Insight Publications

INSIGHT

Trial Exam Paper

2008

BIOLOGY

Written examination 1

STUDENT NAME:

QUESTION AND ANSWER BOOK

Reading time: 15 minutes
Writing time: 1 hour 30 minutes

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	25	25	25
B	8	8	50
			Total 75

- Students are permitted to bring the following items into the examination: pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring sheets of paper or white out liquid/tape into the examination.
- Calculators are not permitted in this examination.

Materials provided
- The question and answer book of 24 pages.
- An answer sheet for multiple-choice questions.

Instructions
- Write your **name** in the box provided.
- You must answer the questions in English.

At the end of the examination
- Place the answer sheet for multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones or any other electronic devices into the examination.

SECTION A – Multiple-choice questions

Instructions for Section A

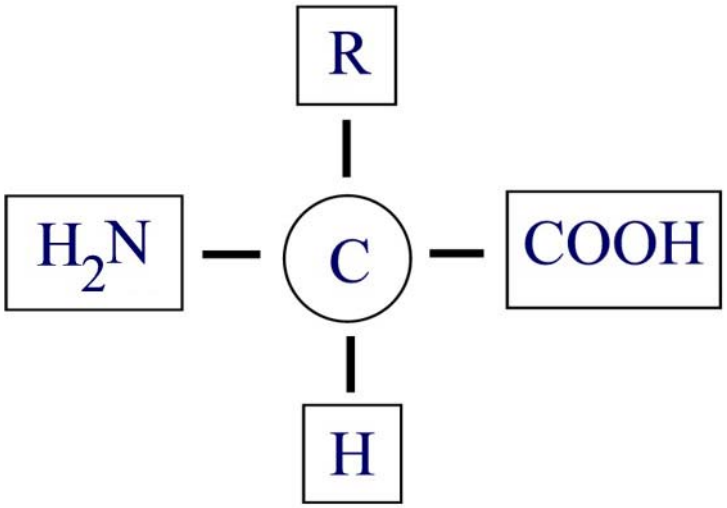
Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** for the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

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 (NH_2).
C. hydrogen atom (H).
D. side chain (R).

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).

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.

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.

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. CO_2.

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.

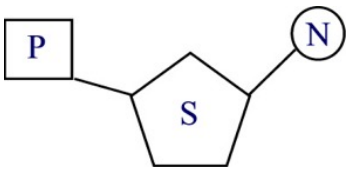
B. sucrose which is an example of a polysaccharide.

C. cellulose which is an example of a polysaccharide.

D. maltose which is an example of a polysaccharide.

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.



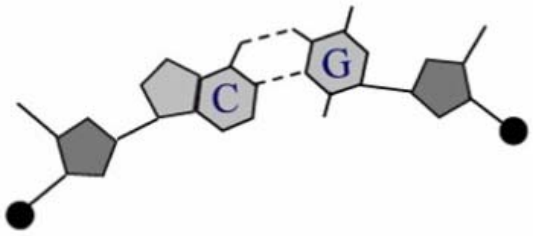
Nucleotides would **NOT** be found in

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

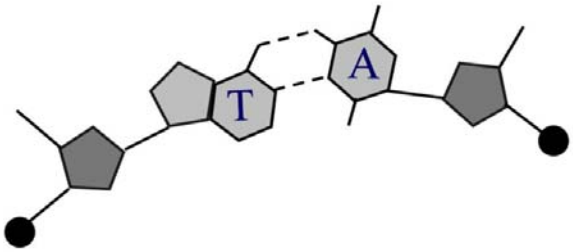
Question 8

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?

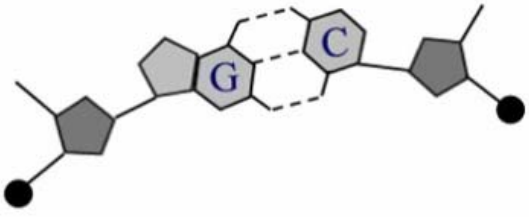
A.



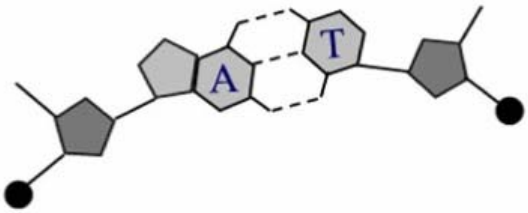
B.



C.



D.



Question 9

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

A. lower the activation energy needed to catalyse a metabolic reaction.

B. increase the activation energy required to catalyse a metabolic reaction.

C. only ever bind one substrate molecule in its active site.

D. undergo a permanent change in its tertiary structure only 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

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.

