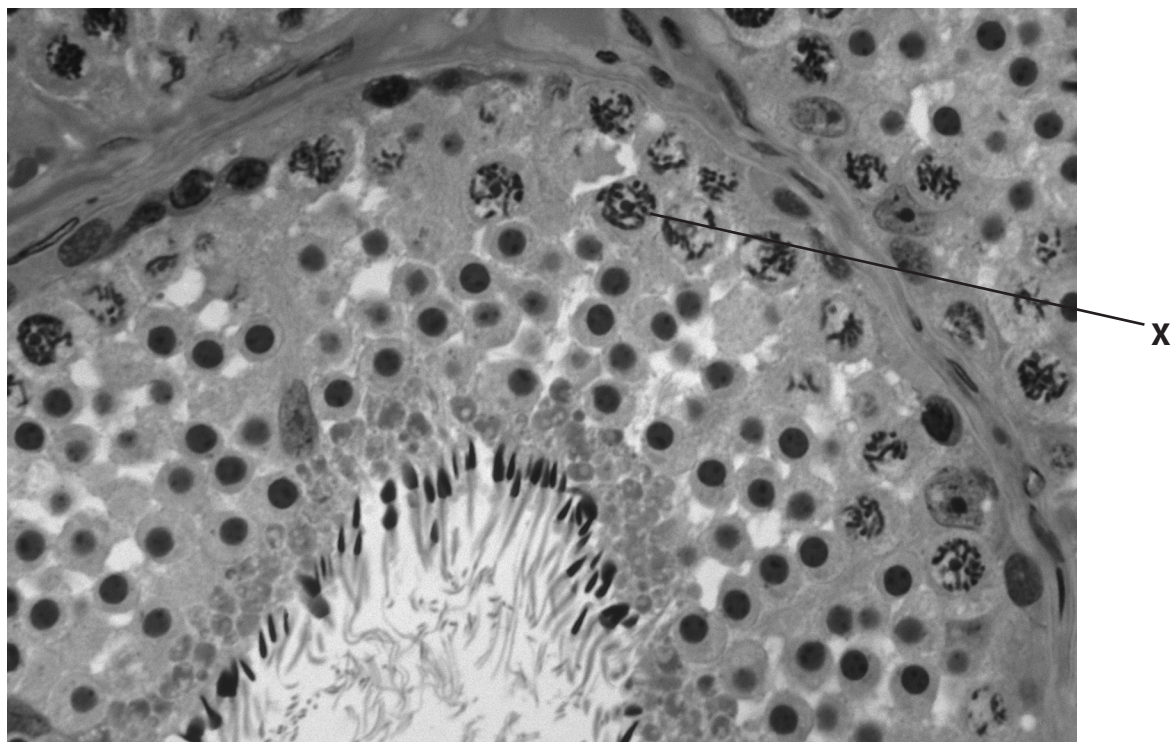
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3 The photograph shows part of a testis, as seen using a light microscope.



(Source: © M. I. WALKER / SCIENCE PHOTO LIBRARY)

(a) The cell labelled X is a primary spermatocyte.

(i) At which stage of cell division is cell X?

(1)

- ☒ A prophase I of meiosis
☐ B prophase II of meiosis
☐ C prophase I of mitosis
☐ D prophase II of mitosis

(ii) In the photograph, cell X has a width of 0.8 cm.

The magnification of the photograph is $\times 1500$.

Calculate the actual width, in micrometres (μm), of cell X.

Give your answer to one decimal place.

(2)

$$0.8 \text{ cm} = 8000 \mu\text{m}$$

$$\text{actual size} = \text{image} \div \text{magnification} = 8000 \div 1500 = 5.333\dots$$

Answer 5.3 μm

- (b) Some pregnancies do not develop to full term, so no baby is born.

