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Candidate surname					Other names				
Centre Number					Candidate Number				

Pearson Edexcel International Advanced Level

Monday 8 January 2024

Afternoon (Time: 1 hour 30 minutes) **Paper reference** **WBI11/01**

Biology
Advanced Subsidiary
UNIT 1: Molecules, Diet, Transport and Health

You must have:
 Scientific calculator, ruler, HB pencil

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.*
- Calculators may be used.
- You must **show all your working out** with **your answer clearly identified** at the **end of your solution**.

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- The marks available for spelling, punctuation and grammar are clearly indicated.
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points 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.

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Answer ALL questions.

Write your answers in the spaces provided.

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

- 1** Red blood cells transport oxygen to the cells of the body.

Read through the following description of how oxygen is transported from the lungs to respiring cells.

Complete the description by writing the most appropriate word or words on the dotted lines.

Oxygen binds to **haemoglobin (1)** inside red blood cells.

Oxygen binds to this molecule in the lungs where the partial pressure of oxygen is **high (1)** compared with elsewhere in the body.

The oxygenated blood returns to the heart in the blood vessel called the **pulmonary vein (1)** and is pumped to the body by the part of the heart called the **left ventricle (1)**

In the tissues, the ability of this molecule to bind oxygen is affected by the higher concentration of carbon dioxide.

This is called the **Bohr (shift) (1)** effect.

(Total for Question 1 = 5 marks)



- 2 The nature of the genetic code of a gene is important in determining the sequence of amino acids in a polypeptide chain.

The diagrams show the genetic code for some amino acids and the sequence of bases in part of a gene.

Genetic code	Amino acid	Genetic code	Amino acid	Genetic code	Amino acid	Genetic code	Amino acid
AAA AAG	Lysine	CAA CAG	Glutamine	GAA GAG	Glutamic acid	TAC TAT	Tyrosine
AAC AAT	Asparagine	CAT CAC	Histidine	GAC GAT	Aspartate	TCA TCC TCG TCT	Serine
ACA ACC ACG ACT	Threonine	CCA CCC CCG CCT	Proline	GCA GCC GCG GCT	Alanine	TGG	Tryptophan

Part of a gene:



The genetic code is described as a triplet code that is non-overlapping and is degenerate.

Explain what each of these phrases means.

Use the information provided to illustrate your answer.

(a) Triplet code

(2)

Three nucleotides (also called bases) form a triplet code known as a codon, and each codon codes for one specific amino acid. (1 mark)

For example, the codon AAA codes for the amino acid lysine. (1 mark)

(b) Non-overlapping code

(2)

The genetic code is read in non-overlapping triplets, meaning each base is only used once and belongs to only one codon. Once three bases are read as a codon, the next three bases are read as the next codon. (1 mark)

For example, AAA is read first (coding for lysine), and then the next set, such as GCA, is read separately (coding for alanine). The bases in AAA are not shared with GCA. (1 mark)

(c) Degenerate code

(2)

Some amino acids have more than one codon, meaning the genetic code is degenerate. Different triplets can code for the same amino acid. (1 mark)

For example, both AAA and AAG code for the amino acid lysine. (1 mark)

(Total for Question 2 = 6 marks)



3 The cell membrane determines which molecules can enter or leave a cell.

(a) Which pair of membrane transport mechanisms only involves a **solute moving down a concentration gradient?**

When solutes move down a concentration gradient, it means they are moving from an area of higher concentration to an area of lower concentration. (1)
This process is called passive transport, and it does not require energy (ATP).

- ☐ A active transport and diffusion
- ☐ B active transport and osmosis
- ☒ C diffusion and facilitated diffusion
- ☐ D facilitated diffusion and osmosis

(b) Which of the following transport mechanisms involve carrier proteins in the membrane?

- active transport requires carrier proteins to move substances against the concentration gradient (from low to high concentration). It also requires energy (ATP).
- diffusion
- exocytosis No, this is a bulk transport mechanism where vesicles fuse with the membrane to release substances outside the cell. It does not use carrier proteins. (1)

- ☒ A active transport only
- ☐ B active transport and exocytosis
- ☐ C diffusion only
- ☐ D diffusion and exocytosis

(c) Which cell transport mechanism is used to take large particles or bacteria into a cell?

(1)

- ☐ A active transport moves small molecules or ions against their concentration gradient using carrier proteins and ATP, not large particles.
- ☒ B endocytosis Endocytosis is the process where the cell engulfs large particles, like bacteria or cell debris, by wrapping its membrane around them and forming a vesicle. A specific type of endocytosis called phagocytosis is used for large solid particles, including bacteria.
- ☐ C exocytosis Used to release substances out of the cell, not take them in.
- ☐ D facilitated diffusion helps small molecules (like glucose or ions) move down their concentration gradient with the help of carrier or channel proteins, not large particles.

