

INSIGHT
Trial Exam Paper

2007

BIOLOGY

Written examination 1

Solutions book

This book presents:

- correct solutions
- explanatory notes
- mark allocations
- tips and guidelines

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SECTION A – Multiple-choice questions

Question 1

Fats, oils and waxes are macromolecules also known as lipids. They are known for their lack of affinity with water. Triglycerides are a form of fat and are

- A. the only lipids which form a solid at room temperature.
- B. always composed of carbon, hydrogen, oxygen and nitrogen.
- C. made of a single fatty acid molecule to which three glycerides are attached.
- D. **made of a single glycerol molecule to which three fatty acids are attached.**

Answer is D

Explanatory notes

- A is incorrect because fats and waxes are usually solids at room temperature.
- B is incorrect because fats are composed only of carbon, hydrogen and oxygen.
- C is incorrect because a fat is made of a single glycerol molecule (glyceride) to which three fatty acids are attached.

Question 2

The formula that represents a polysaccharide is compound

- A. $\text{C}_{312}\text{H}_{520}\text{O}_{260}$
- B. $\text{C}_{736}\text{H}_{1161}\text{N}_{184}\text{O}_{208}\text{S}_3$
- C. $\text{C}_6\text{H}_{12}\text{O}_6$
- D. $\text{C}_{51}\text{H}_{98}\text{O}_6$

Answer is A

Explanatory notes

- A is correct since the compound follows the general formula of a polysaccharide $(\text{C}_6\text{H}_{10}\text{O}_5)_n$.
- B is incorrect because it contains N (nitrogen) and S (sulfur), two elements which are not contained in polysaccharides (carbohydrates).
- C is incorrect because it is the formula for glucose, which is a monosaccharide.
- D is incorrect because it is the formula for palmitin, which is a lipid.

Question 3

Myoglobin is an oxygen-binding protein found in the muscle tissue of vertebrates. Myoglobin does not have a quaternary structure because it

- A. exhibits no β -pleated sheets.
- B. only contains 153 amino acids in its chain.
- C. **is a single-chain globular protein.**
- D. demonstrates no peptide bonds in its structure.

Answer is C

Explanatory notes

- A is incorrect because quaternary structure can be achieved without β -pleated sheets.
- B is incorrect because quaternary structure is not determined by the number of amino acids in a protein.
- D is incorrect because myoglobin is a protein and must have peptide bonds linking its amino acids.

Question 4

Apoptosis and necrosis are both processes that result in cell death. Necrosis occurs as a result of significant chemical or mechanical damage to the plasma membrane of a cell. Apoptosis

- A. only occurs in cells of damaged tissue.
- B. occurs in response to signals via the mitochondrial pathway.**
- C. occurs in response to signals via the ribosomal pathway.
- D. only occurs in embryos.

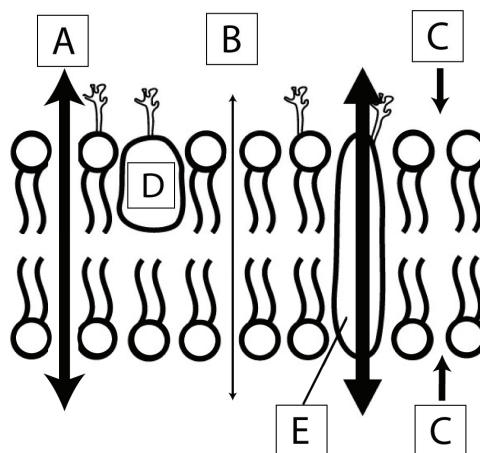
Answer is B

Explanatory notes

- A is incorrect because apoptosis occurs in both damaged and healthy cells.
- C is incorrect because apoptosis occurs via the mitochondrial and death receptor pathway. There is no ribosomal pathway associated with apoptosis.
- D is incorrect because apoptosis occurs both in embryos and developed organisms.

The following information is required for Questions 5 to 7.

Cells are capable of exchanging many substances across the plasma membrane. The plasma membrane can selectively control the movement of molecules entering and leaving the cell.

**Question 5**

The movement of substances across the plasma membrane, represented by arrows **A**, **B** and **C**, is best described as

- A. bulk transport.
- B. endocytosis.**
- C. exocytosis.
- D. diffusion.**

Answer is D

Explanatory notes

- A is incorrect because bulk transport involves movement of large quantities of material in vesicles (made from a phospholipid membrane) which are formed at the cell membrane.
- B is incorrect because endocytosis is a form of bulk transport and bulk transport is not the likely process.
- C is incorrect because exocytosis is a form of bulk transport and bulk transport is not the likely process.

Question 6

Crossing the plasma membrane occurs via many processes including passive and active transport. Arrows represent the pathways of lipid-soluble molecules (**A**), small uncharged molecules (**B**) and most water-soluble molecules (**C**) across a plasma membrane. The substances crossing the plasma membrane at **A**, **B** and **C** are most likely to be

- A. proteins (**A**), sugars (**B**), chloroform (**C**).
- B. alcohol (**A**), urea (**B**) and proteins (**C**).**
- C. ions (**A**), water (**B**) and carbon dioxide (**C**).
- D. sugars (**A**), alcohol (**B**) and amino acids (**C**).

Answer is B

Explanatory notes

- A is incorrect because proteins are water soluble (not lipid soluble), sugar is water soluble (not a small uncharged molecule) and chloroform is lipid soluble (not water soluble).
- C is incorrect because ions are water-soluble molecules (not lipid soluble) and carbon dioxide is a small uncharged molecule (not water soluble).
- D is incorrect because sugars are water soluble (not lipid soluble) and alcohol is lipid soluble (not a small uncharged molecule).

Question 7

The plasma membrane is comprised of many structures, all of which contribute to its functioning. In order, the structures labelled **D** and **E** represent

- A. cholesterol and protein channel.
- B. phospholipid and glycoprotein.
- C. protein channel and cholesterol.
- D. glycoprotein and protein channel.**

Answer is D

Explanatory notes

- A is incorrect because cholesterol molecules are usually found embedded in the fatty acid tails.
- B is incorrect because phospholipids are represented by a round phosphate head with two fatty acid tails; structure D does not have this appearance.
- C is incorrect because structure D does not cross both phospholipid layers of the membrane (a protein channel does) and E is not a cholesterol molecule for the reason that A is incorrect.