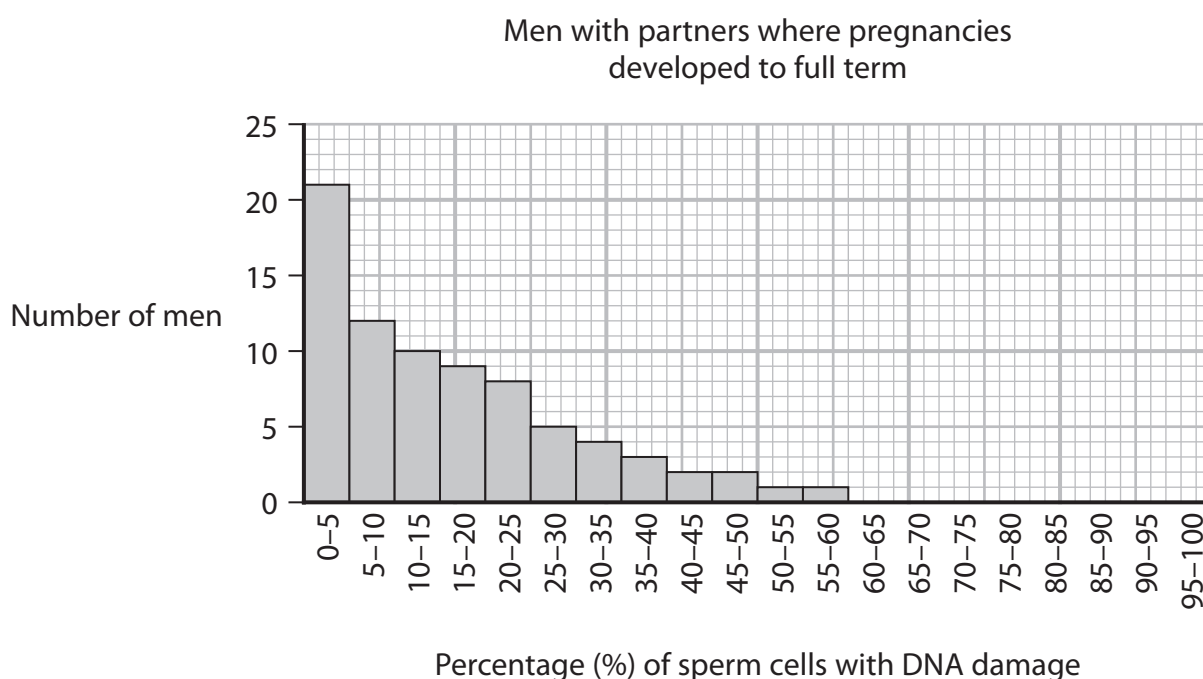
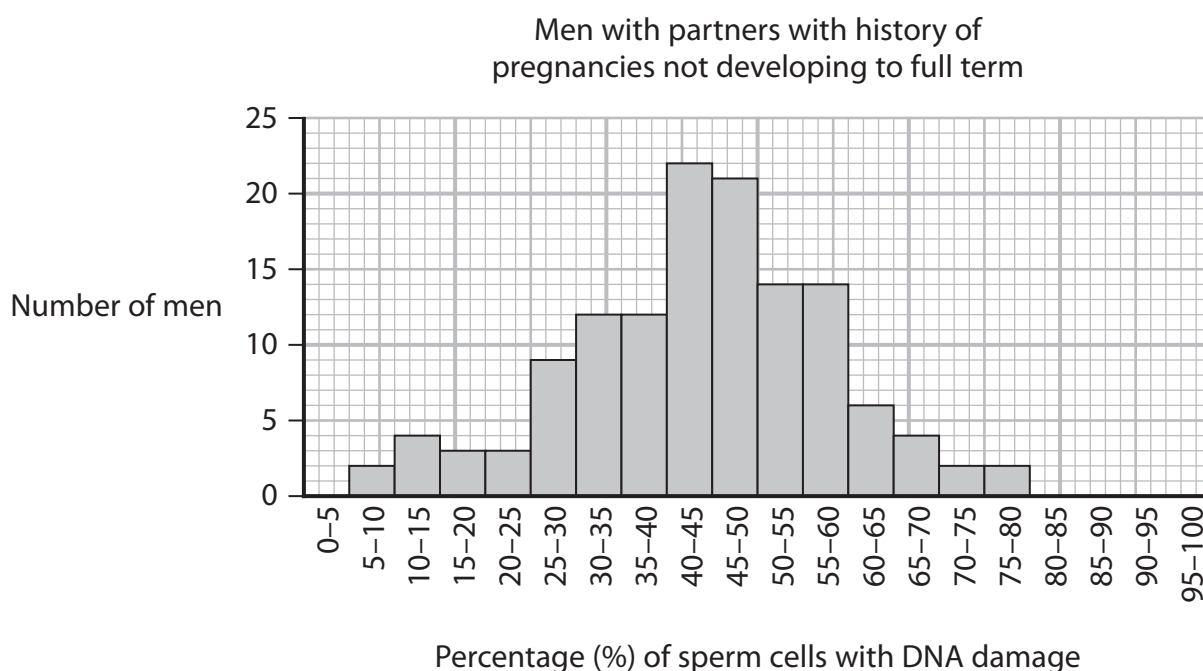
Damage to the DNA of sperm is thought to be one cause of pregnancies not developing to full term.

Scientists investigated if there is an association between the production of sperm with damaged DNA and the risk of pregnancies not developing to full term.

The percentage of sperm cells with DNA damage was determined for 130 men where there was a history of pregnancies not developing to full term.

The percentage of sperm cells with DNA damage was measured for 78 men where pregnancies developed to full term.

The graphs show the results of this investigation.



- (i) Calculate the number of men with partners that have a history of pregnancies not developing to full term that had 25% or less of sperm with DNA damage.

(1)

$$2 + 4 + 3 + 3 = 12$$

Answer 12

- (ii) The scientists concluded that having more than 25% of sperm with damaged DNA leads to a high risk of pregnancies not developing to full term.

Analyse the data to evaluate this conclusion.

(4)

Some data support the conclusion. For men whose partners had a history of pregnancies not going to full term, most had more than 25% DNA damage; only 12 of the 130 men (about 9%) had 25% or less, and the modal class is 40 to 45%. No men in this group had 0 to 5% damage.

In contrast, most men whose partners' pregnancies went to full term had less than 25% damage (60 of 78), the most common class was 0 to 5%, and none had more than 60% damage.

However, some men whose partners' pregnancies did go to full term had high DNA damage (18 of 78 had more than 25%, some with 55 to 60%), so high damage does not always lead to this. It only shows a correlation, not that damage causes it.

The sample sizes are small and uneven (130 and 78), other factors of the men were not accounted for, such as age, diet or genetic conditions, and maternal factors (e.g. the woman's age or health) also affect whether a pregnancy goes to full term.

(Total for Question 3 = 8 marks)

- 4 Saltmarshes are coastal habitats where silt (mud) is deposited. Saltmarshes are colonised by different species of plants and are regularly flooded with seawater.

The photograph shows an area of salt marsh.



(Source ©BOB GIBBONS / SCIENCE PHOTO LIBRARY)

- (a) Conditions close to the sea are very windy.

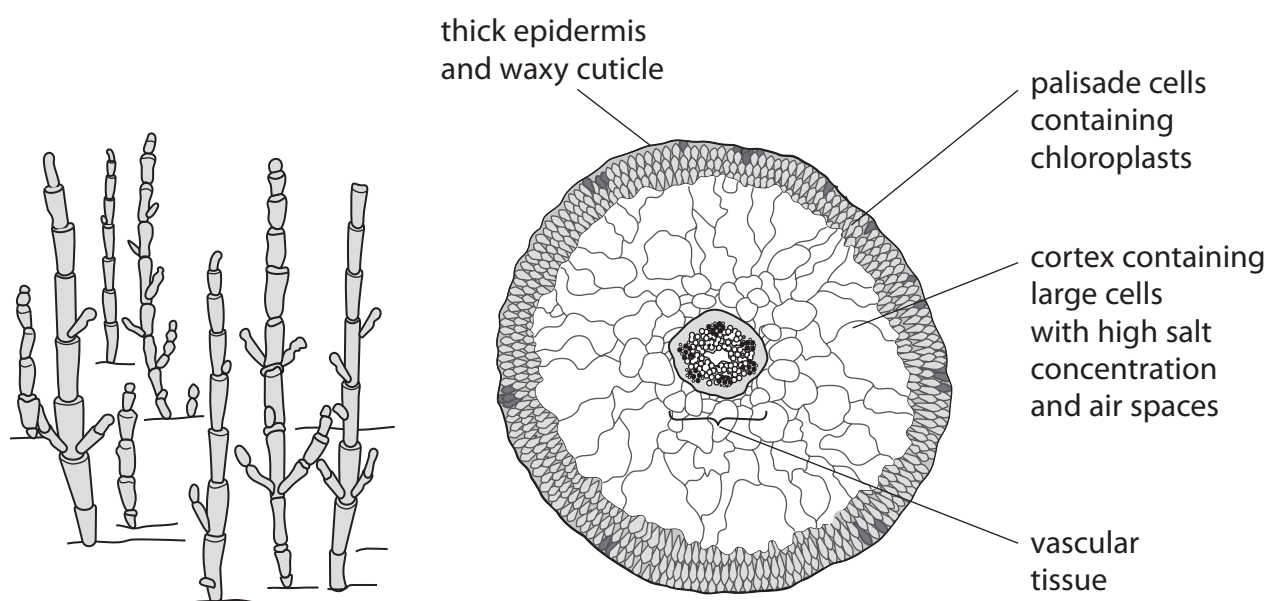
- (i) Which row in the table causes the highest rate of transpiration from a plant?