(d) Which cell transport mechanism moves small lipid-soluble molecules through the membrane?

(1)

- ☐ **A** active transport Requires energy and carrier proteins, usually for ions or polar molecules moving against the concentration gradient.
- ☐ **B** diffusion Diffusion allows small lipid-soluble (non-polar) molecules, such as oxygen and carbon dioxide, to pass directly through the phospholipid bilayer of the cell membrane, moving down their concentration gradient. This is a type of passive transport and does not require energy.
- ☐ **C** facilitated diffusion uses channel or carrier proteins for molecules that cannot pass through the lipid bilayer on their own (like glucose or ions).
- ☐ **D** osmosis Specifically refers to the movement of water, not solutes.

(e) Channel proteins are involved in facilitated diffusion.

Which row of the table describes the charge on the R groups on the amino acids of a channel protein?

The inside of the channel (where ions and polar molecules pass through) must be hydrophilic, so the R groups facing inward must be polar or charged.
The outer part of the protein is embedded in the hydrophobic phospholipid bilayer, so the R groups facing outward must be non-polar.

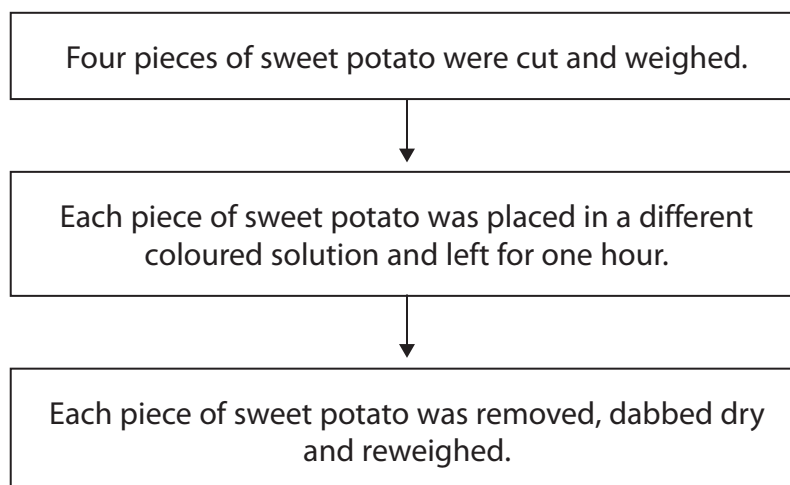
(1)

	Charge on R groups facing inside the channel are mostly	Charge on R groups facing the rest of the membrane are mostly
<input type="checkbox"/> A	polar	polar
<input checked="" type="checkbox"/> B	polar	non-polar
<input type="checkbox"/> C	non-polar	polar
<input type="checkbox"/> D	non-polar	non-polar

(f) A student investigated the effect of four different coloured solutions on the mass of pieces of sweet potato.

Dyes were dissolved in water to produce the coloured solutions.

The diagram shows the method used by the student.

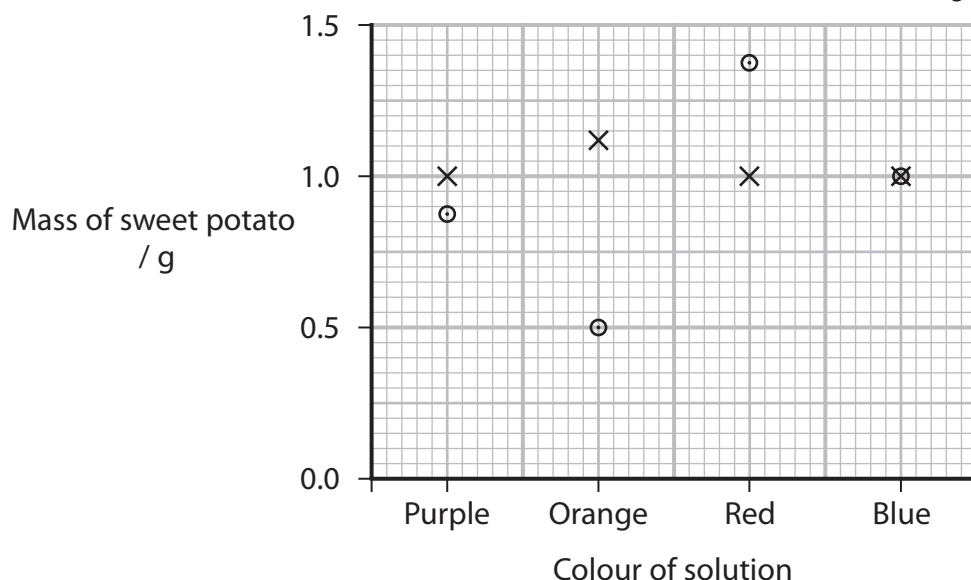


The graph shows the results of this investigation.