Question 8

Proteomics is the name given to the study of the proteome of an organism. A proteome is best described as all the

- A. proteins produced by a single cell or organism in a particular environment.**
- B. genes produced by a single cell or organism in a particular environment.
- C. polysaccharides produced by a single cell or organism in a particular environment.
- D. glycoproteins produced by a single cell or organism in a particular environment.

Answer is A

Explanatory notes

- B is incorrect because genes are not proteins (they can produce proteins).
- C is incorrect because polysaccharides are not proteins.
- D is incorrect, even though glycoproteins are made from proteins, because glycoproteins are not all the proteins produced by a single cell or an organism in a particular environment.

Question 9

Scientists have moved away from studying components of the proteome in isolation because

- A. there are too many components and research funding is not readily available.
- B. proteomes are too complex in structure to study in isolation.
- C. **proteomes do not act in isolation from each other.**
- D. there are only a few components and it is more efficient to group them together.

Answer is C

Explanatory notes

- A is incorrect because even though there are many proteins in the proteome and research funding is limited, this is not the main reason for developing the field of proteomics.
- B is incorrect because protein structure is not an obstacle to studying them in isolation.
- D is incorrect because there are actually many proteins in the proteome.

Question 10

In order to function, living cells link amino acids to make proteins. The organelles directly responsible for the assembly of proteins include

- A. ribosomes, chloroplasts and Golgi apparatus.
- B. ribosomes, chloroplasts and lysosomes.
- C. **ribosomes, mitochondria and chloroplasts.**
- D. ribosomes, mitochondria and the nucleus.

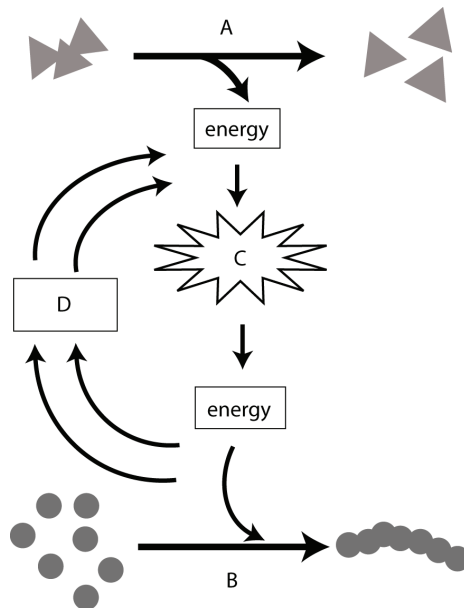
Answer is C

Explanatory notes

- A is incorrect because the Golgi apparatus is associated with transportation of proteins into and out of cells, not protein building.
- B is incorrect because lysosomes are involved with the destruction of unwanted or damaged cell parts and molecules, not protein building.
- D is incorrect because the nucleus does not have a direct role in protein building; it merely contains the DNA with the instructions for protein building.

The following information is required for Questions 11 and 12.

Thousands of metabolic reactions occur simultaneously within living cells. Some of these reactions release energy while others require energy to proceed.



Question 11

In the diagram, **A** could be an example of

- A. photosynthesis.
- B. **cellular respiration.**
- C. reduction.
- D. anabolism.

Answer is B

Explanatory notes

- A is incorrect because photosynthesis is an endergonic or anabolic (energy requiring) process.
- C is incorrect because reduction reactions are endergonic or anabolic (energy requiring) processes.
- D is incorrect because anabolism is an endergonic (energy requiring) process.

Question 12

In the diagram, **C** and **D** respectively are examples of

- A. **ATP and $ADP + P_i$**
- B. ATP and ADP_i
- C. $ADP_i + P$ and ATP
- D. ADP_i and ATP

Answer is A

Explanatory notes

- B is incorrect because exergonic reactions release ATP and when ATP is catabolised, $ADP + P_i$ is released, not just ADP_i .
- C is incorrect because exergonic reactions release ATP, not $ADP + P_i$.
- D is incorrect because exergonic reactions release ATP, not ADP_i .

Question 13

Enzymes are biological catalysts which are highly specific in their action and reduce the amount of energy required to enable metabolism in living organisms. Which of the following statements is **not** correct?

- A. There are two theories of enzyme action: 'lock-and-key' and 'induced-fit'.
- B. Enzyme activity is affected by pH, temperature and concentration of enzyme and substrate.
- C. **Enzymes are made exclusively of protein.**
- D. Enzyme inhibition can occur if a compound binds competitively with the active site of enzymes.

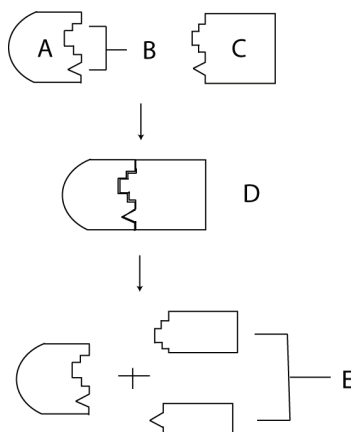
Answer is C

Explanatory notes

- C is correct because enzymes can contain metallic ions as part of their structure.
- A is incorrect because these *are* the two theories of enzyme action.
- B is incorrect because enzyme activity *is* affected by the stated factors.
- D is incorrect because enzyme inhibition *can* occur if a compound binds competitively with the active site of an enzyme.

Question 14

Compound **A** is a protein.



The correct names of the parts **B**, **C**, **D** and **E** in order are

- A. substrate, active site, enzyme-substrate complex, products.
- B. active site, substrate, products, enzyme-substrate complex.
- C. active site, enzyme-substrate complex, substrate, products.
- D. **active site, substrate, enzyme-substrate complex, products.**

Answer is D

Explanatory notes

- A is incorrect because **B** is the active site, not the substrate and **C** is the product, not the active site.
- B is incorrect because **D** is the enzyme-substrate complex, not the products and **E** is the products, not the enzyme-substrate complex.
- C is incorrect because **C** is the substrate, not the enzyme-substrate complex and **D** is the enzyme-substrate complex, not the substrate.

Question 15

Photosynthesis is a metabolic process in which autotrophic organisms harness radiant energy to produce organic compounds from inorganic substances. The process occurs in two stages. Photosynthetic pigments, which include chlorophylls, carotenoids and phycobilins, are integral to the process of harnessing radiant energy. Radiant energy is converted to chemical energy. Trapping of radiant energy is known as the _____ - _____ and occurs within the _____ of the _____ on the _____.