(1)

		Temperature	Wind speed	Air humidity
☐	A	high	high	high
☒	B	high	high	low
☐	C	high	low	high
☐	D	low	high	low

- (ii) Samphire is one of the few plants that can grow in the areas close to the sea. Samphire plants have very small leaves and swollen stems.

The diagrams show a samphire plant and a cross section through the stem of a samphire plant.



Explain how samphire is adapted to grow in areas of saltmarshes closest to the sea.

(4)

The very small leaves give a reduced leaf surface area, so less water is lost by transpiration (evaporation) in the windy conditions.

The thick epidermis and waxy cuticle reduce evaporation, so they reduce water loss.

As the leaves are small, the swollen stem is used as the photosynthetic organ: its palisade cells contain chloroplasts for photosynthesis.

The high salt concentration in the cortex cells lowers their water potential, maintaining a water potential gradient, so less water is lost by osmosis to the salty seawater and water can enter by osmosis.

When submerged, the air spaces provide oxygen for respiration and carbon dioxide for photosynthesis.

(b) A group of students investigated succession in a saltmarsh.

The students measured several factors at 5 m intervals along a transect, starting at the edge of the sea.

The factors measured were:

- ACFOR scales for samphire, sea lavender, and scurvy grass
- index of diversity of all plant species
- percentage of silt (mud) made up of organic material.

The results are shown in the table.

Factor		Distance from sea / m				
		0	5	10	15	20
ACFOR scales	Samphire	Abundant	Common	Rare	Absent	Absent
	Sea lavender	Absent	Rare	Common	Common	Rare
	Scurvy grass	Absent	Absent	Rare	Occasional	Abundant
Index of diversity for all plant species		0.20	0.54	0.85	2.54	2.85
Percentage of silt made up of organic material (%)		15	10	25	35	55

- (i) Give **two** limitations of using ACFOR scales to compare the distribution of different plant species.

(2)

ACFOR is qualitative, not quantitative (not numerical), so statistical tests cannot be

carried out on the results.

It is subjective and difficult to standardise, as different people make different estimates of abundance.



- (ii) Saltmarshes are produced by deposits of silt (mud) from rivers.

As the distance from the sea increases, the age of the saltmarsh increases.

Explain the changes in distribution of the species as distance from the sea increases.

(4)

Succession has occurred. Samphire is the pioneer species (coloniser): it is the only species with adaptations to live close to the sea, where it is salty, windy and often flooded, so it is abundant at 0 m.

Samphire roots bind the silt and stabilise the substrate. When the plants die, decomposition adds organic matter (humus), so organic material in the silt rises from 15% to 55%, giving more nutrients (minerals such as nitrates) for other species.

Further from the sea the abiotic factors change: it is more sheltered, with less wind, less salt and less frequent flooding. So sea lavender, then scurvy grass, can grow, and competition from them results in less samphire, which becomes rare then absent.

Sea lavender is then outcompeted by scurvy grass, which is abundant at 20 m, and the index of diversity increases from 0.20 to 2.85 as more species colonise the older marsh.

(Total for Question 4 = 11 marks)

5 The human retina contains photoreceptors called rod cells and cone cells.

(a) (i) Which of the following occur in the rod cell when it is stimulated by light?

(1)

- 1 rhodopsin breaks down into retinal and opsin
- 2 there is a decrease in the release of neurotransmitter molecules
- 3 there is more diffusion of sodium ions into the rod cell

- ☒ **A** 1 and 2
- ☐ **B** 1 and 3
- ☐ **C** 1, 2 and 3
- ☐ **D** 2 and 3

(ii) Explain why the centre of the retina is less sensitive to low intensity light than the outer areas.

(2)

The centre of the retina (fovea) has mostly cones and few rods, while the outer areas have more rods. Cone cells (iodopsin) are less sensitive to low light intensity than rods (rhodopsin).

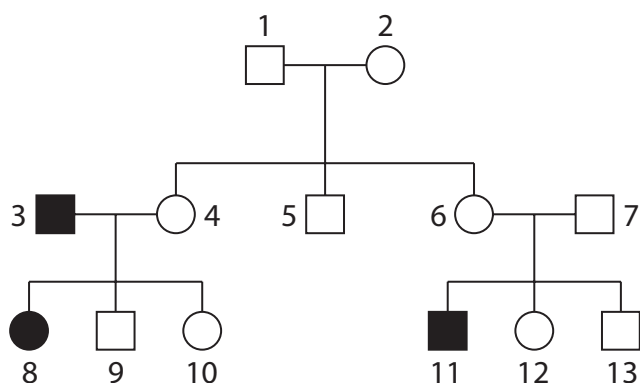
Each cone connects to its own bipolar neurone, so there is no spatial summation (convergence), whereas several rods converge on one bipolar neurone so their generator potentials summate to reach threshold.



- (b) Red-green colour blindness is a sex-linked genetic condition. People with this condition are unable to detect differences between red and green colours.

