

INSIGHT
Trial Exam Paper

2008
BIOLOGY
Written examination 1

Solutions book

This book presents:

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

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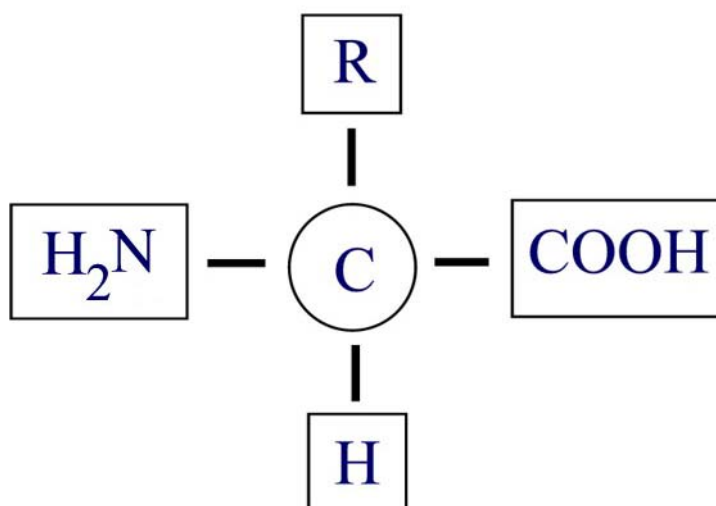
SECTION A – Multiple-choice questions

The following information is required for Questions 1 and 2.

There are over 100 amino acids found in living cells however there are only 20 which commonly occur in proteins. The behaviour of each amino acid is determined by its chemical structure.

Question 1

The general structure of an amino acid can be represented by the following diagram.



Each amino acid has different chemical properties due to the presence of the

- A. carboxyl group (COOH).
- B. amine group (NH₂).
- C. hydrogen atom (H).
- D. **side chain (R).**

Answer is D

Explanatory notes

- A is incorrect – the carboxyl group is the same in all amino acids, hence chemical properties are the same.
- B is incorrect – the amine group is the same in all amino acids, hence chemical properties are the same.
- C is incorrect – the hydrogen group is the same in all amino acids, hence chemical properties are the same.
- D is correct – the side chain is different in all amino acids, it is also known as the variable group.

Question 2

The formation of polypeptide chains can begin when two amino acids are joined together by a peptide bond. This process is best described as

- A. **amino acid + amino acid** → **dipeptide + water (condensation).**
- B. amino acid + amino acid → dipeptide + hydrogen (condensation).
- C. amino acid + amino acid ← dipeptide + water (hydrolysis).
- D. amino acid + amino acid ← dipeptide + hydrogen (hydrolysis).

Answer is A

Explanatory notes

- A is correct – when two amino acids join to form a dipeptide, water is released (condensation).
- B is incorrect – when two amino acids join to form a dipeptide, hydrogen is not released.
- C is incorrect – hydrolysis refers to the splitting of a water molecule and is the process involved in the reforming of two amino acids from a dipeptide.
- D is incorrect – hydrogen is not produced when two amino acids form a dipeptide and hydrolysis refers to the splitting of a water molecule and is the process involved in the reforming of two amino acids from a dipeptide.

Question 3

Polypeptide chains can undergo precise folding to form fibrous or globular proteins. Globular proteins fold into a spherical shape, have a tertiary structure and are water soluble. They are most likely to exhibit

- A. α -helix coils, β -pleated sheets and have a structural role in cells.
- B. α -helix coils, β -pleated sheets and have a contractile role in cells.
- C. **α -helix coils, β -pleated sheets, disulfide bridges and have a transport role in cells.**
- D. α -helix coils, β -pleated sheets, disulfide bridges and have a structural role in cells.

Answer is C

Explanatory notes

- A is incorrect – globular proteins have disulfide bridges and a transport not a structural role.
- B is incorrect – globular proteins have disulfide bridges and a transport not a contractile role.
- D is incorrect – globular proteins have a transport not a structural role.

The following information is required for Questions 4 and 5.

Some organisms have organelles possessing membranes, which are the site of energy transfer.

Question 4

In organisms that photosynthesise, the organelle responsible for converting radiant energy to chemical energy is the

- A. chlorophyll.
- B. **chloroplast.**
- C. thylakoid membrane.
- D. granum.

Answer is B

**SECTION A – continued
TURN OVER**

Explanatory notes

- A is incorrect – chlorophyll is a pigment and not an organelle.
- C is incorrect – thylakoid membrane is not the actual organelle, it is found within the chloroplast.
- D is incorrect – a granum (not an organelle), is a stack of thylakoid membranes, in the chloroplast.

Question 5

The stroma is the liquid interior of the organelle in which the light independent phase of photosynthesis occurs. Molecules that are produced directly from the light independent phase could include

- A. **PGAL.**
- B. NADPH.
- C. ATP.
- D. CO₂.

Answer is A

Explanatory notes

- B is incorrect – the light independent phase ‘unloads’ NADPH molecules, it doesn’t produce them.
- C is incorrect – the light independent phase uses ATP and produces ADP.
- D is incorrect – the light independent phase requires CO₂ and produces O₂.

Question 6

The carbohydrates α -glucose and β -glucose have the same chemical formula and are known as structural isomers because their atoms are arranged differently. Fructose and glucose are also structural isomers and are examples of monosaccharides, unlike

- A. deoxyribose which is an example of a polysaccharide.
- B. sucrose which is an example of a polysaccharide.
- C. **cellulose which is an example of a polysaccharide.**
- D. maltose which is an example of a polysaccharide.

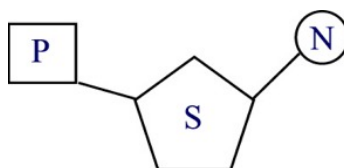
Answer is C

Explanatory notes

- A is incorrect – deoxyribose is a monosaccharide, not a polysaccharide.
- B is incorrect – sucrose is a disaccharide, not a polysaccharide.
- C is correct – cellulose IS an example of a polysaccharide
- D is incorrect – maltose is a disaccharide, not a polysaccharide.

Question 7

Nucleic acids are the biomacromolecules which pass on inherited information from generation to generation. The diagram shows a nucleotide, the basic unit of a nucleic acid which is comprised of three subunits.



Nucleotides would **NOT** be found in

- A. adenosine triphosphate (ATP).
- B. ribonucleic acid (RNA).
- C. flavine adenine dinucleotide (FAD).
- D. **acetyl co-enzyme A (acetyl CoA).**