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.

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. relative amounts of the different amino acids in 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.

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.

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.

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.

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.

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.

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.

The following information is required for Questions 21 and 22.

In humans, normal body temperature can range from 36.2^{o}C – 37.8^{o}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.

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.

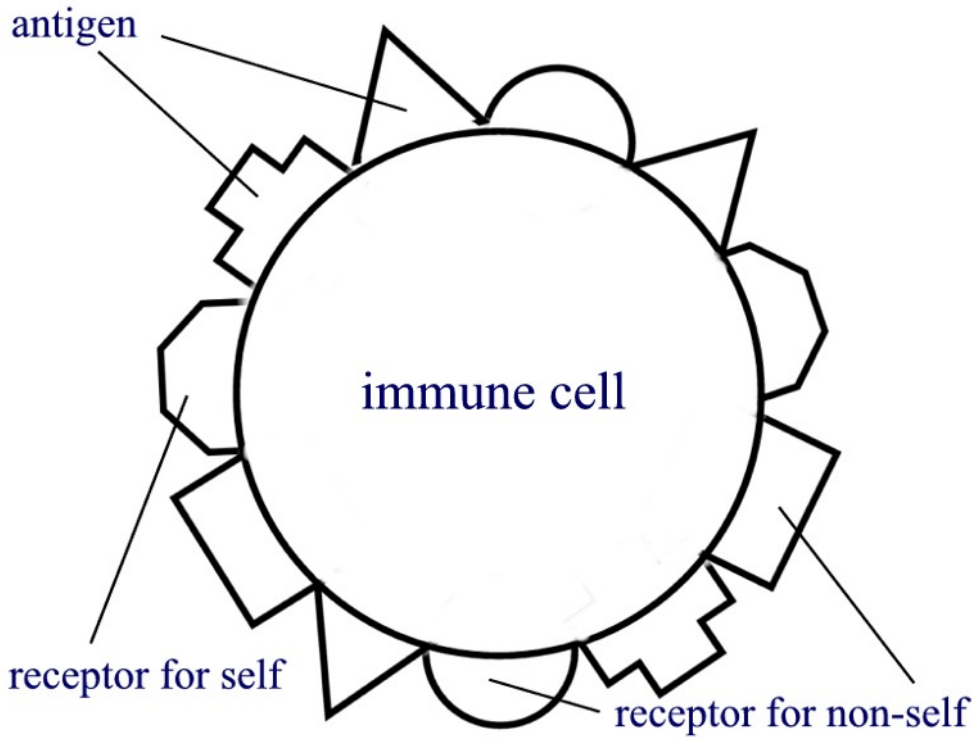
B. are always harmful to living organisms.

C. trigger a response that amplifies the original stimulus.

D. are never harmful to living organisms.

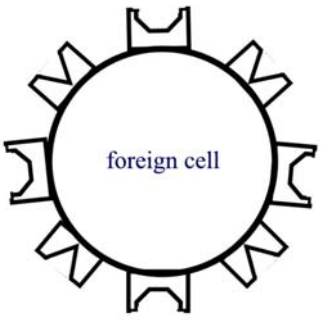
Question 23

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.

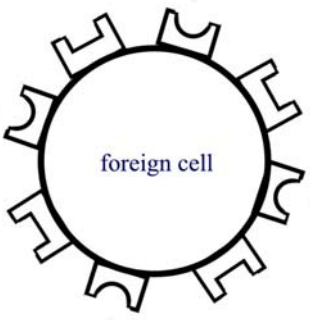


Which of the following foreign cells (below) will likely induce the greatest response from the immune cell shown above?

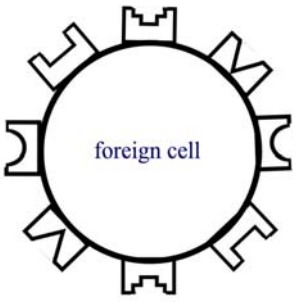
A.



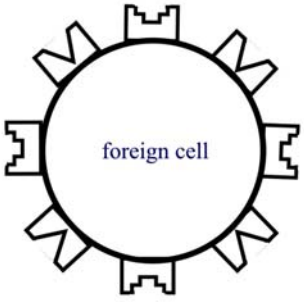
B.



C.



D.



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.

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.

END OF SECTION A

SECTION B – Short-answer questions Question 1

Instructions for Section B

Answer this section in **pen**.
Answer **all** questions in the spaces provided.