The pedigree diagram shows the inheritance of red-green colour blindness in a family.

The allele for red-green colour blindness, X^r , is recessive to the allele for colour vision, X^R .



Key:

- ☐ male without colour blindness
- ☒ male with colour blindness
- ☐ female without colour blindness
- ☒ female with colour blindness

- (i) How many of the individuals in the family must have a genotype of $X^R X^r$?

(1)

- ☐ A 2
- ☐ B 3
- ☒ C 4
- ☐ D 5

- (ii) Explain how this pedigree diagram demonstrates that red-green colour blindness is caused by a recessive allele.

(2)

Individuals 6 and 7 are both not colour blind, but their son 11 is colour blind. Son 11

inherited his X chromosome from his mother, so 6 must be a carrier (heterozygous, $X^R X^r$) with a hidden recessive allele.

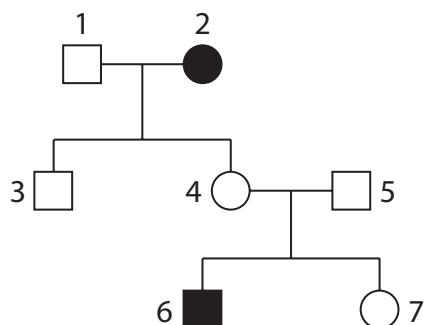
If the allele were dominant, 6 would have to be colour blind herself, so the allele must be recessive.

(c) Pingelap is an isolated island in the Pacific Ocean.

On Pingelap, between 4% and 10% of the population has a condition called achromatopsia. This means that they are unable to see any colour.

In most other countries, the incidence of achromatopsia is around 0.003%.

- (i) The pedigree diagram shows the people who are and are not affected with achromatopsia in a family.



Key:

- male without achromatopsia
- male with achromatopsia
- female without achromatopsia
- female with achromatopsia

Deduce how achromatopsia is inherited.

Use the information in the pedigree diagram to support your answer.

(3)

Achromatopsia is caused by a recessive allele that is not sex linked, as it is on an autosome (autosomal recessive).

It is recessive because 4 and 5 are not affected but their son 6 is affected, so 4 and 5 must both be carriers (heterozygous).

It cannot be sex linked because 2 is an affected female; if it were X-linked all her sons would be affected, but her son 3 is not affected.

- (ii) In 1755, a tsunami reduced the population to 20 people and there has been little immigration to the island.

In 2022, the human population of Pingelap was approximately 250.

Explain why the incidence of achromatopsia is higher in Pingelap than in other countries.

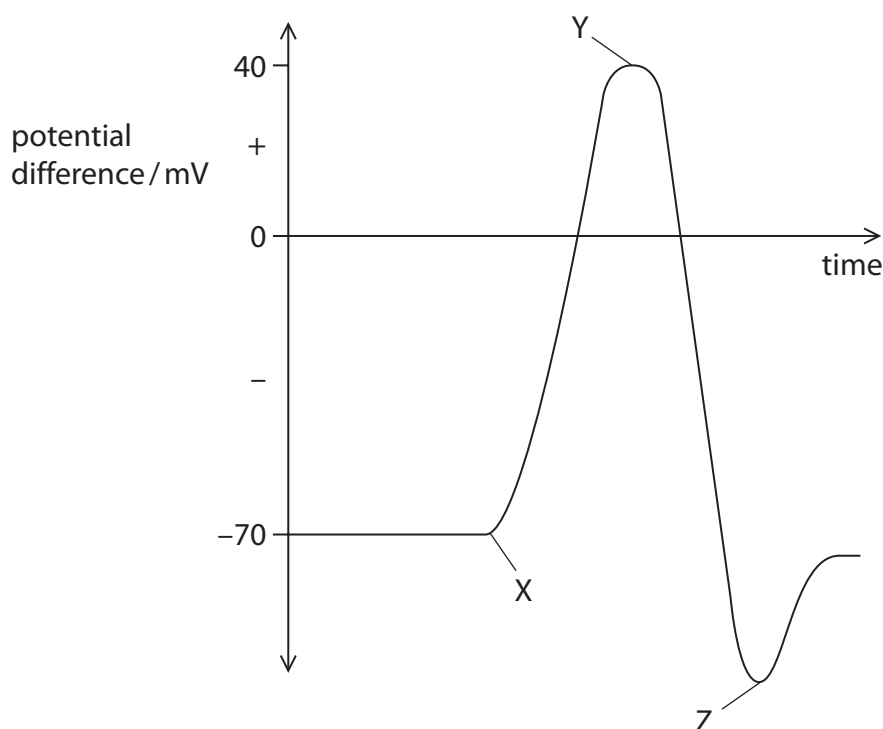
(2)

The tsunami caused a population bottleneck (founder effect): by chance many of the 20 survivors carried the allele, so the frequency of the affected allele increased in the small gene pool.

Little immigration means few new alleles were introduced, so many people are carriers and there is a higher chance of two heterozygous carriers having children together.

(Total for Question 5 = 11 marks)

6 The diagram shows an action potential in a neurone.



(a) (i) Which of the following causes the change in potential between X and Y?

(1)

- ☐ A movement of calcium ions out of the neurone
- ☐ B movement of potassium ions out of the neurone
- ☒ C movement of sodium ions into the neurone
- ☐ D movement of sodium ions out of the neurone

(ii) Explain how membrane proteins cause the change in potential between Y and Z.

(2)

Between Y and Z the voltage-gated sodium channels close and voltage-gated potassium channels open, so the membrane becomes more permeable to potassium ions.

K⁺ ions diffuse out of the neurone, repolarising the membrane (and making it more negative than resting at Z).

(b) The photograph shows an African crested rat.



(Source: © https://commons.wikimedia.org/wiki/File:Lophiomys_imhausi.jpg)

This rat has several adaptations to prevent it being eaten by predators.

These adaptations include:

- The rat chews the bark of a tree called the arrow tree. The bark of this tree contains a poison called ouabain.
- The rat rubs the poison onto its fur, which is hollow to absorb the poison.
- The rat produces proteins in its saliva that prevent the ouabain harming it.

(i) Which types of adaptation has the rat evolved?