Key

× initial mass of sweet potato

○ final mass of sweet potato



Explain the results of this investigation.

(4)

The change in mass of the potato pieces is due to osmosis, which is the movement of water across a partially permeable membrane from a region of higher water potential to a region of lower water potential. (1 mark)

The potato lost mass in the purple and orange solutions because these solutions were more concentrated (hypertonic) than the cytoplasm of the potato cells, causing water to move out of the cells. (1 mark)

The greatest decrease in mass occurred in the orange solution, as it was the most concentrated, meaning it had the lowest water potential, so more water moved out of the potato. (1 mark)

In contrast, the potato gained mass in the red solution because it was less concentrated (hypotonic) than the potato cytoplasm, resulting in water moving into the cells by osmosis. (1 mark)

(Total for Question 3 = 9 marks)

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4 Water is an important molecule in living organisms.

(a) Water is a dipolar molecule that forms hydrogen bonds with other water molecules.

(i) Explain the dipole nature of water.

(2)

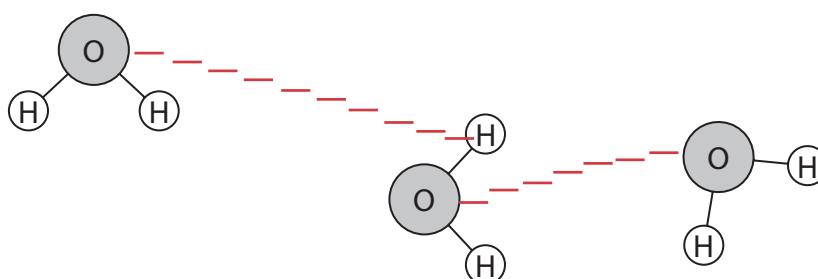
The replication of bacteria in the digestive system uses up energy sources such as glucose or sugar, meaning some of the energy from food is used by the bacteria rather than the person. (1 mark)

This happens because oxygen is more electronegative than hydrogen—it has more protons and pulls the shared electrons closer to itself, causing an uneven distribution of electrons across the molecule. (1 mark)

(ii) The diagram shows three water molecules.

Complete the diagram to show a hydrogen bond between two water molecules.

(1)



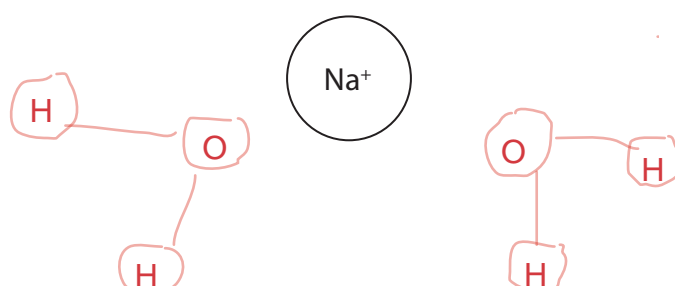
(b) Water plays a role as a solvent.

Sodium chloride dissolves in water.

The diagram shows a sodium ion (Na^+).

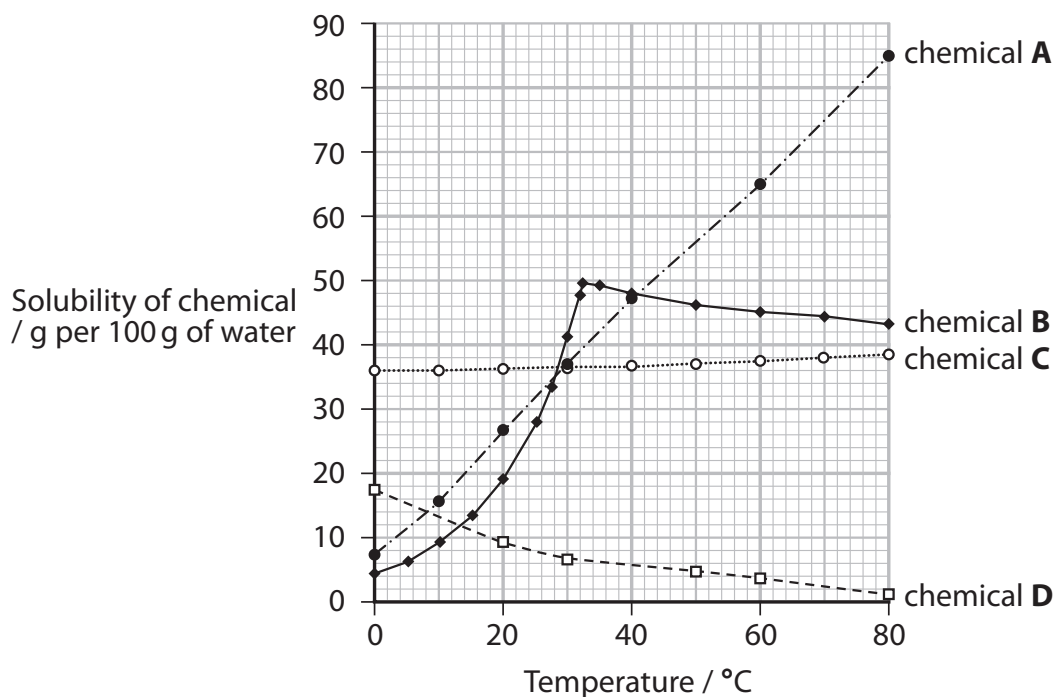
Complete the diagram to show the arrangement of two water molecules around a sodium ion when it is dissolved.