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.

$$CO_2 + H_2O \xleftarrow{\text{carbonic anhydrase}} H_2CO_3 \longleftrightarrow H^+ + HCO_3^-$$

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

_____

1 mark

1b i. What is a transmembrane channel?

_____

_____

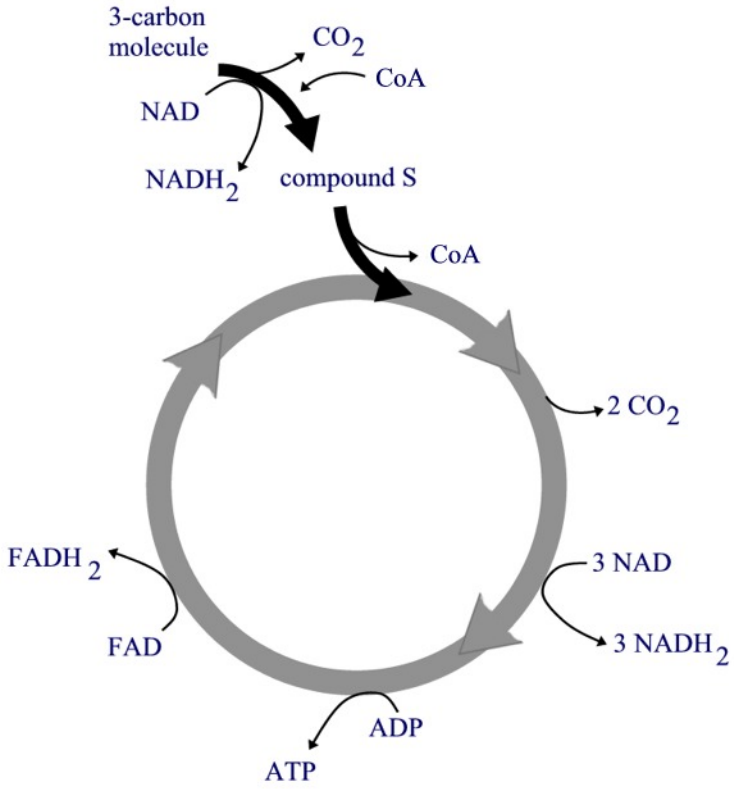
1 mark

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

_____

1 mark

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?

_____

1 mark

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

_____

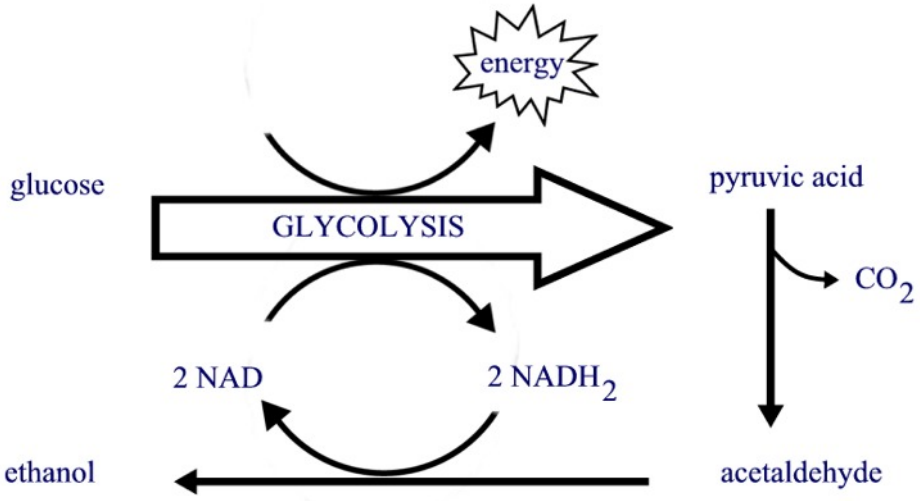
1 mark

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

_____

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?

_____

1 mark

1e. Explain why this process cannot continue indefinitely.