- A. light-dependent reaction, chloroplasts, thylakoid membranes, grana.
- B. light-dependent reaction, grana, chloroplasts, thylakoid membranes.**
- C. light-independent reaction, thylakoid membranes, grana, chloroplasts.
- D. light-independent reaction, grana, chloroplasts, thylakoid membranes.

Answer is B

Explanatory notes

- A is incorrect because the light-dependent reaction occurs within the grana of the chloroplasts on the thylakoid membranes.
- C is incorrect because it is a light-dependent reaction (not independent) and occurs within the grana of the chloroplasts on the thylakoid membranes.
- D is incorrect because it is a light-dependent reaction (not independent).

Question 16

The second stage of photosynthesis is reliant on some of the outputs from the conversion of radiant energy to chemical energy. These outputs are

- A. NADPH and ATP.**
- B. NADPH, ATP and CO₂.
- C. NADP⁺, ATP and CO₂.
- D. NADP⁺ and ADP + P_i.

Answer is A

Explanatory notes

- B is incorrect because CO₂ is not an output from the conversion of radiant energy to chemical energy.
- C is incorrect because NADP⁺ is an input to the light-dependent stage of photosynthesis and CO₂ is not an output from the conversion of radiant energy to chemical energy.
- D is incorrect because NADP⁺ and ADP + P_i are both inputs to the light-dependent stage of photosynthesis, not outputs.

Question 17

Homeostatic mechanisms regulate the internal environment of birds and mammals and can be described as stimulus-response mechanisms. In a stimulus-response model, a change (stimulus) in the external and internal environment is detected by receptors and a response is produced by effectors. There are two types of stimulus-response model: the negative feedback and the positive feedback systems. Which of the following is **not** true about negative feedback systems?

- A. Negative feedback mechanisms act to restore the original homeostatic state of an organism.
- B. **Negative feedback mechanisms act to increase the effect of the original disturbance.**
- C. Most negative feedback systems operate as proportional control systems.
- D. Some negative feedback systems operate as on-off control systems.

Answer is B

Explanatory notes

- A is incorrect because negative feedback mechanisms *do* act to restore the original homeostatic state of an organism.
- C is incorrect because most negative feedback systems *do* operate as proportional control systems.
- D is incorrect because some negative feedback systems *do* operate as on-off control systems.

Question 18

Endocrine glands are ductless glands that produce hormones and release them directly into the bloodstream. Sometimes in mammals, endocrine glands may not function appropriately, resulting ultimately in detrimental effects. Which of the following accurately represents an endocrine defect with its likely effect?

	DEFECT	EFFECT
A.	overactive pituitary	decrease in metabolic rate
B.	underactive thyroid	overproduction of thyroxine
C.	overactive adrenal gland	prolonged fight-or-flight response
D.	overactive parathyroid gland	decrease in blood calcium levels

Answer is C

Explanatory notes

- A is incorrect because an overactive pituitary results in an increase in metabolic rate.
- B is incorrect because an underactive thyroid gland results in the underproduction of thyroxine.
- D is incorrect because an overactive parathyroid gland increases the level of calcium in the blood.

The following information is required for Questions 19 to 21.

Cells can communicate with each other through signalling molecules, which are chemicals that can act on nearby cells, travel to another location within the body or even interact with cells in another organism.

Question 19

Hormones are signalling molecules and, based on their chemical structures, are classified into three groups. Which of the following is correct about the synthesis and life span of the three groups of hormones?

	AMINO ACID DERIVATIVES	STEROID HORMONES	PEPTIDE HORMONES
A.	synthesised in advance, short life span	synthesised on demand, long life span	synthesised in advance, short life span
B.	synthesised on demand, long life span	synthesised in advance, short life span	synthesised on demand, long life span
C.	synthesised in advance, short life span	synthesised in advance, short life span	synthesised on demand, long life span
D.	synthesised on demand, long life span	synthesised on demand, long life span	synthesised on demand, long life span

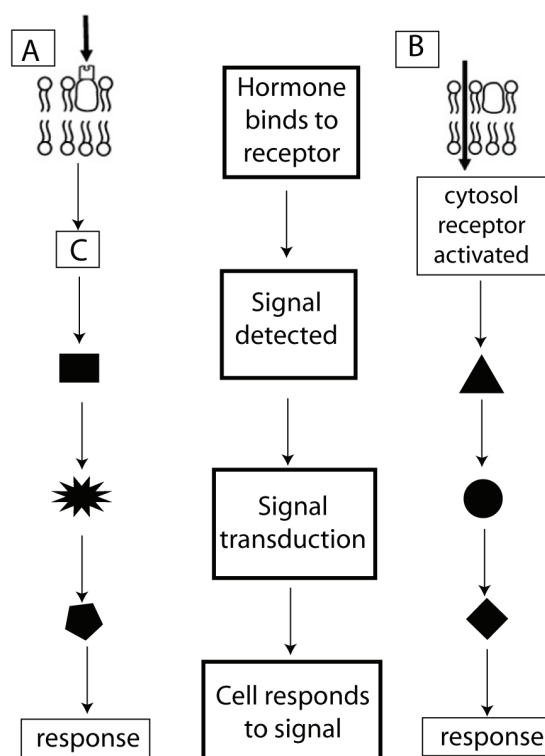
Answer is A

Explanatory notes

- B is incorrect because amino acid derivatives are synthesised in advance (not on demand) and have a short life span (not long) AND steroid hormones are synthesised on demand (not in advance) and have a long life span (not short) AND peptide hormones are synthesised in advance (not in demand) and have a short life span (not long).
- C is incorrect because steroid hormones are synthesised on demand (not in advance) and have a long life span (not short) AND peptide hormones are synthesised in advance (not in demand) and have a short life span (not long).
- D is incorrect because amino acid derivatives are synthesised in advance (not on demand) and have a short life span (not long) AND peptide hormones are synthesised in advance (not on demand) and have a short life span (not long).

Question 20

The chemical nature of hormones influences the manner in which they transmit signals to the inside of a cell. The diagram indicates the sequence of events that occurs in signalling pathways, depending on the chemical nature of the hormone. The pathway at **A** is taken by water-soluble hormones and the pathway at **B** is taken by lipid-soluble hormones.



Pathway **B** would be taken by

- A. amino acid derived hormones.
- B. protein hormones.
- C. **steroid hormones.**
- D. peptide hormones.