(1)



(c) Temperature affects the solubility of chemicals in water.

The graph shows the effect of temperature on the solubility of four chemicals, **A**, **B**, **C** and **D**.



Describe the effects of temperature on the solubility of these chemicals.

(4)

The effect of temperature on solubility varies between different substances—each chemical has its own solubility pattern as temperature changes. (1 mark)

For substance A, an increase in temperature leads to a linear increase in solubility—there is a positive correlation between temperature and solubility. (1 mark)

For substance B, solubility increases exponentially with temperature up to 32°C, then decreases, showing a non-linear trend. (1 mark)

For substance C, there is only a slight increase in solubility with rising temperature, indicating a weak positive effect. (1 mark)

For substance D, solubility actually decreases with increasing temperature, showing a negative correlation. (1 mark)

(Total for Question 4 = 8 marks)

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- 5 Several factors are associated with the risk of developing cardiovascular disease (CVD).

Obesity is one risk factor associated with CVD.

The ability of a group of people to lose weight was investigated.

This investigation considered:

- the body mass index (BMI) of the person
- the levels of amylase in their saliva
- the bacteria present in their digestive system.

- (a) The BMI of a person can be calculated using the formula:

$$\text{BMI} = \text{mass in kg} \div (\text{height in m})^2$$

- (i) Name **one** other obesity indicator. ACCEPT / WHR / hip to waist ratio / waist size / waist measurement / waist to hip index / percentage body fat / skin fold measurement (1)

waist-to-hip ratio / skin fold thickness / waist (circumference) (1)

- (ii) Which of the following is the BMI of a person who has a mass of 65 kg and a height of 165 cm?

(1)

- ☐ A 23
- ☒ B 24
- ☐ C 39
- ☐ D 40

- (iii) A person's BMI is used to put them into a weight category.

A person with a BMI of 25 and above, but below 30, is considered to be overweight but not obese.

Which describes the body mass of a person who is obese?

(1)

- ☐ A BMI > 30
- ☒ B BMI \geq 30
- ☐ C BMI < 30
- ☐ D BMI \leq 30

(b) People who are overweight or obese are encouraged to lose weight.

State **two** ways in which a person could lose weight. To reduce body weight, a person needs to make lifestyle changes that create a calorie deficit. (1)

- 1 To lose weight, a person should decrease their intake of energy-rich nutrients, such as calories, fats, sugars, or carbohydrates, and increase physical activity or exercise levels. (1 mark) Ignore vague references like just "regular exercise" without the comparison or indication of an increase.
- 2 To lose weight, a person should decrease their intake of energy-rich nutrients, such as calories, fats, sugars, or carbohydrates, and increase physical activity or exercise levels. (1 mark)

(c) Amylase in saliva breaks down amylose into maltose.

Other accepted changes include:

Starting weight-reducing medication

Having a gastric band fitted

(i) Which row of the table describes the action of amylase?

(1)

	Type of reaction	Glycosidic bond broken
<input type="checkbox"/> A	condensation	1 – 4
<input type="checkbox"/> B	condensation	1 – 6
<input checked="" type="checkbox"/> C	hydrolysis	1 – 4
<input type="checkbox"/> D	hydrolysis	1 – 6

(ii) People with low levels of amylase in their saliva were found to lose weight more easily.

Suggest why these people lost weight more easily.

(2)

Weight loss occurred because starch (or amylose) was not fully broken down or hydrolysed, meaning less glucose was produced from digestion. (1 mark)

As a result, there was less glucose absorbed into the blood, leading to less being available for conversion into fat, or the body had to break down existing fat stores for energy. (1 mark)



(d) The bacteria in people's digestive systems replicate.