_____

_____

1 mark

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

_____

_____

_____

1 mark
Total 9 marks

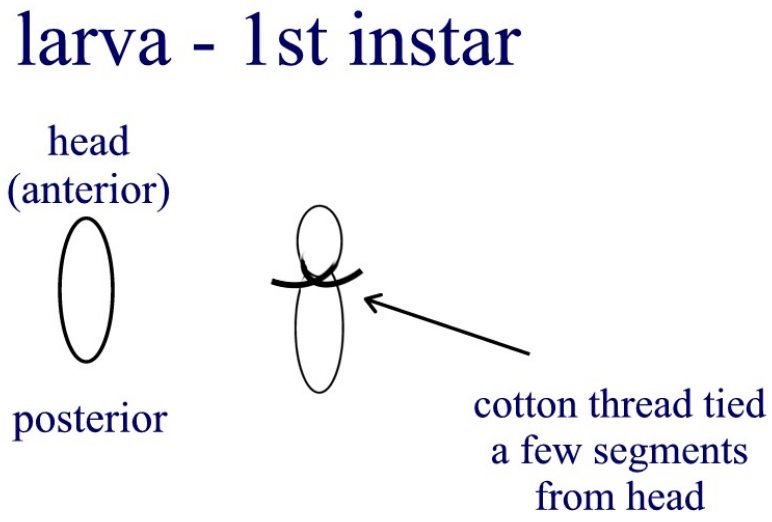
Question 2

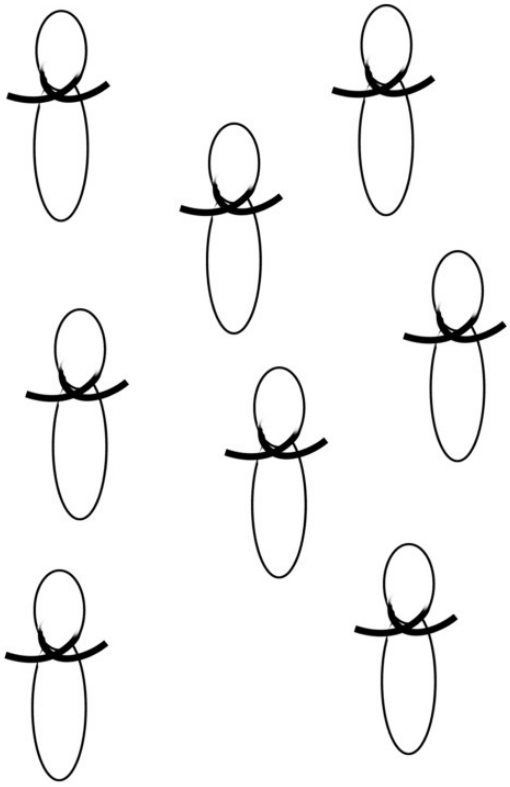
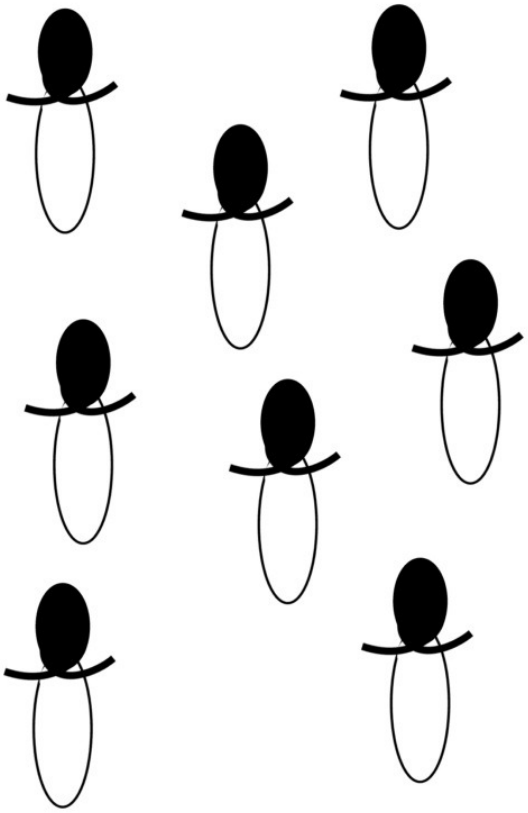
The blowfly, *Chrysomya rufifacies*, is capable of picking up faint traces of the odour of decay and can fly up to 20 km in search of a suitable corpse in which to lay eggs. After hatching, the larvae of the blowfly will grow and moult, three times. At the end of the third growth stage (3rd instar), 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.



Larvae (0 hours)	Larvae (96 hours)
	