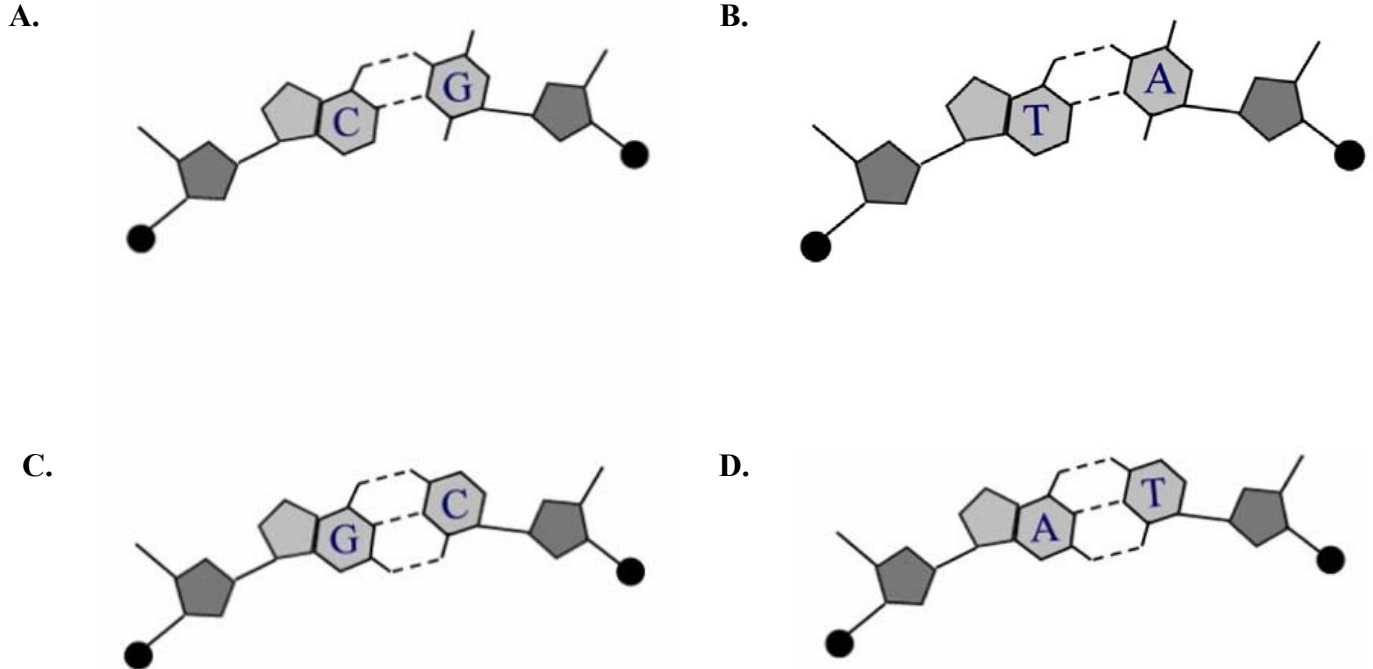
Answer is D

Explanatory notes

- A is incorrect – adenine (A) is found in the molecule adenosine triphosphate.
- B is incorrect – RNA contains the nucleotides adenine (A), cytosine (C), guanine (G) and uracil (U).
- C is incorrect – FAD (flavine adenine dinucleotide) contains the nucleotide adenine (A).
- D is correct – acetyl CoA does not have any nucleotides.

Question 8

Deoxyribonucleic acid (DNA) is comprised of a double strand of nucleotide bases linked together in a specific bonding pattern. The nucleotide bases are attracted to each other and form hydrogen bonds. In the diagrams below, which representation shows the correct structural arrangement of complementary nucleotide base pairs?



Answer is C

Explanatory notes

purines: adenine & guanine consist of a two ring structure whereas pyrimidines: cytosine & thymine consist of a one ring structure.

- A is incorrect – cytosine has been shown as a purine and guanine as a pyrimidine.
- B is incorrect – thymine has been shown as a purine and adenine as a pyrimidine.
- D is incorrect – adenine and thymine share a double hydrogen bond, not a triple bond.

Question 9

Enzymes are molecules which act as organic catalysts in biochemical processes. An enzyme will

- lower the activation energy needed to catalyse a metabolic reaction.**
- increase the activation energy required to catalyse a metabolic reaction.
- only ever bind one substrate molecule in its active site.
- undergo a permanent change in its tertiary structure only after participating in a metabolic reaction.

Answer is A

Explanatory notes

- B is incorrect – enzymes lower the activation energy required to catalyse a metabolic reaction.
- C is incorrect – enzymes can bind more than one substrate molecule in the active site.
- D is incorrect – enzymes may alter their structure during catalysis but remain unaffected in terms of structure after participating in a metabolic reaction.

Question 10

Metabolic reactions can occur simultaneously within organisms. Some of these reactions release energy while others require energy to proceed. A student was asked to construct a table summarising the relationship between metabolic reactions, identifying the energy requirements and reaction type for each. Which of the following is the only correct statement?

	Reaction		
A.	cellular respiration	endergonic	catabolic
B.	chemical digestion (hydrolysis)	exergonic	catabolic
C.	Photosynthesis	exergonic	anabolic
D.	protein synthesis	exergonic	anabolic

Answer is B

Explanatory notes

- A is incorrect – cellular respiration is associated with the release of energy (exergonic); not endergonic.
- B is correct – chemical digestion, also called enzyme-catalysed hydrolysis is associated with the release of energy (exergonic) and involves the metabolic breakdown of larger molecules into smaller ones (catabolic).
- C is incorrect – photosynthesis requires energy (endergonic); not exergonic.
- D is incorrect – protein synthesis involves building of molecules and requires energy (endergonic); not exergonic.

Question 11

Cells are involved in the production of many different biomacromolecules, many of which must be packaged and transported out of the cell. Polypeptides that require such transport are synthesised by

- A. the smooth endoplasmic reticulum.
- B. the Golgi apparatus.
- C. free ribosomes found in the cytosol.
- D. **membrane-bound ribosomes.**

Answer is D

Explanatory notes

- A is incorrect – proteins must be synthesised by ribosomes, smooth ER has no associated ribosomes.
- B is incorrect – Golgi apparatus is responsible for storing and dispatching transport vesicles of packaged protein, but the polypeptide needs to be synthesised by ribosomes first.
- C is incorrect – free ribosomes are associated with the formation of polypeptides that will remain dissolved in the cytosol, not proteins for transport.

The following information is required for Questions 12 and 13.

Proteomics is the study of proteins and their structure and function. The term proteome is a hybridisation of the words protein and genome. The proteome is the entire collection of proteins produced by an organism during its lifetime, whilst the genome is the full complement of genes.

Question 12

Proteomics is considered more complex than genomics because

- A. the genome of an organism is relatively constant unless the environment changes.
- B. proteins are smaller molecules than genes.
- C. **the proteome of an organism varies due to its biochemical interactions with the genome and the environment.**
- D. everything about the human genome has been discovered.

Answer is C

Explanatory notes

- A is incorrect – the genome is subject to change independent of changes in the environment, such as spontaneous mutations arising during DNA replication.
- B is incorrect – proteins are not necessarily smaller molecules than genes.
- D is incorrect – much is known about the genomes of some organisms however not everything has been discovered.

Question 13

Proteomics relies on the use of many technologies in order to increase understanding of the proteome. One such technology is the use of gel electrophoresis which can be used to identify the

- A. **relative mass of a protein.**
- B. relative length of a protein.
- C. three-dimensional structure of a protein.
- D. the relative amounts of the different amino acids in protein.

Answer is A

Explanatory notes

- B is incorrect – gel electrophoresis does not identify the length of a protein.
- C is incorrect – gel electrophoresis does not identify the 3D structure of a protein.
- D is incorrect – gel electrophoresis does not identify the amounts of amino acid in a protein.

Question 14

In the past, drugs were often discovered and developed through a haphazard process of trial and error. In contrast, rational drug design uses knowledge of the specific chemical responses of an organism, to develop an appropriate and effective treatment. Examples of rational drug design would NOT involve

- A. determining the activity of a drug at its binding site.
- B. the use of three-dimensional information about biomacromolecules.
- C. **testing chemical substances on organisms and correlating the effects with treatments.**
- D. preventing the function of a key molecule, thereby interrupting a metabolic pathway.

Answer is C

Explanatory notes

- A is incorrect – determining the activity of a drug at its binding site uses molecular knowledge.
- B is incorrect – the use of three-dimensional information about biomacromolecules is an example of rational drug design.
- C is the best response – although clinical trials are an important part of the drug development process, the focus of rational drug design is the targeted development of a chemical treatment using molecular knowledge and the specific chemical responses of target organisms, rather than relying on trial and error
- D is incorrect – preventing the function of a key molecule and interrupting a metabolic pathway uses molecular knowledge.