Answer is C

Explanatory notes

- A is incorrect because amino acid derived hormones are water soluble; Pathway **B** is taken by lipid-soluble hormones.
- B is incorrect because protein hormones are water soluble; Pathway **B** is taken by lipid-soluble hormones.
- D is incorrect because peptide hormones are water soluble; Pathway **B** is taken by lipid-soluble hormones.

Question 21

Water-soluble hormones bind with receptors found on cell membranes. This activates a cascade of chemical reactions, also known as signal transduction, which is sustained by water-soluble molecules. At C, signal transduction could be initiated by a

- A. relay molecule.
- B. G protein.**
- C. transduction molecule.
- D. primary messenger.

Answer is B

Explanatory notes

- A is incorrect because relay molecules are responsible for progressing signal transduction, not initiating it.
- C is incorrect because transduction molecule is an alternative name for relay molecule.
- D is incorrect because secondary messengers are the initiators of signal transduction.

Question 22

An axon is an extension of a nerve cell along which nerve impulses are transmitted. Axons can range from a few millimetres to over a metre in length and can be linear or branching. The presence of a myelin sheath provides insulation which increases the rate at which an impulse is conducted along the axon. When a nerve impulse reaches an axon terminal, the next event is

- A. transmitter substance binds to a receptor molecule on the muscle cell membrane.
- B. transmitter substance is inactivated by an enzyme.
- C. transmitter substance is secreted from a neuron.**
- D. the muscle cell contracts.

Answer is C

Explanatory notes

- A is incorrect because transmitter substance has to be secreted before it can bind to a receptor molecule on the muscle cell membrane.
- B is incorrect because transmitter substance has to be secreted and bind to a receptor molecule on the muscle cell membrane before it becomes inactivated by an enzyme.
- D is incorrect because transmitter substance has to be secreted, bind to a receptor molecule on the muscle cell membrane and become inactivated by an enzyme before the muscle cell contracts.

Question 23

Neuron transmission can be interrupted by adverse events. Substances such as venom contain toxins that can act on the nervous system to affect the neuromuscular synapses or to block the transmission of an impulse along an axon. Compounds known as antivenoms can be used to rapidly reverse the effects of venom. Antivenoms contain

- A. antigens which bind with antibodies in the venom to form an antigen–antibody complex.
- B. antibodies which bind with antigens in the venom to form an antigen–antibody complex.**
- C. toxoids which are capable of destroying the active site of the venom.
- D. plasma cells which are capable of producing antibodies to act against the venom.

Answer is B

Explanatory notes

- A is incorrect because the venom contains antigens (not antibodies) and antibodies are required to form an antigen–antibody complex.
- C is incorrect because toxoids are produced by treating toxins to produce substances that act as antigens but are unable to cause disease. In addition, toxoids are usually derived from toxins produced by micro-organisms, not from toxins found in venom.
- D is incorrect because even though plasma cells are capable of producing antibodies (which are essential for disabling venom) they would not be able to differentiate rapidly enough to produce a sufficient quantity of antibodies to prevent the action of the venom.

Question 24

A group of proteins that are important in immunity are interferons. Interferons are released by some cells when the cells have been infected with virus particles. Interferons act on uninfected cells by making them more resistant to the infecting virus. Other important proteins associated with non-specific immunity include

- A. complement proteins and cytokines.**
- B. complement proteins and MHC markers.
- C. cytokines and antibodies.
- D. cytokines and immunoglobulins.

Answer is A

Explanatory notes

- B is incorrect because whilst MHC markers are proteins, they are associated with specific immunity.
- C is incorrect because whilst antibodies are proteins, they are associated with specific immunity.
- D is incorrect because whilst immunoglobulins are proteins, they are associated with specific immunity.

Question 25

A woman is exposed to chicken pox (*Varicella zoster* virus) in her second month of pregnancy. She has never been exposed to chicken pox or immunised against it. She consults her health practitioner who recommends treatment with varicella-zoster immunoglobulin (VZIG), a substance that triggers an immune response against the virus. This method of treatment will provide the woman with

- A. natural passive immunity.
- B. natural active immunity.
- C. **induced passive immunity.**
- D. induced active immunity.

Answer is C

Explanatory notes

- A is incorrect because natural passive immunity occurs when a foetus receives maternal antibodies across the placenta. This may occur inadvertently; however, this is not the focus of the question.
- B is incorrect because whilst the woman may begin to develop a primary response to the virus, the question is asking what form of immunity the woman will be provided with as a result of the treatment.
- D is incorrect because the treatment is providing the woman with VZIG immunoglobulins which are not an attenuated form of the virus.

SECTION B – Short-answer questions

Question 1

The molecules that living organisms are composed of can be grouped into five principle classes. Interactions occur between these molecules constantly and ultimately their shapes determine their function. The functions of some of these molecules are outlined in the table below.

1a. Complete the table by identifying each of the biological molecules described.

Solution

Biological Function	Biological Molecule
solvent, support, turgor, site for metabolic reactions	<i>water</i>
insulation, source of energy, structural	<i>lipid</i>
provide information about construction and function	<i>nucleic acid</i>
structural, energy storage, cellular recognition	<i>carbohydrate</i>

2 marks

Mark allocation

- 2 marks if all answers are correct.
- 1 mark if 2 or 3 answers are correct.
- 0 marks if 0 or 1 answer is correct.

Explanatory notes

- Proteins are three-dimensional biological molecules which are classified on the basis of their shape and form as primary, secondary, tertiary and quaternary. The tertiary structure is a precise folded configuration of the secondary structure.

1b. What is one form of bonding that holds the tertiary structure together?

Solution

Disulfide bridges OR hydrophobic interactions OR hydrogen bonds OR ionic/salt bridges

1 mark

Explanatory notes

- The protein folds because various points on the secondary structure are attracted to each other, the strongest attraction being between cysteine amino acids, which form disulfide bonds. Weak bonding interactions may include ionic (between positively and negatively charged side chains), hydrogen bonds (between polar side chains) and hydrophobic interactions (amino acids with hydrophobic side chains cluster out of contact with water).

Tip

- *It is a good idea to be generally familiar with the types of bonding associated with each of the protein structures.*

Proteins are produced in their simplest form at the ribosomes. They can, however, have other biological molecules added to them and they become modified to form conjugated proteins. An example of a conjugated protein is a glycoprotein.

1c i. What is a glycoprotein?