The investigation found that people with greater weight loss had bacteria with increased rates of replication.

(i) Explain why this finding can be described as a positive correlation.

(2)

There is a correlation because a change in one variable is reflected by a change in another—a pattern can be seen between the two factors. (1 mark)

It is a positive correlation, because as one factor increases, the other also increases—for example, as weight loss increases, the number of bacteria (or replication) also increases. (1 mark)

(ii) Suggest why the rate of replication of the bacteria could affect weight loss.

(2)

The replication of bacteria in the digestive system uses up energy sources such as glucose or sugar, meaning some of the energy from food is used by the bacteria rather than the person. (1 mark)

As a result, there is less energy available for absorption or storage as fat, so the person may need to break down their own fat reserves for energy. (1 mark)

(Total for Question 5 = 11 marks)

6 The cell membrane consists of phospholipids and proteins.

(a) Name the current model for the structure of the cell membrane.

fluid mosaic (model) (1)

This model explains how the membrane is flexible (fluid) and made up of a patchwork (mosaic) of proteins embedded within the lipid layer, which allows movement of components within the membrane. (1)

(b) Describe the arrangement of phospholipids in the cell membrane in this model.

(3)

Phospholipids are arranged in a bilayer (two layers) within the cell membrane. (1 mark)

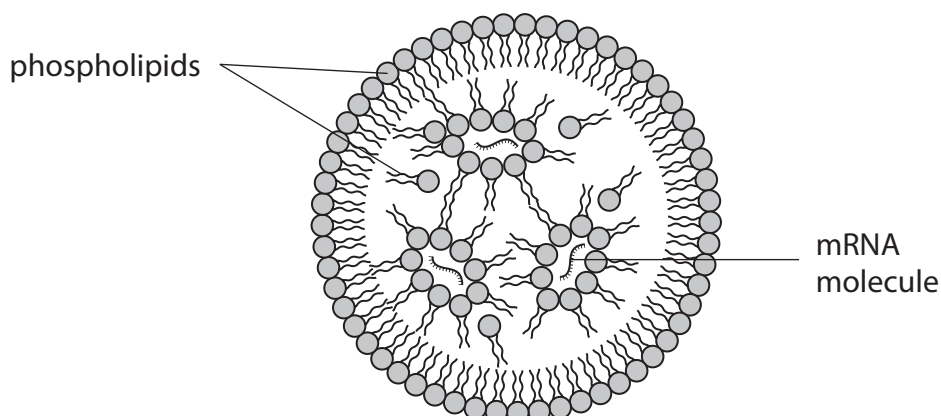
The phosphate heads are hydrophilic and point outwards towards the aqueous environments, both inside (cytoplasm) and outside (extracellular fluid) of the cell. (1 mark)

The fatty acid tails are hydrophobic and point inwards, away from water, facing each other in the center of the membrane. (1 mark)

(c) Phospholipids can be used to form lipid nanoparticles.

Lipid nanoparticles can be used to carry nucleic acids to tissues in the body.

The diagram shows a lipid nanoparticle containing messenger RNA (mRNA) molecules.



- (i) Lipid nanoparticles are very small.

Calculate the diameter of a lipid nanoparticle with a volume of $0.108 \mu\text{m}^3$.

Use the formula

$$V = \frac{4}{3}\pi r^3$$

Use $\pi = 3.0$

$$0.108 = \frac{4}{3} \times 3.0 \times r^3$$

$$0.108 = 4r^3$$

$$r^3 = 0.108/4$$

$$r = 0.3$$

$$d = r \times 2$$

(3)

Answer μm

- (ii) Describe the structure of a mRNA molecule.

(3)

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(iii) Explain the arrangements of phospholipids in this lipid nanoparticle that carries mRNA to tissues in the body.

(3)

The phospholipids are arranged with the hydrophilic heads pointing outwards because they are polar and interact with the water (environment), while the hydrophobic fatty acid tails point away from the water. (1 mark)

The mRNA is surrounded by the phosphate heads because mRNA is a polar molecule (due to its phosphate group), and the heads interact with it. (1 mark)

The fatty acid tails of the phospholipids (in both groups) face each other because they are hydrophobic and do not interact with water. (1 mark)

(Total for Question 6 = 13 marks)



7 Cystic fibrosis is an inherited disorder caused by a mutation in the gene coding for the CFTR protein.

(a) Explain how this mutation results in reduced gas exchange in the lungs.

(3)

(b) The number of new cases of cystic fibrosis in the USA in 2015 was 964.