Question 15

Adenosine diphosphate (ADP) has the potential to become the principle energy carrier for a cell. With the addition of a phosphate, ADP is converted to adenosine triphosphate (ATP). An energy releasing molecule that would NOT be involved in the conversion of ADP to ATP would be

- A. **glucagon.**
- B. glycerol.
- C. glycogen.
- D. glucose.

Answer is A

Explanatory notes

- A is correct – glucagon is a hormone associated with regulation of blood glucose levels.
- B is incorrect – glycerol can be metabolised to release energy that can bind ADP + Pi to produce ATP.
- C is incorrect – glycogen is metabolised to release energy that can bind ADP + Pi to produce ATP.
- D is incorrect – glucose is metabolised to release energy that can bind ADP + Pi to produce ATP.

Question 16

Follicle stimulating hormone (FSH) is a peptide hormone which is released from the pituitary gland into the bloodstream. It is transported through the circulatory system until reaching target cell receptors in the ovaries. Receptors for peptide hormones are found

- A. in the cytosol of target cells.
- B. on the plasma membrane of target cells.**
- C. in the nuclear membrane of target cells.
- D. within the nucleus of target cells.

Answer is B

Explanatory notes

- A is incorrect – receptors for steroid (not peptide) hormones are found in the cytosol of target cells.
- C is incorrect – receptors for peptide hormones are found in the plasma (not nuclear) membrane of target cells.
- D is incorrect – receptors for peptide hormones are found in the plasma membrane, not within the nucleus of target cells.

Question 17

Sensory receptors act as biological signal transducers when they detect stimuli and respond with the generation of an electrochemical signal which will always demonstrate particular properties. Which one of the following statements is NOT a true property of the receptor cell response?

- A. The frequency of impulses in a receptor cell is directly proportional to the strength of the stimulus.
- B. Action potentials are generated from within the cell body of an axon.**
- C. Sensory cells demonstrate sensory adaptation and will eventually stop responding to a stimulus.
- D. The receptor cell response has the capacity to change energy from one form to another.

Answer is B

Explanatory notes

- A is incorrect – the frequency of impulses in a receptor cell IS directly proportional to the strength of the stimulus.
- B is correct – action potentials are NOT generated from the cell body of an axon, they are generated at the beginning of an axon.
- C is incorrect – sensory cells DO demonstrate sensory adaptation and WILL eventually stop responding to a stimulus.
- D is incorrect – receptor cell response DOES have the capacity to change energy from one form to another.

Question 18

In mammals, pheromones are used as a means of communication with other organisms. Rabbits are known to release a mammary pheromone which initiates feeding behaviour in the young. A pheromone is a chemical

- A. produced by an organism and travels in the bloodstream to its target tissue.
- B. which acts interspecifically.
- C. which is large, inert and insoluble in water.
- D. produced by an organism and is released into the external environment.**

Answer is D

Explanatory notes

- A is incorrect – pheromones are released into the external environment, not into the bloodstream.
- B is incorrect – pheromones act intraspecifically, not interspecifically.
- C is incorrect – pheromones are small, volatile and water-soluble molecules.

Question 19

Like animals, plants also possess biochemical and structural defence mechanisms. These defence mechanisms can be classified into two different groups. Passive defences are barriers of a structural or chemical nature whereas active defences are triggered in direct response to physical attack or infection by a pathogen. An example of active defence in plants is

- A. sealing off infected areas with the production of cork cells.**
- B. bad tasting chemicals that deter insects.
- C. a thick waxy cuticle to act as a barrier against pathogenic enzymes.
- D. hairs on the stomata to prevent entry by pathogens.

Answer is A

Explanatory notes

- B is incorrect – this is an example of a chemical barrier which is a passive defence strategy.
- C is incorrect – this is an example of a physical barrier which is a passive defence strategy.
- D is incorrect – this is an example of a physical barrier which is a passive defence strategy.

Question 20

The immune system relies entirely on the coordination of the humoral and cell-mediated responses. The humoral immune response is associated with the serum and involves the action of antibodies. The humoral response effectively protects the body against

- A. parasitic protozoans, fungi and worms.
- B. viruses and bacteria found within cells.
- C. circulating viruses and bacterial toxins.**
- D. the development of tumours that cause cancer.

Answer is C

Explanatory notes

- A is incorrect – protection from parasitic protozoans, fungi and worms is primarily cell-mediated.

**SECTION A – continued
TURN OVER**

- B is incorrect – protection from viruses and bacteria found within cells is cell-mediated.
- D is incorrect – protection from the development of tumours that cause cancer is primarily cell-mediated.

The following information is required for Questions 21 and 22.

In humans, normal body temperature can range from 36.2°C – 37.8°C. When a pathogen infects an organism, one observable response is an increase in body temperature (fever) which is caused by a change in the body's thermostat. An increase in body temperature can be beneficial as it facilitates defence responses.

Question 21

Fever would NOT

- A. speed up metabolism to assist in the repair of body tissues.
- B. increase heart rate to enable more efficient supply of white blood cells to sites of infection.
- C. be due to the release of pyrogens which set the body's thermostat at a higher temperature.
- D. **be associated with vasoconstriction which causes shivering.**

Answer is D

Explanatory notes

- A is incorrect – fever DOES speed up metabolism to assist in the repair of body tissues.
- B is incorrect – fever DOES increase heart rate to enable more efficient supply of white blood cells to sites of infection.
- C is incorrect – fever CAN BE due to the release of pyrogens which set the body's thermostat at a higher temperature.
- D is correct – fever and shivering WILL NOT be associated with vasoconstriction, rather vasodilation.

Question 22

The raising of the body's thermostat to a slightly higher temperature is an example of positive feedback. Positive feedback mechanisms

- A. trigger a response that counteracts the original stimulus.
- B. are always harmful to living organisms.
- C. **trigger a response that amplifies the original stimulus.**
- D. are never harmful to living organisms.