Solution

A protein with a carbohydrate molecule attached to it

1 mark

1c ii. Describe **one** role of a glycoprotein.

Solution

Glycoproteins are important recognition markers on cell membrane surfaces.

OR

Glycoproteins are secretory proteins.

1 mark

Explanatory notes

- Glycoproteins form when protein molecules bond covalently with carbohydrate molecules. This occurs in the interior of the rough endoplasmic reticulum. Once formed, the carbohydrate group can act as a marker which can determine the destination of a glycoprotein (whether it remains in the cell or becomes exported). The carbohydrate group can help orientate and maintain the position of the glycoprotein in the cell membrane and may perform a function in recognition between cells (tissue formation and immune response). Some glycoproteins become incorporated within transport vesicles and move toward the Golgi apparatus.

Tip

- Be able to transfer basic structural knowledge about proteins (and all biological molecules) and apply it to the function of the molecule within a cell or living organism.*

If its three-dimensional structure changes, the biological function of the protein is almost always permanently lost.

1d i. What is the name given to this process?

Solution

Denaturation

1 mark

1d ii. Identify **one** agent that can cause the loss of three-dimensional structure in a protein.

Solution

Concentrated acids (must say concentrated) OR concentrated alkalis (must say concentrated) OR heavy metals OR heat OR radiation OR detergents OR organic solvents

1 mark

Explanatory notes

- Denaturation occurs when the bonds that support the secondary and tertiary structure of the protein are altered or broken.

Total 7 marks

SECTION B – continued

Question 2

Cardiovascular disease (CVD) is a complex disease state which the World Health Organisation cites as the principle cause of death in humans worldwide. CVD is caused by atherosclerosis in which fatty deposits build up along the endothelial lining of blood vessels resulting in formation of blood clots. CVD can occur in the form of heart attack, stroke and heart failure, and is related to factors such as lifestyle, diet, genetics, age and high blood pressure. During a heart attack or a stroke, blood flow to surrounding tissue is blocked; however, the cells which make up the tissue continue to metabolise for some time.

2a. Explain how cellular function can continue during a heart attack or stroke.

Solution

The cells in the surrounding tissue switch from performing aerobic cellular respiration to anaerobic cellular respiration.

1 mark

Explanatory notes

- Living tissue requires a constant supply of oxygen to perform cellular respiration. In circumstances where oxygen is readily available, living tissue will perform aerobic cellular respiration. When oxygen is in short supply (or becomes absent – as in the case with interrupted blood flow) cells in living tissue will switch to anaerobic cellular respiration which does not require oxygen to continue. However, it can only be sustained for a short time due to the increasing build-up of lactic acid which is toxic to living tissue.

If blood flow to the affected area is restored, reactive oxygen species (radicals) form. The presence of these free radicals can cause serious damage to essential cellular components because they can form preferential bonds with nucleic acids, lipids and proteins. Knowledge of this aspect of the molecular mechanism associated with CVD means that it is possible to develop a drug to treat it.

2b i. What is the name given to this process of drug development?

Solution

Rational drug design

1 mark

2b ii. What is a disadvantage associated with this process?

Solution

Rational drug design is of no use when nothing is known about the molecular mechanism of the disease.

1 mark

Explanatory notes

- Flavonoids are compounds metabolised in plants and are found in fruits, vegetables, tea and red wine. Studies of human populations have shown that those with diets rich in fresh fruit and vegetables and/or regular moderate wine consumption have low incidence of CVD (even when their diet is high in dairy fat – a contributor to CVD).
- Proteins often interact and so the targeting of only one aspect of cellular function with a single drug may not account for this.

2c. Using the information provided above, explain on a molecular basis, how foods rich in flavonoids might contribute to the low incidence of CVD?

Solution

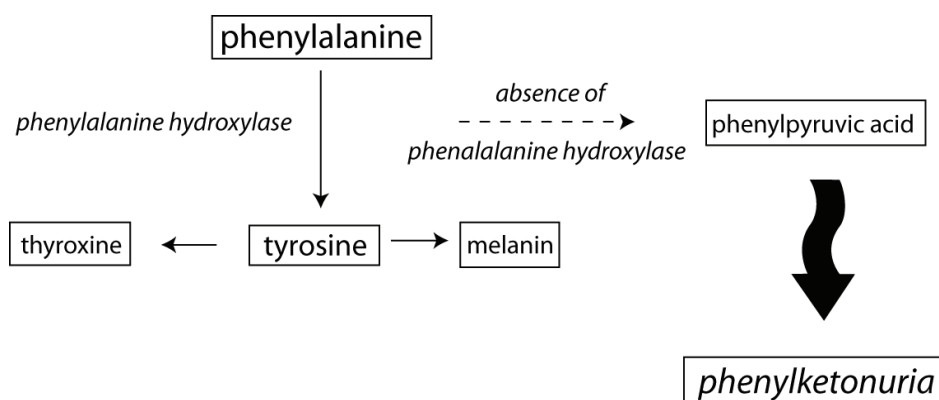
They are able to react chemically or preferentially bind with the reactive oxygen species (radicals) which stabilises them and prevents any tissue damage.

1 mark

Total 4 marks

Question 3

Metabolic pathways form a complex network in the regulation of homeostasis in an organism. Metabolic disorders arise when there are errors in the normal pathway. Phenylketonuria (PKU) is a condition that occurs when the amino acid phenylalanine (phe) is not converted to tyrosine and affects one in every 10,000 babies. Instead, the unconverted phenylalanine becomes metabolised to another compound known as phenylpyruvic acid. The accumulation of phenylpyruvic acid causes various symptoms including mouse-like body odour, light skin colour, pronounced muscle tension and activity and eczema. A partial description of the metabolism of phenylalanine is presented in the following diagram.



3a i. In which group of biomacromolecules is phenylalanine found?

Solution

Proteins

1 mark

Explanatory notes

- All proteins are formed primarily from essential amino acids – of which there are 20 known in humans. Phenylalanine is an essential amino acid and is fundamental in the formation of some proteins.

3a ii. Phenylalanine hydroxylase is a specific biological compound. What is the name given to this compound?

Solution

An enzyme

1 mark

Explanatory notes

- The presence of phenylalanine hydroxylase results in the production of tyrosine. The compound also ends with the suffix *-ase* indicating that it is an enzyme.

After birth, the accumulation of phenylpyruvic acid in the body, particularly in brain tissue, can cause severe damage in a developing child.