It is predicted that this value will have fallen to 839 by 2025.

(i) Calculate the predicted percentage decrease in the number of new cases from 2015 to 2025.

(1)

new_cases_2015 = 964
new_cases_2025 = 839

Formula for percentage decrease: $((\text{old_value} - \text{new_value}) / \text{old_value}) * 100$
percentage_decrease = $((\text{new_cases_2015} - \text{new_cases_2025}) / \text{new_cases_2015}) * 100$

Answer %

(ii) Explain why the number of cases could fall.

(3)

More or improved genetic screening can help identify more carriers of the CF allele (Cystic Fibrosis gene) in the population. (1 mark)

This is because more couples are choosing IVF (in vitro fertilization), and with improved identification of affected embryos, it becomes more reliable to screen for genetic disorders before pregnancy. (1 mark)

As a result, more couples may choose not to have a child with Cystic Fibrosis, based on the genetic screening results. (1 mark)

Over time, as more CF carriers are identified and choose not to have affected children, the frequency of the CF allele decreases in the population, which leads to a decrease in the CF phenotype (i.e., fewer individuals with Cystic Fibrosis). (1 mark)

Additionally, more migration and change in population diversity may affect the genetic makeup of the population, potentially influencing the prevalence of genetic conditions like CF. (1 mark)

*(c) One complication of cystic fibrosis is lung disease caused by the build-up of bacteria in the airways.

This may be due to the inability of the person to clear mucus from the airways.

People with cystic fibrosis can inhale a salt solution to treat their symptoms. This gives improvements in the clearance of mucus, lung function and quality of life, for a short time.

It has been suggested that pre-treatment with drug A could extend the effects of inhalation of a salt solution.



Devise an investigation to determine if pre-treatment with drug A is more effective than inhalation of a salt solution on its own.

Give reasons for your choice of method.

(6)

Regimen outlined

- Before inhalation, drug A must be administered because the focus is on the effect of pre-treatment on the outcome. (1 mark)
- A placebo needs to be given to a control group to compare the effect of drug A against no pre-treatment, which will help eliminate bias. (1 mark)
- The inhalation should be daily because the drug is likely to not stay in the body for a long time, and regular treatment will help assess the continuous effects. (1 mark)
- The trial should run for at least 4 weeks because the effects of the treatment will not be immediate and a longer time is needed to observe significant changes. (1 mark)

Design of the trial

- The trial should include two or three groups of patients with CF, with a minimum of 6 patients per group to ensure the sample size is large enough for reliable results. (1 mark)
- One group should receive drug A, while the other group should receive the placebo, allowing a comparison between the treatment and no treatment. (1 mark)
- A large number of patients should be included in each group to ensure repeatability of results and to account for variability. (1 mark)
- The patients should be of similar age, sex, and severity of CF to ensure the results are valid and not skewed by other variables. (1 mark)
- Patients should not be taking other medications, as these could interfere with the results by masking the effects of drug A and inhalation. (1 mark)
- The trial should be double-blind to prevent bias, where neither the patients nor the researchers know who is receiving drug A or the placebo. (1 mark)

What is measured

- The volume or mass of mucus removed should be measured to assess whether the clearance of mucus has improved, which is a key parameter for evaluating the treatment's effectiveness. (1 mark)
- Lung function tests, such as spirometry or peak flow measurements, should be taken to assess whether lung function has improved as a result of the treatment. (1 mark)
- A questionnaire should be given to assess improvements in quality of life, as this is also an important measure of the drug's overall effect on the patients. (1 mark)
- Statistics should be used to analyze the results and determine the significance of the data, ensuring the findings are statistically meaningful and not due to chance. (1 mark)

(Total for Question 7 = 13 marks)

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8 The types of lipid consumed in the diet can affect the health of individuals.

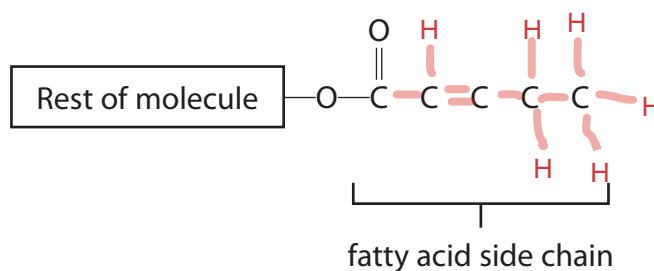
(a) Tropical sprue is a disorder that limits the absorption of nutrients into the blood.

Consumption of unsaturated lipids has been proposed as a cause of tropical sprue.

The diagram shows part of an unsaturated lipid.

Complete the diagram to show one possible structure of a fatty acid side chain of an unsaturated lipid.