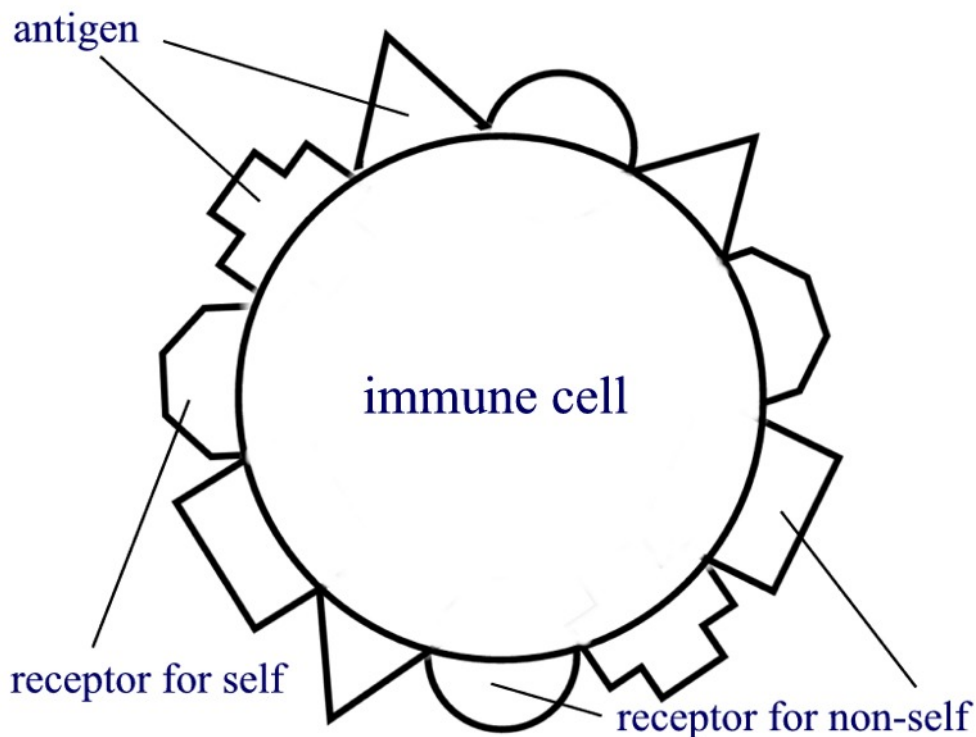
Answer is C

Explanatory notes

- A is incorrect – positive feedback mechanisms trigger a response which amplifies the original stimulus.
- B is incorrect – positive feedback mechanisms are not always harmful e.g. childbirth, lactation or bloodclotting.
- D is incorrect – positive feedback mechanisms can be harmful e.g. escalating body temperature.

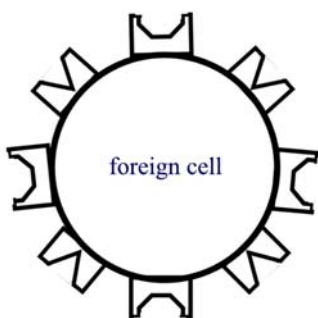
Question 23

Immune cells carry many different kinds of receptors on their plasma membrane. Immune cells are capable of recognising the nature of the threat posed by non-self cells. The more non-self antigens detected by an immune cell, the greater the response will be when it comes into contact with a foreign cell. The diagram shows an example of an immune cell.

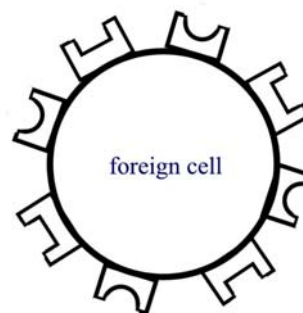


Which of the following foreign cells (below) will likely induce the greatest response from the immune cell shown above?

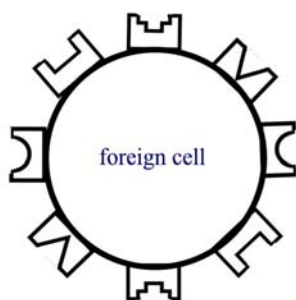
A.



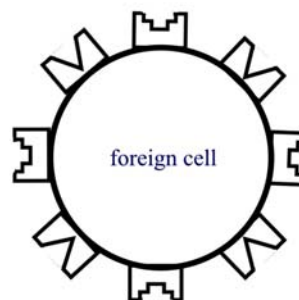
B.



C.



D.



Answer is B

**SECTION A – continued
TURN OVER**

Explanatory notes

- A is incorrect – Cell A does not have any of the specified non-self antigens as Cell B, therefore induces a lesser response from the immune cell.
- C is incorrect – Cell C does not have as many non-self antigens as Cell B, therefore a lesser response.
- D is incorrect – Cell D does not have any of the specified non-self antigens that Cell B does, therefore a lesser response.

The following information is required for Questions 24 and 25.

Triple Antigen is a multivalent vaccine made from a mixture of toxoids from organisms causing diphtheria and tetanus, in addition to killed organisms from strains of *Bordetella pertussis*. The vaccine is administered by deep intramuscular injection to infants at the age of 2 months, 4 months and 6 months.

Question 24

Following intramuscular administration, Triple Antigen stimulates production of antibodies which protect against the diseases caused by each of the three infective organisms. This response should provide the immunised infant with

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

Answer is D

Explanatory notes

- A is incorrect – not natural (exposure is induced) or passive (antibodies have been actively made).
- B is incorrect – not natural (exposure is induced).
- C is incorrect – not passive (antibodies have been actively made).

Question 25

Effective protection requires the administration of three consecutive injections of Triple Antigen, preferably at 4 to 8 week intervals. It is necessary to schedule three injections because

- A. at this early stage of life, the toxoids are naturally absorbed from the infant bloodstream.
- B. **immunity is usually not acquired until the third administration.**
- C. the immature immune system cannot produce any antibodies until the third administration of toxoids.
- D. the antibodies provided in the vaccination have a short lifespan.

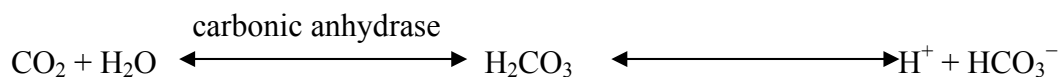
Answer is B

Explanatory notes

- A is incorrect – toxoids are not reabsorbed from the bloodstream.
- C is incorrect – the immune system produces antibodies after the first injection however it takes time to build up immunity.
- D is incorrect – there are no antibodies provided in the vaccination, only toxoids.

SECTION B – Short-answer questions**Question 1**

Carbonic anhydrase is found in red blood cells where it catalyses a reaction to form carbonic acid from carbon dioxide and water. The carbonic acid then readily dissociates into a hydrogen ion and bicarbonate ions. This enables the transport of carbon dioxide (produced during cellular respiration in cells) from the tissues of the body to the lungs.



1a. Name the class of biomacromolecules that carbonic anhydrase is a member of.

Solution

Protein

1 mark

Explanatory notes

- Carbonic anhydrase is an enzyme. Enzymes are a class of proteins which act as biological catalysts. Enzymes increase the rate of the reaction without being consumed by the reaction.
- It is likely that bicarbonate ions cross cell membranes by diffusing through transmembrane channels in the plasma membrane.

1b i. What is a transmembrane channel?

Solution

A pore in the phospholipid bilayer of a plasma membrane, through which ions and some small hydrophilic molecules can pass.

1 mark

1b ii. Why must bicarbonate ions use transmembrane channels to leave a cell?

Solution

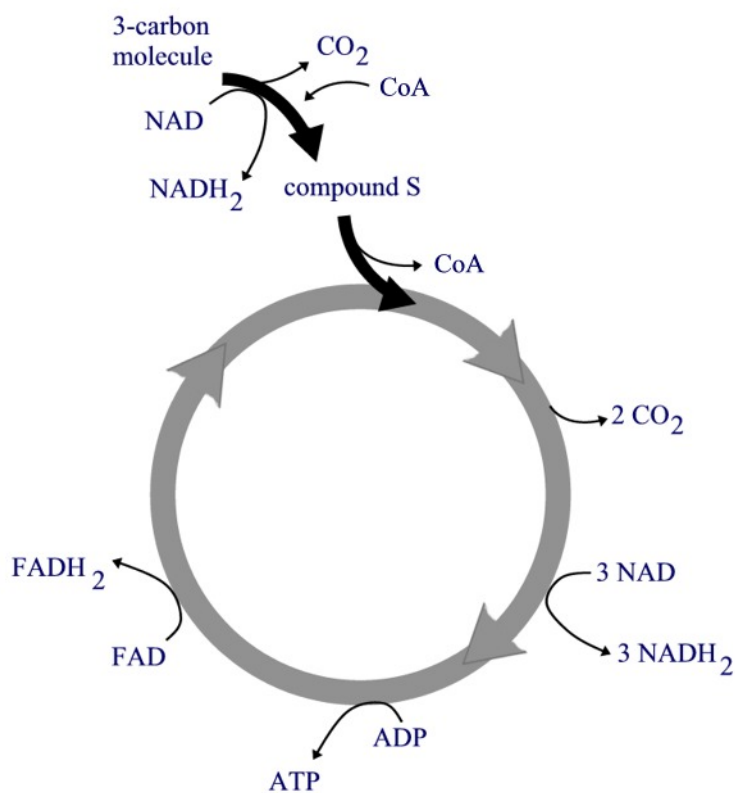
The lipid bilayer is not permeable to charged chemical substances (ions) and bicarbonate is an ion therefore must leave via the transmembrane channels.