3b. Why does this disorder only develop in infants after birth?

Solution

Phenylpyruvic acid does not accumulate in the foetus because the mother's body produces phenylalanine hydroxylase which breaks down phenylalanine and then supplies the metabolites to the developing foetus.

2 marks

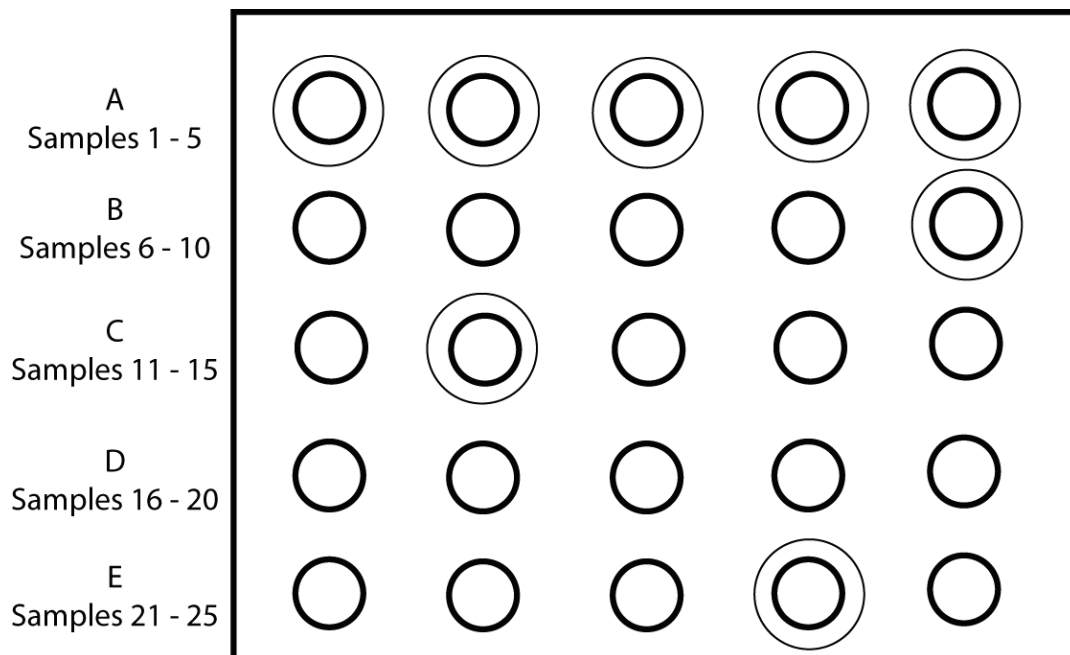
Mark allocation

- 1 mark – that phenylpyruvic acid does not accumulate in the foetus.
- 1 mark – because that the mother's body produces phenylalanine hydroxylase to break down phenylalanine.

Explanatory notes

- The disorder occurs when a person does not produce the enzyme phenylalanine hydroxylase to break down phenylalanine. Whilst the foetus is *in utero*, the mother will be producing phenylalanine hydroxylase and breaking down the phenylalanine. After birth the infant needs to produce phenylalanine hydroxylase but is unable to do so. This leads to an accumulation of phenylalanine which is metabolised to phenylpyruvic acid and causes damage to brain tissue.

To determine whether a newborn has PKU, a heel prick blood test is performed shortly after birth and the levels of phenylalanine in the blood are determined. A technique that was previously used to diagnose the condition involved the use of Guthrie plates on which discs containing blood samples were tested for high levels of phenylalanine. The plates were coated with agar which contained a strain of bacteria that would only grow in the presence of phenylalanine. Growth occurred in a ring around the disc which was placed on the agar. The diagram shows the results of a series of tests.



The discs in Row A all show a distinct band of growth around them.

- 3c i.** Explain the likely purpose of the discs in Row **A** and indicate what is known about them.

Solution

The discs in Row **A** function as a control and each will contain a known concentration of phenylalanine.

2 marks

Mark allocation

- 1 mark – discs in Row **A** function as a control
- 1 mark – contain a known concentration of phenylalanine

Explanatory notes

- The discs in Row **A** all show a distinct band of growth around them.

- 3c ii.** What conclusion can be drawn about Samples **10**, **12** and **24**?

Solution

Samples **10**, **12** and **24** indicate that the babies from whom these blood samples were taken have PKU.

1 mark

Explanatory notes

- Samples **10**, **12** and **24** have a concentration of phenylalanine that is high enough to enable bacterial growth therefore the babies from whom these blood samples were taken have PKU.

Once a diagnosis of PKU is made, the condition can be managed.

- 3d.** Suggest **one** strategy that can be used in the management and treatment of PKU.

Solution

Introducing a low protein diet that incorporates foods that are low in phenylalanine and include drinks which supply other essential amino acids, vitamins and minerals

1 mark

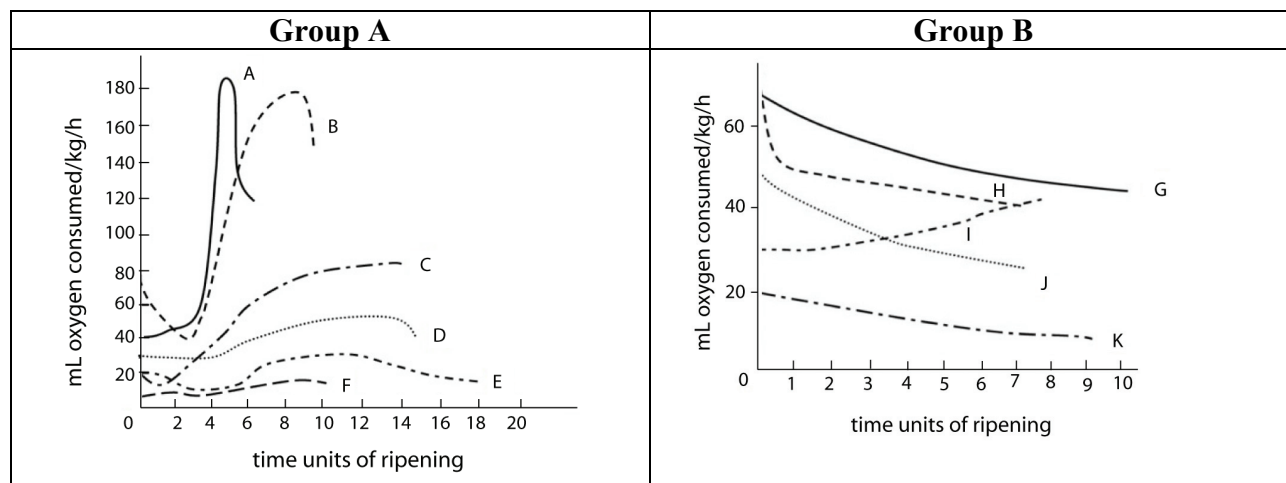
Explanatory notes

- It is essential to minimise the amount of phenylalanine in the diet. The effects of PKU can be avoided by reducing the amount of protein which contains phenylalanine (most protein) and supplementing the diet with a supply of phenylalanine-free amino acids OR by administering regular/controlled injections of stabilised phenylalanine hydroxylase.