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

_____

_____

1 mark

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

_____

_____

_____

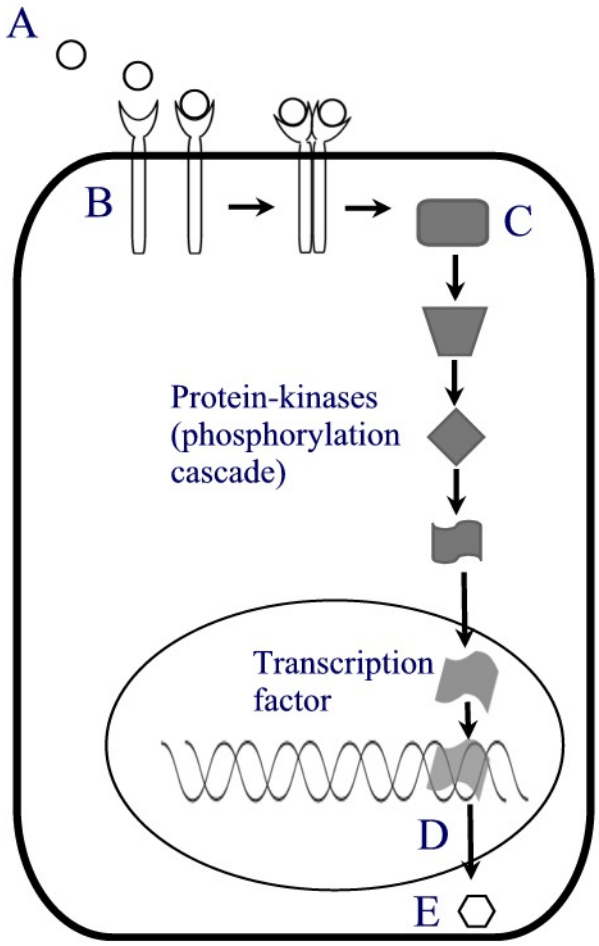
2 marks

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

3 marks
Total 6 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.



3a i. What is substance A?

_____

1 mark

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

_____

_____

_____

2 marks

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

_____

1 mark

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

_____

1 mark

3c i. What will occur at D?

_____

1 mark

3c ii. Explain the likely function of substance E?

_____

1 mark
Total 7 marks

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 E1α gene in which there is an A → T substitution at position 438.

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

Normal E1α Exon 9 sequence ↓438
Nucleotide sequence ACCTACGGGGAGCAC**A**ACCCACTGGATCACTTC

Mutated E1α Exon 9 sequence ↓438
Nucleotide sequence ACCTACGGGGAGCAC**T**ACCCACTGGATCACTTC

4a i. How many amino acids does the normal E1α Exon 9 sequence code for?

_____

1 mark

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

Normal	Mutant
AAC	TAC

1 mark

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

_____

1 mark

4b ii. Explain why a substitution in the E1α gene of A → G at position 438 does not change the expression of the gene.

_____

_____

1 mark

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

_____

1 mark

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 µl	1 – 5 µl
Newborn screening time	11 – 14 hours minimum	4 – 5 hours

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

_____

_____

_____

1+1=2 marks
Total 7 marks

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.

_____

1 mark

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

_____

_____

2 marks

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

_____

1 mark

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

_____

_____

1 mark

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

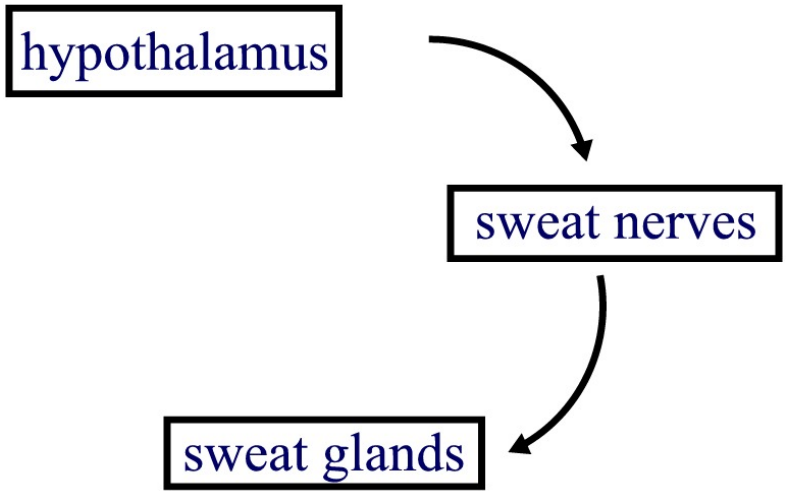
_____

_____

1 mark
Total 6 marks

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.

_____

_____

1 mark

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

_____

1 mark

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

_____

_____

_____

1 mark

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.

_____

_____

1 mark
Total 4 marks

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?

_____

_____

_____

1 mark

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?

_____

_____

1 mark

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

_____

1 mark

The exact cause of MS is unknown however is it 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.

_____

_____

_____

_____

2 marks
Total 5 marks

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?

_____

_____

1 mark

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

Characteristic 1:

_____

Characteristic 2:

_____

1+1=2 marks

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?

_____

_____

1 mark

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

_____

_____

_____

1 mark

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

_____

_____

_____

1 mark
Total 6 marks

END OF EXAM PAPER