1 mark

Explanatory notes

- Some ions and hydrophilic molecules are insoluble in the plasma membrane and cannot diffuse across. The water filled transmembrane pore is found in the phospholipid bilayer of a plasma membrane and ions and some small hydrophilic molecules can pass through it passively via the process of facilitated diffusion.

Cellular respiration is a process essential to all living cells. The following diagram summarises the Krebs cycle.



1c i. Where exactly does the Krebs cycle occur?

Solution

The matrix of the mitochondria

1 mark

1c ii. What is the name of the 3-carbon molecule that is the source of compound S?

Solution

Pyruvate

1 mark

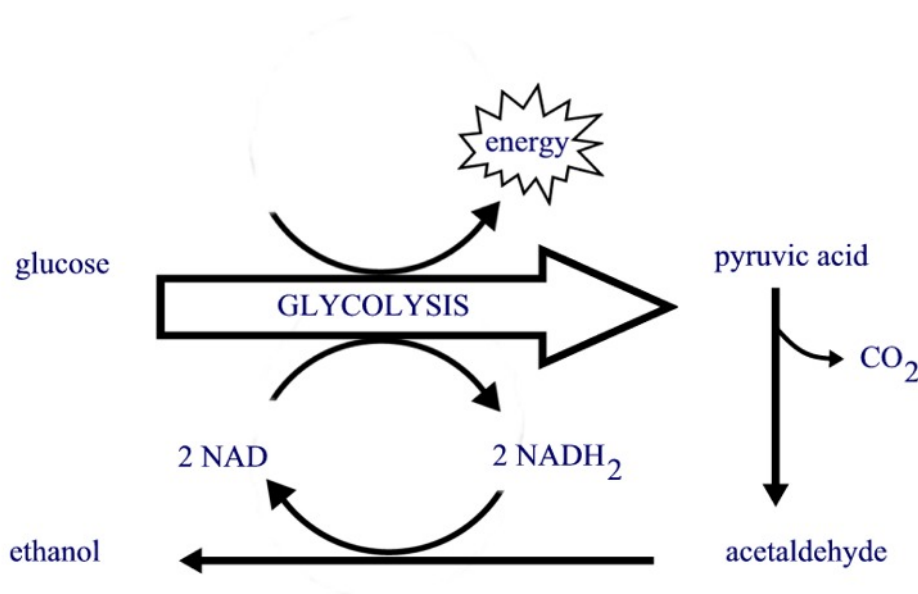
1c iii. During the Krebs cycle, what chemical process results in the formation of 'loaded' acceptor molecules?

Solution

Oxidation

1 mark

Saccharomyces cerevisiae is a species of yeast that has been used in baking and the production of alcoholic beverages for many centuries. In the presence of oxygen, yeast are capable of performing cellular respiration. In the absence of oxygen, glycolysis still occurs in the cytosol, however if there are no molecules available to accept the electrons produced by the glycolytic pathway, the process stops. This is represented in the following diagram.



1d. What is the name of this process?

Solution

Fermentation NOT anaerobic respiration

1 mark

Explanatory notes

- Even though fermentation and anaerobic respiration are terms that are often used interchangeably they are different. Anaerobic respiration involves hydrogen ions passing down a chain of carriers to a terminal acceptor and this does not occur in fermentation.

1e. Explain why this process cannot continue indefinitely.

Solution

The accumulation of toxic products (in this case ethanol) inhibits any further metabolic activity.

1 mark

1f. What conclusion can be made about the efficiency of this process? Explain your answer.

Solution

Not a very efficient process as it only yields 2 ATP in comparison with the 36(38) ATP from aerobic respiration.

1 mark

Question 2

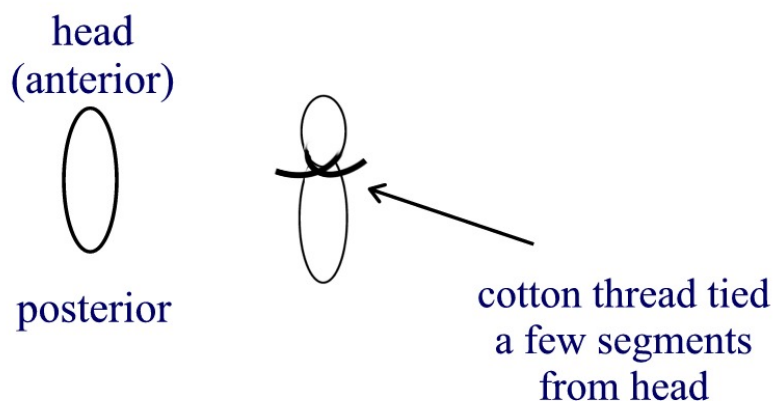
The blowfly, *Chrysomya rufifacies*, is capable of picking up faint traces of the odour of decay and can fly up to 20 km in search of a suitable corpse in which to lay eggs. After hatching, the larvae of the blowfly will grow and moult, three times. At the end of the third growth stage (3rd instar), the larva leaves the corpse and burrows into the ground where it develops into a pupa. After around 14 days of reorganisation, the pupa emerges as an adult fly. The life cycle of *Chrysomya rufifacies* is described in the following diagram.