Total 8 marks

Question 4

The ripening of many different types of fruit is associated with the production of a chemical, the gas ethylene. Ethylene acts to increase the levels of certain enzymes, including amylase and pectinase, within plant tissue. A researcher made a series of observations of a group of fruiting plants. In particular, the volume of oxygen consumed per kilogram per hour during the ripening process was recorded. The results were divided into two distinct groups and are shown in the following table.



4a. Why has the researcher made a distinction between Group **A** and Group **B** when presenting the results of the observations?

Solution

Overall, the fruit in Group **A** demonstrate a peak in the rate of oxygen consumption at some stage of their ripening whereas overall the fruit in Group **B** demonstrate a gradual decline in their rate of oxygen consumption during their ripening process.

2 marks

Mark allocation

- 1 mark for fruit in Group **A** demonstrate a peak in the rate of oxygen consumption
- 1 mark for fruit in Group **B** demonstrate a gradual decline in their rate of oxygen consumption

4b i. The consumption of oxygen is associated with a specific biochemical process in plants that occurs whether fruit is ripening or not. What is the name given to this biochemical process?

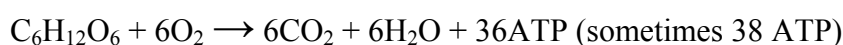
Solution

Cellular respiration

1 mark

4b ii. What is the balanced chemical equation for this biochemical process?

Solution



2 marks

Mark allocation

- 1 mark if all reactants and products are correct
- 1 mark for correct molecular ratios

- 4c.** Identify the specific role that oxygen plays in the biochemical process referred to in Question **4bii**. What happens to it?

Solution

Oxygen is the final electron acceptor in the electron transport chain and is reduced to water.

2 marks

Mark allocation

- 1 mark for oxygen is the final electron acceptor in the electron transport chain
- 1 mark for oxygen is reduced to water

Total 7 marks

Question 5

The ripening of many different types of fruit is associated with the production of a chemical, the gas ethylene. Certain other aspects of plant growth and development are also controlled by chemical substances.

- 5a.** What is the name given to the chemical substances that control plant growth and development?

Solution

Hormones

1 mark

Auxins such as indoleacetic acid (IAA) is a group of hormones which are produced by the growing tips of plants and are associated with a number of different processes, depending on their location and concentration. A synthetic auxin 2,4-dichlorophenoxyacetic acid (2,4-D) is a known selective herbicide to which dicotyledon weeds are generally susceptible. It is sprayed over crops and pastures in which the weeds grow, killing the dicotyledons but not the monocotyledons.

- 5b i.** What is a selective herbicide?

Solution

A weedkiller that kills some plants but not others

1 mark

- 5b ii.** Suggest **one** way that 2,4-D is effective in controlling growth of weeds.

Solution

2,4-D is an auxin and disrupts normal growth of dicotyledons by inhibiting the growth of coleoptiles (shoot tips).

1 mark

Explanatory notes

- It is thought that 2,4-D operates due to toxic accumulation within plant cells. Indoleacetic acid (IAA) enters and leaves cells by two different transmembrane transporters. Suggestions have been made that the transmembrane importer brings 2,4-D successfully into cells; however, the transmembrane exported is unable to remove the 2,4-D from the cell and it is this accumulation that becomes toxic to the cell, thus inhibiting function and growth.

Despite previous success with controlling weeds, 2,4-D has become less effective at killing weeds over time. Funding for further research on the commercial use of the herbicide has been made available.

- 5c i.** What is the most likely reason for the re-emergence of weeds in crops after spraying with 2,4-D?

Solution

Weeds may have several strains. Some strains have a naturally occurring resistance to the herbicide and can withstand the effects of the 2,4-D.

1 mark

- 5c ii.** Identify **one** other reason that agricultural scientists might want to investigate 2,4-D.

Solution

They may wish to investigate the possible effects of long-term exposure (for humans and other animals) to the herbicide 2,4-D.

OR

They may wish to study the mechanisms of resistance development and its transfer to other species.

1 mark

Total 5 marks

Question 6

Neurons are an essential means of communication within multicellular organisms. They form part of a complex system which also includes the brain and spinal cord. The brain and spinal cord form the central nervous system (CNS) while the nerve cells that lie outside the brain and spinal cord form the peripheral nervous system (PNS) which has both sensory and motor divisions.

The table presents a summary of the peripheral nervous system.

- 6a.** Complete the table.

Solution (in *italics*)

sensory nervous system	<i>somatic sensory neurons</i>	conveys information to CNS from the external environment
	<i>visceral sensory neurons</i>	<i>conveys information to CNS from the internal environment</i>
motor nervous system	<i>somatic nervous system</i>	<i>conveys signals to skeletal muscles</i>
	<i>autonomic nervous system</i>	conveys signals that regulate internal environment

4 marks

Mark allocation

- 1 mark each correct response

Neurons act by transmitting information in the form of an electrical impulse. In order for this to occur, the cell membrane of a nerve cell must be polarised.

6b i. Explain what is meant by ‘polarised’.

Solution

If a nerve cell is polarised, a potential difference in charge exists between the inside and outside of the cell.

1 mark

6b ii. How is a polarised state achieved in nerve cells?

Solution

Sodium–potassium pumps in the cell membrane actively pump sodium ions out of and potassium ions into the nerve cell.

1 mark

Explanatory notes

- Sodium–potassium pumps in the cell membrane actively pump sodium ions out of and potassium ions into the nerve cell. As a result an excess of sodium ions accumulate outside the cell and potassium inside. Even though both ions are positively charged, the overall difference in accumulation leads to a relatively negative interior and relatively positive exterior.