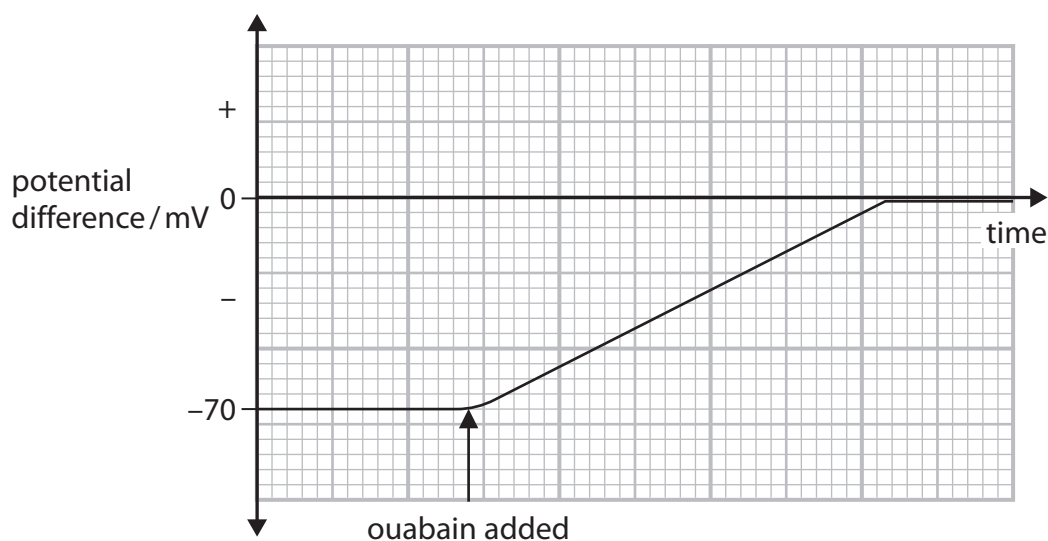
- 1 anatomical
- 2 behavioural
- 3 physiological

- ☐ A 1 and 2
- ☒ B 1, 2 and 3
- ☐ C 1 and 3
- ☐ D 2 and 3

(1)

(ii) Ouabain inhibits sodium–potassium exchange pumps.

The diagram shows the effect of ouabain on the potential difference across a motor neurone membrane.



Explain how ouabain prevents the transmission of nerve impulses.

(3)

Ouabain inhibits the sodium–potassium pumps, so fewer sodium ions are pumped out of the neurone and fewer potassium ions are pumped in.

Sodium ions leak in through the membrane, so the resting potential is not maintained; the potential difference rises from -70 mV to 0 mV, so there is no potential difference across the membrane.

There is no longer a diffusion gradient for sodium ions, so when stimulated sodium ions will not diffuse in. The membrane cannot depolarise and no action potential can occur, so nerve impulses are not transmitted.

(Total for Question 6 = 7 marks)

- 7 Scientists investigated the role of ex-situ conservation of plant species on genetic biodiversity.

The scientists investigated the variability of DNA sequences of 30 different genes for a number of species of plants in seed banks and in the wild.

- (a) (i) Which row gives correct statements about the genetic code in eukaryotes?

(1)

	Overlapping	Degenerate	Contains introns in genes
☐ A	yes	yes	yes
☐ B	yes	no	yes
☐ C	no	yes	no
☒ D	no	yes	yes

- (ii) Explain why the DNA sequences of genes are more variable than the sequences of amino acids in the proteins coded for by these genes.

(2)

The genetic code is degenerate: most amino acids are coded for by more than one triplet, so many base changes do not change the amino acid.

Genes also contain introns (non-coding DNA) that are not translated, so changes in them do not affect the protein.

- (iii) Describe how the scientists could use technology to find out whether gene sequences of two species are similar.

(2)

Use DNA sequencing (Sanger sequencing) to find the base sequence of each gene in both species, after amplifying the DNA by PCR.

Then use bioinformatics to compare the sequences in databases and count the differences (or compare DNA band patterns after gel electrophoresis).

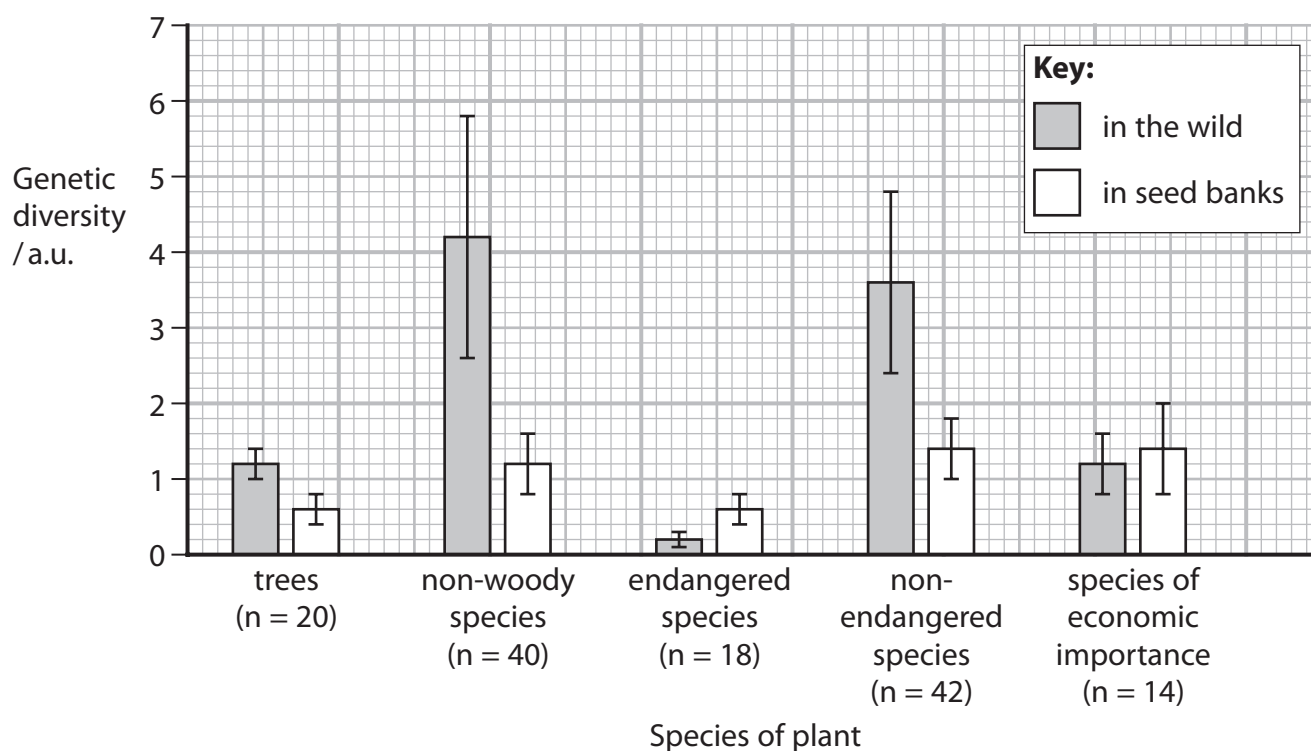
*(b) The scientists measured the mean genetic diversity of species in the wild and the mean genetic diversity of the same species in seed banks.