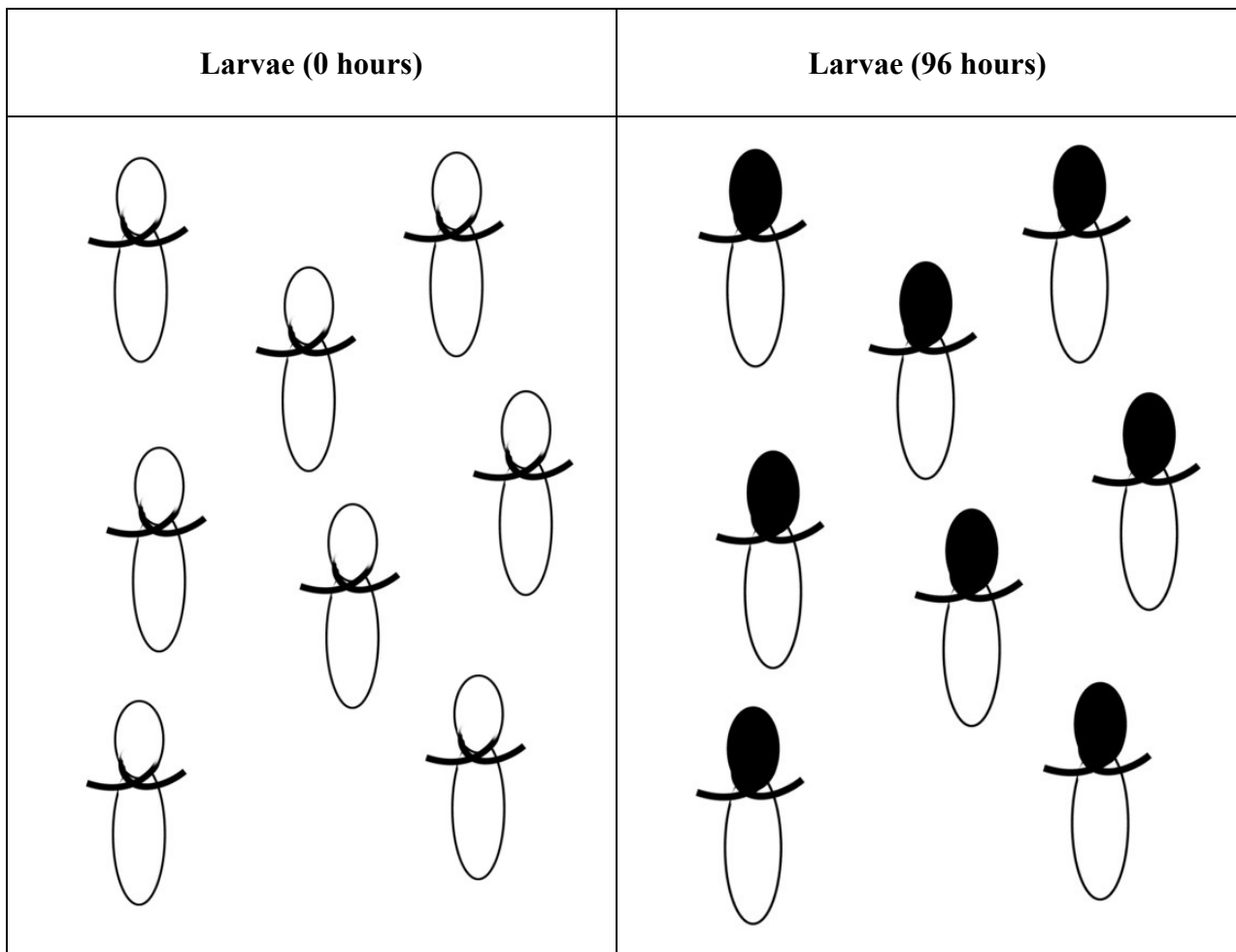
Egg → larva (1st instar) → larva (2nd instar) → larva (3rd instar) → pupa → adult

When a larva develops into a pupa, the larval case darkens in colour, becoming thin and forming a rigid case inside which the adult blowfly will develop.

It is known that pupation is under the control of a hormone. A researcher carried out an experiment to investigate this idea.

larva - 1st instar





2a. State the hypothesis being tested by the researcher.

Solution

That pupation is under the control of a hormone produced in the head/anterior end of the larva.

1 mark

Explanatory notes

- Information is given in the stem which indicates that pupation is under the control of hormones. All that is required is to observe the diagram(s) and notice that the larva has been tied off at the anterior end, thus investigating whether the hormone originates in this area of the body.

2b. Do the experimental results support the researcher's hypothesis? Explain the reason for your choice.

Solution

Yes, the results support the hypothesis. Diagram shows that the anterior region of each larva has darkened due to the effect of the hormone produced in the head.

2 marks

Explanatory notes

- In experimental larvae, the anterior region of each larva has darkened due to the effect of the hormone produced in the head. The larvae do not show darkened bodies below the tied cotton thread suggesting that the hormone, constrained by the thread, has not moved beyond the anterior section.

2c. Design an experiment that would enable you to determine the time at which the hormone controlling pupation becomes active.

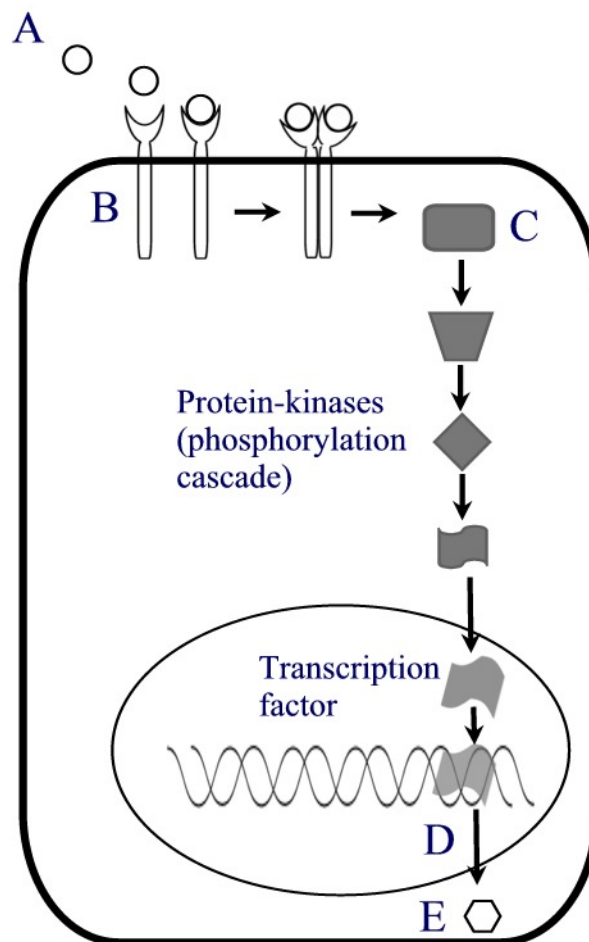
Solution

Experimental design needs to show controlled variables (such as genetic stock, temperature of environment, humidity, food source) except the one being investigated (experimental variable). The experimental variable is the time during the larval stage at which the cotton is tied around the head of the larvae. Experiment must show an adequate number of replicates (more than 5 in each treatment).

3 marks

Question 3

Cell growth can be controlled by the action of a regulatory signalling pathway. The cell cycle is stimulated due to the action of an intracellular molecule known as *Ras*. The diagram illustrates the signalling pathway that regulates cell growth.



3ai. What is substance A?

Solution

Hormone OR growth factor.

1 mark

Explanatory notes

- The stem provides information which relates to cell growth (cell growth can be controlled depending on the regulatory signalling pathway) and the diagram illustrates the signalling pathway that regulates cell growth. It can be reasonably concluded that substance A is a hormone or a growth factor.

3a ii. Explain what is happening to substance A at structure B. Why is this process essential in the signalling pathway?

Solution

Growth factor (or hormone) is binding to the receptor. This is an essential process in the signalling pathway because if growth factor does not bind to the receptor, signal transduction cannot occur.

2 marks

3b i. The molecule represented at C is known as *Ras*. By what other name could it be known?

Solution

G protein OR second messenger

1 mark

Explanatory notes

G proteins (second messengers) are essential signal transducing molecules which are involved in second messenger cascades in cells. The term G protein is short for guanine nucleotide-binding proteins.

3b ii. What is the name of the process which occurs during the phosphorylation cascade?

Solution

Signal transduction

1 mark

Explanatory notes

- Signal transduction is a process in which a cell converts a signal or stimulus into another. Generally, signal transduction involves ordered sequences of biochemical reactions inside a cell, which are enabled by enzymes, activated by second messengers, and ultimately culminate in a signal transduction pathway.

3ci. What will occur at D?

Solution

Gene expression/transcription

1 mark

3cii. Explain the likely function of substance E.

Solution

Substance E is most likely a protein which will be involved in the initiation of the cell cycle to stimulate cell growth.

1 mark

Explanatory notes

- At the end of the signal transduction pathway, a transcription factor (activator) enters the nucleus of the cell and turns on a gene (or genes) which will produce one or more proteins that stimulate the cell cycle, resulting in cell growth.