Total 6 marks

Question 7

Until recently, all infective agents were thought to contain some form of nucleic acid.

7a i. Identify **two** basic forms of nucleic acid commonly found in infective agents.

Solution

Deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).

1 mark

Mark allocation

- 1 mark – both identified correctly (either full name or acronym)
- 0 marks if only one identified correctly

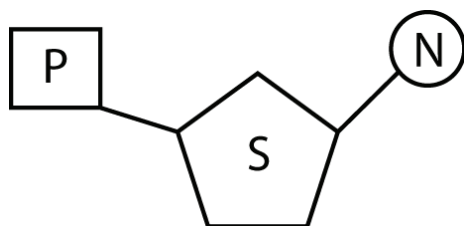
Explanatory notes

- Essentially the two basic forms of nucleic acid are DNA and RNA. Even though pathogens may contain mitochondrial DNA and/or messenger, ribosomal or transfer RNA, the question asks for the *basic* forms of nucleic acid.

7a ii. Draw a labelled diagram of a monomer of **one** of the nucleic acids.

Solution

Monomer of DNA (or RNA)



P – phosphate

S – sugar

N – nitrogen base

3 marks

Mark allocation

- 1 mark for title indicating whether monomer is DNA or RNA
- 1 mark for presenting correct molecules (named, i.e. phosphate, sugar, nitrogen base)
- 1 mark for correct positions and links between molecules

Transmissible spongiform encephalopathies (TSEs) are a group of degenerative nervous diseases which affect mammals. They are caused by infective agents lacking nucleic acid and are comprised entirely of protein. These agents are capable of replication and causing infection in previously uninfected tissue.

7b. What is the name given to these infective agents?

Solution

Prions

1 mark

Total 5 marks

Question 8

In healthy living tissue, cell death and cell production are regulated. Sometimes when regulation is interrupted, tumours or cancers can form in living tissue and can present life-threatening conditions.

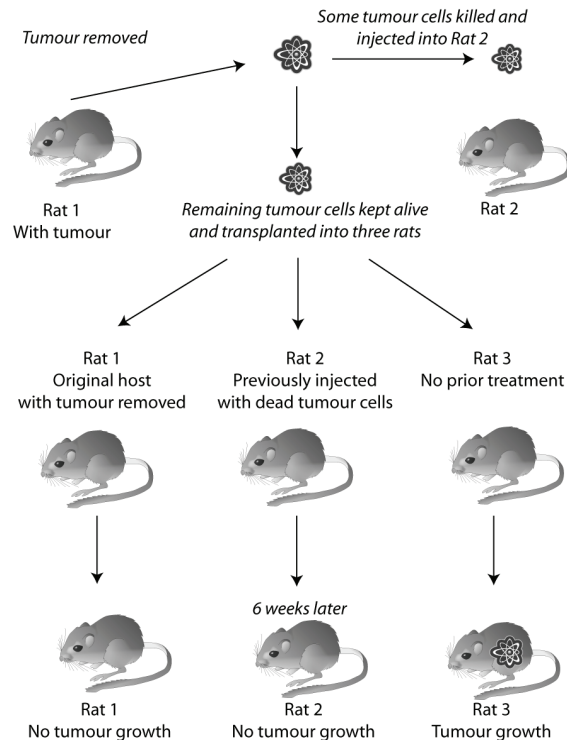
8a. What is the name given to the group of molecules that controls whether a cell lives or dies?

Solution

Regulator proteins

1 mark

Using laboratory rats bred from the same parents, research was carried out to determine if the development of tumours could be prevented by vaccination. Growth of a tumour was induced in a single laboratory rat (Rat 1). The tumour was then removed and some of the cells were killed and the rest were kept alive in tissue fluid for four weeks. Some of the dead cells were injected into another rat (Rat 2). After four weeks the living tumour cells were divided into three groups and administered to Rat 1, Rat 2 and a new rat (Rat 3). Observations were made of the rats over 6 weeks. The process is described in the following diagram.



8b. What was the purpose of injecting dead tumour cells into Rat 2?

Solution

To vaccinate the rat through the induction of an immune response due to presence of tumour antigens

1 mark

8c. What events occur in the immune system of Rat 2 after the injection of dead tumour cells?

Solution

Antigens on tumour cells are recognised by the immune system. The rat's immune system becomes competent following the production of antibodies which serve to prime the rat in the event of potential further infection.

2 marks

Mark allocation

- 1 mark for antigens on tumour cells are recognised by the immune system which promotes production of antibodies
- 1 mark for rat immune system becomes competent, priming the rat against potential further infection

Explanatory notes

- Some dead tumour cells will activate B cells, which will differentiate into plasma cells (which generate antibodies) and memory B cells. The production of tumour antibodies will continue in the long term (possibly for life) providing immunity to the rat.
- Some dead tumour cells are engulfed by macrophages which stimulate helper T cells (some of which will become memory helper T cells).

8d. In the experiment, Rat **1** and Rat **3** are both injected with live tumour cells; however, after 6 weeks only Rat **3** shows tumour growth. Explain why this occurs.

Solution

Rat **1** is exposed to tumour cells and consequently its immune system has had a chance to make antibodies in response to the tumour cell membrane surface antigens. At the same time, the tumour has been removed and so causes no more damage. When live tumour cells are introduced, antibodies are present and form antibody–antigen complex with tumour antigens. Rat **3** has not had prior opportunity to form antibodies against tumour antigens and therefore is unable to respond rapidly to the presence of the tumour which grows unchecked and out of control.

2 marks

Mark allocation

- 1 mark for Rat **1** is exposed to tumour cells and immune system makes antibodies in response to the tumour cell membrane surface antigens
- 1 mark for tumour has been removed and causes no more damage

Before the results of the research were ready to be published it was necessary to make some modifications to the experimental design.

8e. Explain clearly **one** modification that would need to be made to the experimental design and why it is required.

Solution

If experimental results are to be published, it is essential to replicate using genetically identical rats within each treatment. Each of the treatments had only one replicate (one rat each) which does not provide enough data to substantiate results. There should be at least five per treatment group, otherwise results are not robust and reliable enough.

2 marks

Mark allocation

- 1 mark for experimental results to be published the experiments must be replicated using genetically identical rats
- 1 mark for there should be at least 5 per treatment group, otherwise results are not robust, reliable enough

Total 8 marks

END OF SOLUTIONS BOOK