The species examined included:

- trees
- non-woody species of plant
- plant species classed as endangered
- plant species classed as not endangered
- plants of economic importance that are harvested by people.

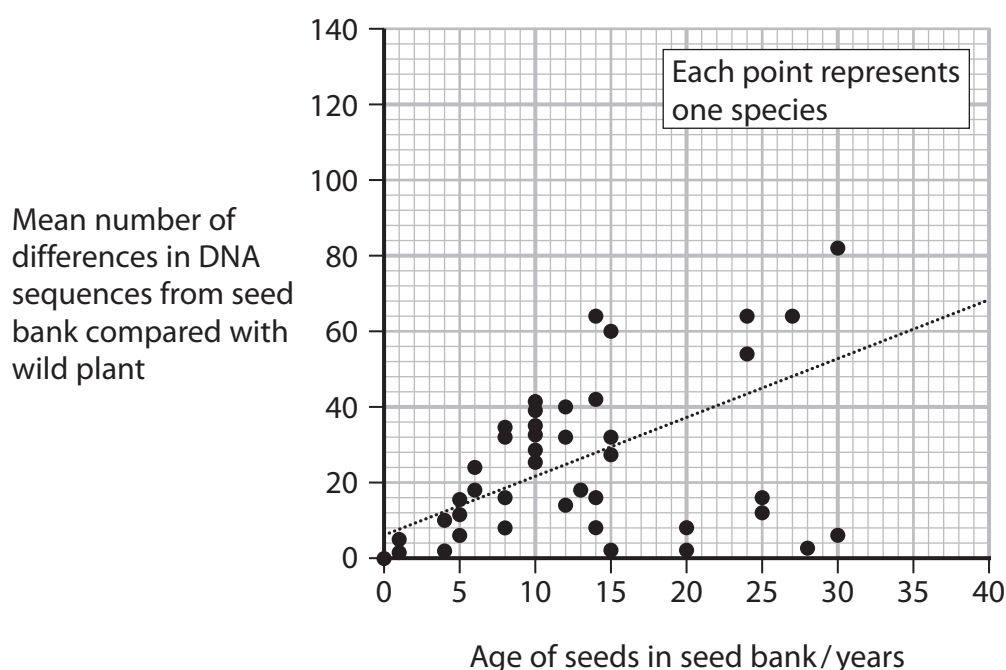
The scientists also measured the mean number of differences in the DNA sequences of the seeds that had been stored for different lengths of time compared with plants in the wild.

The graphs show the results.



Error bars represent ± 1 standard deviation
 n = number of different species





Analyse the data to discuss the results of this investigation.

(6)

Diversity is higher in the wild than in seed banks for trees (about 1.2 v 0.6 a.u.), non-woody species (4.2 v 1.2) and non-endangered species (3.6 v 1.4). However, for endangered species (0.2 v 0.6) and species of economic importance (1.2 v 1.4) it is higher in seed banks.

In the wild, breeding (meiosis, crossing over, mutation) and gene flow generate variation and natural selection acts. In seed banks there is no breeding and only a sample of seeds is stored, so fewer alleles are kept. Non-woody species reproduce quickly, so have high diversity; trees grow slowly and live long, so breed less.

Non-endangered species have large populations with more breeding. Endangered species have suffered a genetic bottleneck and inbreeding, so the wild gene pool is small; seed banks may hold seeds stored before the decline, so conserve more diversity.

Non-woody and non-endangered species have large standard deviations, trees and endangered species small ones. The error bars overlap for endangered species and for species of economic importance, so these differences may not be significant, but not for non-woody and non-endangered species, so those are probably significant. Group

sizes differ (14 to 42), reducing validity.

The scatter graph shows a positive correlation: the older the seeds, the more differences in DNA from wild plants, as wild plants keep changing by selection and drift. But there are many outliers, few points for old seeds, and we do not know which point is which species.

So seed banks help conserve genetic diversity, especially of endangered species, but stored plants should be regrown and rebred regularly to maintain diversity.

(Total for Question 7 = 11 marks)



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- 8 (a) Explain why a double circulatory system enables mammals to have a high metabolic rate.

(2)

Oxygenated and deoxygenated blood are kept separate, and blood is pumped at high pressure to the body but lower pressure to the lungs.

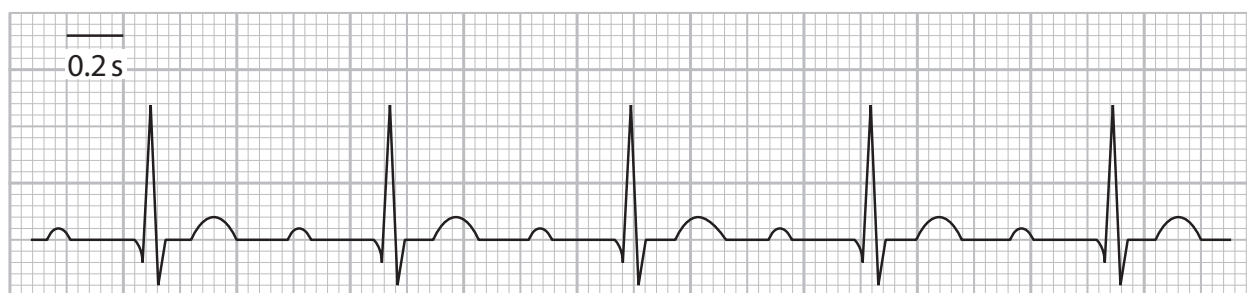
So oxygen for respiration is delivered to the tissues at a high rate, allowing a high metabolic rate.