Question 4

Maple-syrup urine disease (MSUD) is an autosomal recessive disorder in which the body is unable to properly process certain amino acids and is characterised by progressive neurological dysfunction and a sweet, burnt-sugar or maple-syrup smell in the urine. Generally, newborns appear normal at birth however within 4 – 7 days symptoms, including vomiting, lethargy, failure to thrive, seizures and coma, begin to appear. MSUD can be life-threatening if untreated and affects an estimated 1 in 225,000 infants worldwide.

Affected individuals carry high levels of the amino acids leucine, isoleucine and valine which are present in many kinds of food, especially protein-rich foods such as milk, meat, and eggs. One type of mutation occurs in the E1 α gene in which there is an A \rightarrow T substitution at position 438.

The DNA triplet sequences found at position 438 in the normal and mutated gene are shown below.

Normal E1 α Exon 9 sequence ↓438
Nucleotide sequence ACCTACGGGGAGCACAACCCACTGGATCACTTC

Mutated E1 α Exon 9 sequence ↓438
Nucleotide sequence ACCTACGGGGAGCACTACCCACTGGATCACTTC

4ai. How many amino acids does the normal E1 α Exon 9 sequence code for?

Solution

11 amino acids

1 mark

4a ii. In the table below, write the base sequences for the normal and mutant triplet in the complementary strands of DNA?

Solution

Normal	Mutant
AAC	TAC
TTG	ATG

1 mark

Explanatory notes

- In a sequence of DNA, each triplet (group of 3 nucleotides) codes for 1 amino acid. There are 33 nucleotides present in the normal E1 α Exon 9 sequence and therefore the sequence codes for 11 amino acids. According to the rule of base pairing (A pairs with T, C pairs with G), the complementary base sequences of DNA for the normal and the mutant triplets are TTG (normal) and ATG (mutant).

4b i. What do the **A** in AAC and the **T** in TAC stand for?

Solution

A – adenine and T – thymine

At position 438, the DNA triplet **AAC** codes for the amino acid leucine (*leu*). Substitution of A → G at the same position would still produce *leu*.

1 mark

4b ii. Explain why a substitution in the E1 α gene of A → G at position 438 does not change the expression of the gene.

Solution

Different DNA triplets can code for the same amino acid.

1 mark

Explanatory notes

- The genetic code demonstrates a built in redundancy which means that different DNA triplets can code for the same amino acid e.g. AAC and GAC both code for *leucine* and TAA and TAG both code for *isoleucine*.
- It is possible, using DNA diagnostic methods, to identify individuals who have the A → T mutation at position 438 and who are at risk of developing MSUD.

4c. What is one advantage of early newborn diagnosis?

Solution

Development of MSUD can be averted with modification of diet e.g. restriction of leucine, isoleucine, valine through a modified protein diet.

Two methods are available to test for MSUD in individuals. A comparison of the two methods is shown in the table below.

	PCR-RFLP Assay	Taqman Assay
Samples tested	127	126
Samples requiring repeat testing	48	10
% repeat samples	38%	8%
% agreement	100%	100%
Relative sensitivity	20 μ l	1 – 5 μ l
Newborn screening time	11 – 14 hours minimum	4 – 5 hours

1 mark

4d. Explain which method is likely to lend itself more to commercial application.

Solution

Taqman Assay enables more rapid diagnosis of infants with MSUD prior to clinical disease and because of its rapid screening time (and increased sensitivity and validity in terms of a lower % of samples requiring repeat testing) it is likely to be of economic advantage.

2 marks

Explanatory notes

- When considering suitability for commercial application it is necessary to consider the most efficient, effective and inexpensive method of testing. As demonstrated by the comparative study, it is the Taqman Assay.

Mark allocation

4aii.

1 mark 2 correct = 1 mark
1 or none correct = 0 marks

4bi.

1 mark 2 correct = 1 mark
1 or none correct = 0 marks

4d.

2 marks 1 mark – Taqman Assay
1 mark – rapid screening time (and increased sensitivity as well as validity) lends it to commercial application

Question 5

All living organisms encounter predators and parasites during their lifecycle. Observations of the interactions between hosts and their parasites provide a clear example of evolutionary adaptation. As the host evolves strategies that give it greater protection from a parasite, the parasite evolves counterstrategies. There are many ways by which parasites can evade host defence strategies.

5a. Identify two pathways by which parasites can enter a host.

Solution

Food and/or water OR air OR through bites from a vector (e.g. mosquito, tick, flea)

1 mark

Explanatory notes

- Parasites can enter a host in a variety of ways, depending on their type. Generally, the most common strategies for entry include through food and/or water, air and through bites from a vector (e.g. mosquito, tick, flea).

Schistosomes, also known as flatworms, are blood flukes that live in the bloodstream. *Schistosoma mansoni* is a flatworm that takes up final residence in the veins which carry blood away from the large intestine of humans.

5b. Describe the likely immune response of the host to the presence of the resident flatworm.

Solution

Presence would induce the production of antibodies assisted by macrophages and eosinophils.

2 marks

Explanatory notes

- Flatworms present a size problem to the immune system as they are too big to phagocytose. They present as ‘non-self’ to the host immune system, which is detected by macrophages which present ‘non-self’ antigens (from flatworms) to helper T cells. When helper T cells are activated they respond in 2 ways. They produce cloned activated helper T cells (which can produce B cells and antibodies) and memory helper T cells. In addition, eosinophils align themselves against the external wall of the flatworm and release destructive enzymes from cytoplasmic granules.

In most instances, despite the host’s response the resident flatworm remains unaffected and does not die.

5c. What is the advantage of the host’s response if the resident flatworm is not killed?

Solution

The host is protected from infection by any future invasions of that particular flatworm.

1 mark

Explanatory notes

- Whilst the antibodies generated by B cells do not provide protection from the resident flatworm, their sheer numbers (due to recognition by the memory cells and rapid proliferation of more antibodies) ensure protection from new invasions.

It has been suggested that the resident worms are capable of presenting themselves as ‘self’ in the host.

5d i. Explain what is meant by the term ‘self’.

Solution

‘Self’ describes all the components (receptors and antigens) that are recognised by the immune system of an organism as being part of that particular organism.

1 mark

5d ii. Suggest how the flatworms could present as ‘self’.

Solution

Flatworms could coat themselves with host antigens (e.g. ABO blood group antigens OR histocompatibility molecules).

1 mark

Explanatory notes

- If a parasite is able to remain undetected by the immune system of its host it will maximise its chance of survival. If the flatworm is capable of incorporating the antigens of its host into its exterior surfaces, then it will appear as ‘self’ and be protected from attack by the immune system. The exact mechanism by which a flatworm does this is not yet fully understood.

Mark allocation**5a.**

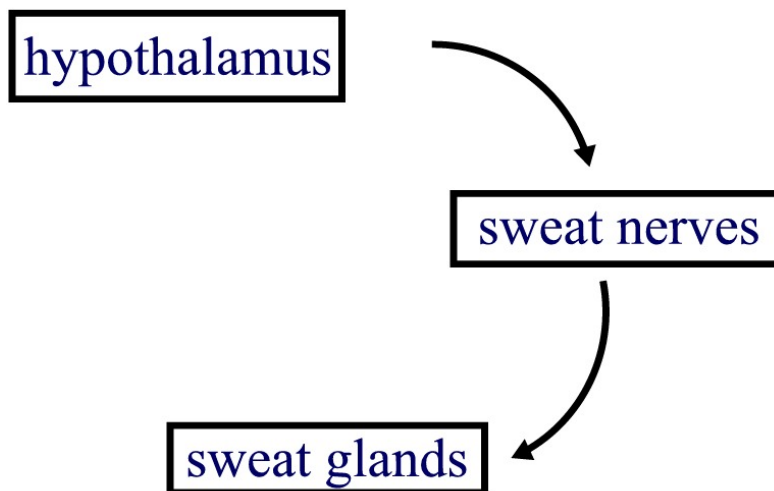
1 mark 2 correct = 1 mark
 1 or none correct = 0 marks

5b.