(2)



(b) Consumption of high levels of cholesterol is associated with atherosclerosis.

In the development of atherosclerosis, lesions form in the coronary arteries and these develop into atheromas (plaques).

In an investigation, one group of primates was fed a diet supplemented with cholesterol and saturated fatty acids.

A second group was fed a diet supplemented with cholesterol and unsaturated fatty acids.

The primates were fed these diets from a young age and then monitored over a period of 60 months.

Primates are a higher order of mammals that include monkeys.



The results of the investigation are shown in the graphs.

Key

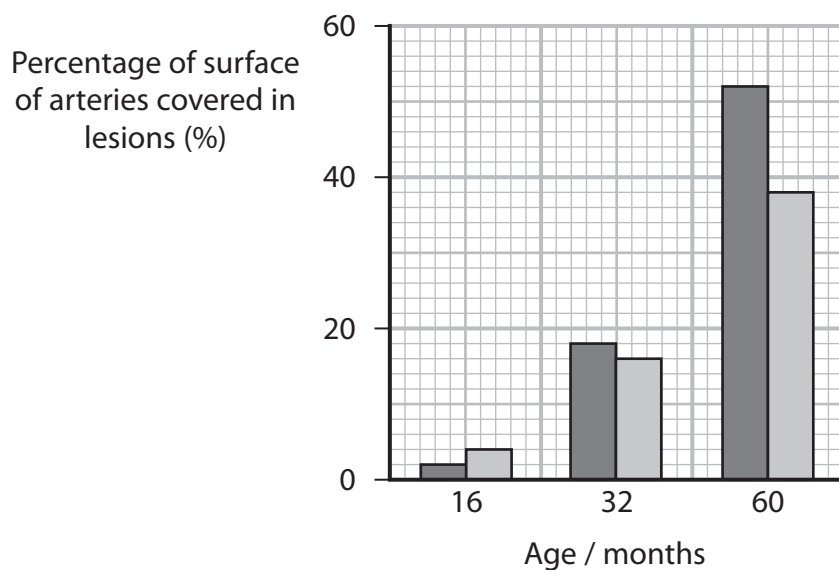


saturated lipids

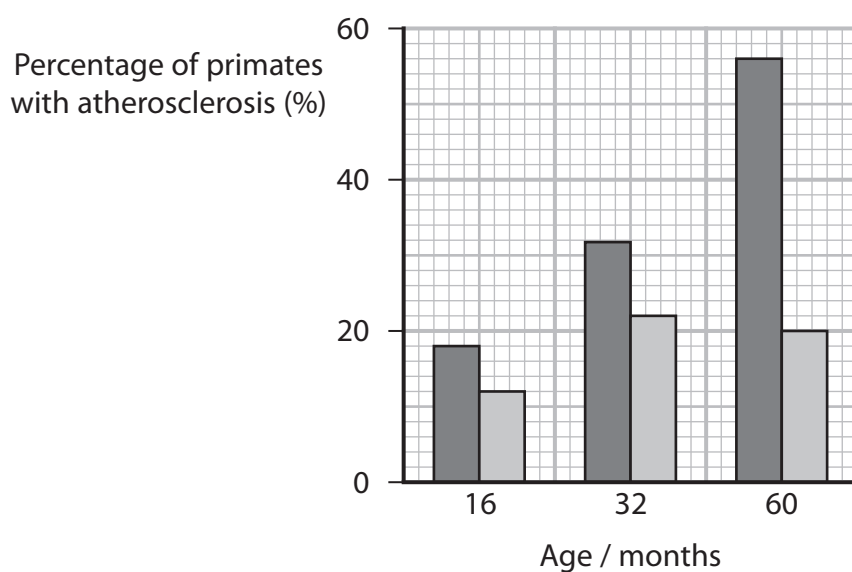


unsaturated lipids

Graph 1



Graph 2



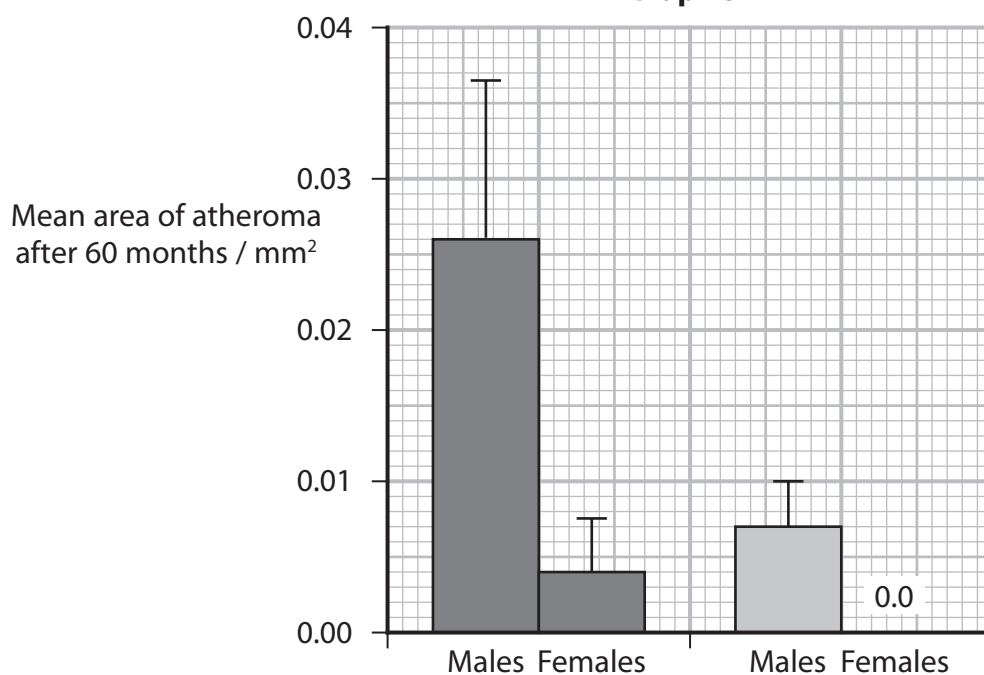
Key



saturated lipids



unsaturated lipids

Graph 3

- (i) Calculate the mean rate of increase in the surface of arteries covered in lesions from 16 to 60 months in the primates given saturated lipids (graph 1).

(1)

At 16 months, the surface area is 2.

At 60 months, the surface area is 52.

The time difference is $60 - 16 = 44$

Answer percentage per month

- (ii) Calculate the ratio of primates with atherosclerosis given saturated lipids to those given unsaturated lipids, at 32 months (graph 2).

(1)

Answer



- (iii) Calculate the difference in the area of the atheromas in males compared with females, in primates given saturated fats (graph 3).

Give your answer in μm^2 .

(2)

Step 1: Convert mm^2 to μm^2

Step 2: Calculate the difference

$$26,000 - 4000 = 22,000$$

Male:

$$0.026\text{mm}^2 = 0.026 \times 1,000,000 = 26,000\mu\text{m}^2$$

Female:

$$0.004\text{mm}^2 = 0.004 \times 1,000,000 = 4000\mu\text{m}^2$$

Answer 22,000 μm^2

- *(iv) These primates were fed a diet supplemented with cholesterol and either saturated lipids or unsaturated lipids.

Deduce the effects of these two diets on the development of lesions in the coronary arteries, atherosclerosis and atheromas.

(6)

Graph 1: Surface Area of Arteries Covered in Lesions

Arteries developed lesions with both saturated and unsaturated lipids.

The percentage of the surface area covered in lesions increased over time for both types of lipid.