- (b) Abnormal heart rhythms can be identified in ECG traces.

The diagram shows ECG traces of a person with a regular, healthy heart rhythm and a person with an abnormal heart rhythm.



Person with regular heart rhythm



Person with abnormal heart rhythm

- (i) Calculate the heart rate, in beats per minute, of the person with an abnormal heart rate.

Give your answer to the nearest whole number.

(2)

$$\text{one heart cycle (R to R)} = 0.85 \text{ s}$$

$$\text{heart rate} = 60 \div 0.85 = 70.6$$

Answer 71 beats per minute

- (ii) Explain how the ECG traces show this abnormal heart rhythm is due to damage to the septum in the centre of the heart between the left and right sides.

(2)

The abnormal trace has a longer gap between the P wave and the QRS complex (extended PQ time) than the regular trace.

So ventricular systole is delayed after atrial systole, because the impulse takes longer to pass through the bundle of His and Purkinje fibres in the damaged septum.

- (iii) Bradycardia is a heart condition that results in a heart rate that is slower than normal.

Atropine is a drug that can be used to treat some forms of bradycardia.

Atropine is a competitive inhibitor of acetylcholine.

Explain why atropine will lead to an increase in heart rate.

(3)

Acetylcholine is released from the parasympathetic neurones at the SAN, where it binds to receptors and slows the heart rate by reducing the frequency of depolarisation.

Atropine binds to and blocks the acetylcholine receptors at the SAN, competing with acetylcholine, so it reduces acetylcholine binding.

This removes the slowing effect, so the SAN depolarises more frequently and heart rate increases.

- (iv) Describe how exercise leads to the stimulation of the cardiac centre in the medulla oblongata.

(4)

During exercise the respiration rate increases, so the blood carbon dioxide concentration increases (and oxygen concentration decreases), forming carbonic acid, so blood pH decreases.

This is detected by chemoreceptors in the aorta and carotid arteries (aortic and carotid bodies) and in the medulla.

Baroreceptors (stretch receptors) in the aorta and carotid sinus detect changes in blood pressure.

Impulses are sent along sensory neurones from these receptors to the cardiac centre (cardio-acceleratory centre) in the medulla oblongata, stimulating it.

(Total for Question 8 = 13 marks)



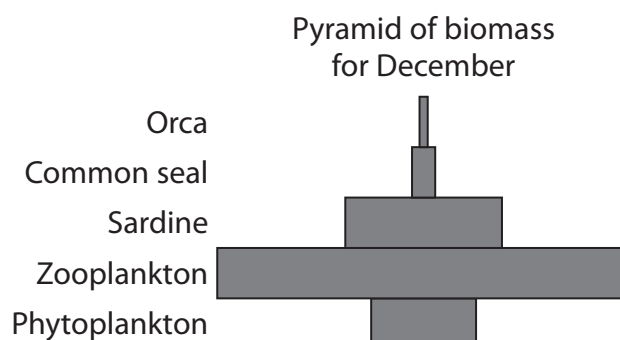
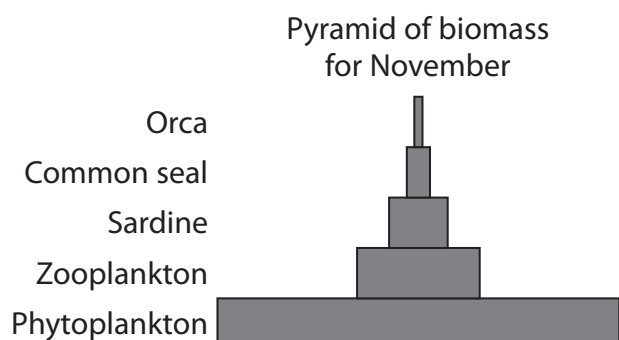
9 Phytoplankton are producer organisms in marine ecosystems.

Zooplankton are small animals that live in the surface waters of the oceans.

The diagram shows a food chain for the South Atlantic Ocean.

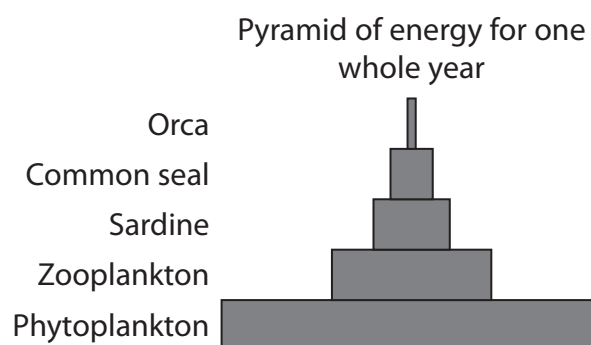
phytoplankton → zooplankton → sardine → common seal → orca

The diagrams below show ecological pyramids for this food chain.