2 marks 1 mark – resident flatworm induces production of antibodies
 1 mark – production of antibodies is assisted by macrophages and eosinophils

Question 6

In humans, sweating is a normal process which the body uses to control temperature and hydrate the skin. Primary hyperhidrosis is an inherited condition which affects around 2 – 3 % of the population. It is characterised by an abnormally increased level of sweating (mostly from the hands, feet and underarms), in excess of that required for control of body temperature. The actual cause of primary hyperhidrosis is unknown, one theory suggests that the brain overstimulates the glands that are responsible for sweating. Normally, the hypothalamus sends sensory signals to the sweat nerves. These nerves, part of the sympathetic nervous system, are located in the chest cavity and send signals to the sweat glands causing the production of sweat. This pathway is shown in the diagram below.



6a. Is the overstimulation of sweat glands in primary hyperhidrosis likely to be due to the action of the autonomic or somatic nervous system? Explain.

Solution

The overstimulation of sweat glands is likely to be due to the autonomic nervous system because it is this system that is responsible for transmitting messages to glands (and smooth muscle and heart muscle).

1 mark

6b i. Name a hormone that might be involved in this pathway.

Solution

Acetylcholine or any suitable neurotransmitter.

1 mark

6b ii. Explain the role of this particular hormone in this pathway.

Solution

Acetylcholine changes the permeability of postsynaptic membranes to specific ions thereby enabling transfer of nerve impulse which results in contraction of sweat gland and release of sweat.

1 mark

Explanatory notes

- Acetylcholine is one of the most common neurotransmitters and functions by binding to receptors on post synaptic membranes, thus altering their permeability to specific ions.

It is possible to treat hyperhidrosis using a surgical procedure known as endoscopic thoracic sympathectomy (ETS). ETS involves the cutting or clamping of the sympathetic nerve node and has been shown to reduce excessive sweating.

6c. Explain how cutting segments of the sympathetic nerve node can control excessive sweating.

Solution

Cutting segments of the sympathetic nerve impedes the normal transmission of nerve signals and thus reduces sweating.

1 mark

Explanatory notes

- Nerve signals require a medium along which the electrical impulse can pass. If there is a gap in the neuron the nerve impulse will terminate at the break. This occurs naturally at the end of an axon however release of neurotransmitters ensures the impulse continues toward its destination. When cuts are made in the neuron, there is no way for the impulse to continue.

Question 7

Multiple sclerosis (MS), affecting 1 in 1000 people of northern European origin, is a disease of the central nervous system in which oligodendrocytes, cells which make up the myelin in the brain and spinal cord, are destroyed.

7a. What is the function of myelin?

Solution

Myelin forms an insulating coat around processes of nerve cells and speeds the transmission of nerve impulses.

1 mark

Explanatory notes

- Myelin is fatty connective tissue (white matter) which forms an insulating coat around processes of nerve cells. Myelin speeds transmission of nerve impulses by electrically insulating nerves from the surrounding environment. Myelin is produced by cells known as oligodendrocytes.

MS is also known as an autoimmune disorder and typically begins early in adult life and includes symptoms such as numbness, tingling, muscle weakness and eventually paralysis.

7b i. What is an autoimmune disorder?

Solution

A disorder in which the body's immune cells fail to distinguish between self and non-self and begin to attack its own tissues.

1 mark

7b ii. What cells are most likely to be involved in this response?

Solution

T-lymphocytes OR T-cells

1 mark

Explanatory notes

- There are many diseases (multiple sclerosis, rheumatoid arthritis, diabetes mellitus) which are caused by the reaction of an individual's immune system against 'self'. In normal circumstances, there are lymphocytes (T-lymphocytes or T-cells) which are capable of reacting against self (e.g. in apoptosis) however these are suppressed unless required. When lymphocytes manage to avoid suppression or when a body tissue becomes altered so that it is no longer recognised as self, an autoimmune condition occurs. The triggers of autoimmune conditions are not well understood but are thought to be associated with interaction with environmental factors such as pathogens or drugs.

The exact cause of MS is unknown however it is thought to occur when individuals who have a genetic predisposition to the disorder are exposed to viruses, triggering a process known as molecular mimicry.

7c. Clearly outline how and why molecular mimicry is likely to occur.

Solution

There is a similarity between the surface antigens (proteins) expressed by cells in the myelin (oligodendrocytes) and the proteins expressed by viral pathogens. The immune system directs an attack on both the viral proteins (appropriately) and the myelin proteins (inappropriately) leading to an autoimmune response.

2 marks

Mark allocation

7c.

2 marks

1 mark – Why? Similarity exists between surface proteins of myelin and viral pathogens
1 mark – How? Immune system attacks both types of protein (viral and self) leading to autoimmune response

Question 8

Recently, in order to prevent the transmission of illnesses, hospitals have emphasised the need for strict hand hygiene in their staff. In an assessment of 124 staff at a particular hospital, it was found that 47 were wearing lanyards around their necks, 10 of which carried *Staphylococcus aureus*. In addition, plastic badges attached to lanyards were also found to be carrying the bacteria *S. aureus* and *Enterococcus* spp.

Staphylococcus aureus and *Enterococcus* spp are both bacterial pathogens.

8a i. What is a pathogen?

Solution

A pathogen is a cellular agent/organism capable of causing an infectious disease in a host.

1 mark

8a ii. What are two characteristics these bacterial species would have in common?

Characteristic 1:

Characteristic 2:

Solution

Two of: a cell wall, a single major chromosome, nucleus not membrane bound, organelles not membrane bound

2 marks

SECTION B – continued

Explanatory notes

- Disease in hosts can be caused by non-cellular and cellular agents. Non-cellular agents are generally classified as non-living and include prions and viruses. Cellular agents are living organisms and include micro-organisms (bacteria and fungi) and multicellular organisms (worms). Bacteria are pathogens found everywhere. They have varied characteristics and requirements however they all have the following characteristics: a cell wall, a single major chromosome, nucleus not membrane bound, organelles not membrane bound.

Staphylococcus aureus is normally a harmless strain of bacteria, however it has become a superbug known as methicillin-resistant *Staphylococcus aureus* (MRSA). In Australian hospitals, MRSA infects 2000 patients (killing 33% of infected individuals) annually.

8b. What is meant by the term methicillin-resistant?

Solution

Methicillin resistant means that the bacteria is not susceptible to methicillin antibiotic treatment (methicillin cannot be used to control or kill this strain of *Staphylococcus aureus*).

Despite the vigilance in observing strict hand hygiene, repeated outbreaks of deadly illnesses continue to occur in hospitals.

1 mark

8c i. Suggest one reason why MRSAs have persisted as a problem in hospitals.

Solution

Staphylococcus aureus is not only carried on the hands of staff, sources can also include lanyards and plastic name badges OR *Staphylococcus aureus* can be carried into hospitals by visiting friends and family who do not necessarily observe strict handwashing requirements.

1 mark

8c ii. Identify one method which could be employed to control the spread of MRSAs in hospitals.

Solution

Staff lanyards and name tags to be thoroughly washed/sterilised. Visiting family/friends to observe strict handwashing techniques during all visits.

1 mark

Mark allocation

8a ii.

2 marks 1 mark for correct shared characteristic 1
 1 mark for correct shared characteristic 2