However, the overall increase was greater with saturated lipids, suggesting that diet plays a significant role.

This shows that the type of lipid in the diet does influence the extent of arterial damage.

However, the validity of the data may be questioned, as there are no experimental details provided and no error bars shown, making it difficult to assess repeatability or reliability.

Graph 2: Percentage of Atherosclerosis

Atherosclerosis is observed with both types of lipid.

The percentage of primates with atherosclerosis is higher with saturated lipids at all three ages (e.g., 16, 32, and 60 months), compared to unsaturated lipids.

With saturated lipids, the percentage increases with age, showing a clear trend.

However, the effect of age is less clear with unsaturated lipids, possibly due to variability or other unknown factors.

As with Graph 1, the data may not be entirely valid or significant due to the lack of experimental details, absence of error bars, and no statistical test results.

Graph 3: Area of Atheromas

Atheromas are larger in both males and females when fed saturated lipids compared to unsaturated lipids.

Males have a larger area of atheromas than females regardless of the type of lipid consumed, suggesting a sex-based influence.

Therefore, both diet and sex affect the development of atheromas.

This data is likely to be significant, as error bars do not overlap, indicating a meaningful difference between groups.

There is also more variability in the data for males, shown by wider error bars.

- (v) Discuss the ethical issues relating to the use of primates and other animals in investigations such as this one.

(3)

It may be considered unethical as it can cause pain, harm or discomfort to the animals, which some people see as cruel.

Additionally, animals are unable to give consent, meaning the experiments are carried out against their will.

However, others argue it is more ethical than experimenting on humans, especially since primates are biologically similar to humans, making the research valuable for improving future human health.

(Total for Question 8 = 15 marks)

TOTAL FOR PAPER = 80 MARKS

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