The units for biomass are kg m^{-3}

The units for energy are $\text{kJ m}^{-3} \text{yr}^{-1}$



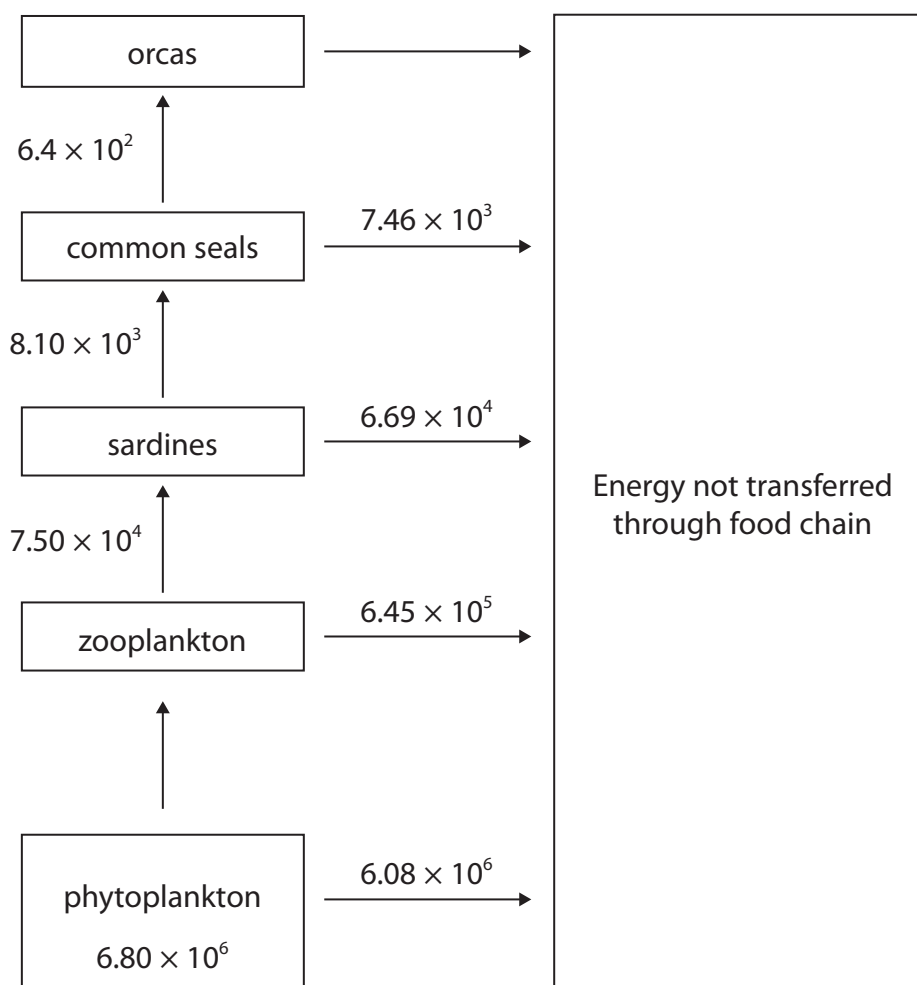
(a) Comment on the shapes of these three ecological pyramids.

(3)

Phytoplankton biomass is highest in November but lower in December, when zooplankton and sardine biomass are higher, so the December pyramid has a narrow base. This is because the phytoplankton were consumed by the zooplankton, which increased as they had more food.

The biomass pyramids show one moment in time (one month), but the energy pyramid is for a whole year, so it always has a pyramid shape: energy decreases along the food chain as energy is lost by respiration, egestion, excretion and parts not eaten.

(b) The diagram shows the flow of energy through this food chain.



All values are measured in $\text{kJ m}^{-3} \text{yr}^{-1}$

- (i) Calculate the percentage efficiency of energy transfer between the phytoplankton and the zooplankton.

Give your answer to the nearest whole number.

(2)

$$\text{energy transferred} = 6\,800\,000 - 6\,080\,000 = 720\,000$$

$$\% \text{ efficiency} = 720\,000 \div 6\,800\,000 \times 100 = 10.6\%$$

Answer 11 %



(ii) Common seals and orcas are endotherms.

Sardines are ectotherms.

Explain why the transfer of energy from sardines to orcas is less efficient than the transfer of energy from zooplankton to common seals.

(3)

Zooplankton to seals includes a transfer into sardines, which are ectotherms: they are the same temperature as the environment, so have a low respiration rate and lose little heat, so more energy is stored in biomass.

Sardines to orcas involves two transfers into endotherms (seals then orcas), which maintain a constant body temperature. So they have a high metabolic rate (high respiration rate) and lose more heat to the environment, leaving less energy for growth.

Seals may also have more indigestible parts (bones, fur), so less is eaten or digested and more is lost in egestion and excretion.

(c) Scientists investigated the impact of global warming on marine productivity.

They determined the effect of temperature and light intensity on the net primary productivity (NPP) of phytoplankton.

Phytoplankton were exposed to different light intensities at three different temperatures for one month. After one month, the scientists measured the increase in dry biomass of phytoplankton.

The results are shown in the table.

Light intensity /arbitrary units	Mean increase in dry biomass of phytoplankton / g		
	10 °C	20 °C	30 °C
5	4	6	2
10	8	10	4
15	10	20	15
20	12	24	28
25	12	28	35

(i) State what is meant by the term net primary productivity (NPP).

(1)

NPP = GPP - R: the energy left after respiration, stored in biomass and available for primary consumers.



*(ii) Some effects of global warming include the following:

- Atmospheric carbon dioxide could cause an increase in temperature.
- Increased atmospheric temperature could increase cloud cover.
- Increased ocean temperature could reduce the movement of nutrients such as nitrates from the seabed to the surface water.
- The scientists concluded that if the use of fossil fuels is not reduced, there will be a fall in populations of orcas in the South Atlantic Oceans.
- Analyse the data in the table and the information given to discuss this conclusion.

(6)

Increasing light intensity increases biomass. At 10 °C biomass increases then levels off at 12 g, as temperature limits it at high light intensity. At 20 °C and 30 °C it keeps increasing, so light is limiting. At low light intensity, 30 °C gives less biomass than 20 °C (2 g v 6 g at 5 units), but at high light intensity 30 °C gives the most (35 g).

Burning fossil fuels releases carbon dioxide, so temperature rises. Warmer temperatures increase evaporation and cloud cover, which lowers light intensity. Respiration rate increases with temperature, so at low light intensity and high temperature NPP is lower. Warmer oceans bring fewer nitrates to the surface, needed to make proteins and DNA. So less energy enters the food chain, less food reaches seals, and orca numbers fall.

However, at high light intensity warmer water gives more NPP, so orca numbers could stay the same or increase, and extra CO₂ may increase photosynthesis. The data are from one experiment lasting only one month, there is no evidence cloud cover will increase, other factors and greenhouse gases (methane) affect temperature, CO₂ may cause acidification, and orcas eat other food in other food chains, so the conclusion is not fully supported.

(Total for Question 9 = 15 marks)

TOTAL FOR PAPER = 90 MARKS



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