INSIGHT

Trial Exam Paper

2011

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*	*Suggested times (minutes)*
A	25	25	25	30
B	8	8	50	60
			Total 75	90

- 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 33 pages.
- An answer sheet for multiple-choice questions.

Instructions

- Write your **name** in the box provided and on the answer sheet for multiple-choice questions.
- You must answer the questions in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions in the front cover of the question and answer 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** or that **best answers** the question.

1 mark will be awarded for a correct answer; no marks will be awarded for an incorrect answer.

Marks are **not** deducted for incorrect answers.
No marks will be awarded if more than one answer is completed for any question.

Question 1

A polypeptide is

A. formed when many amino acids join together in sequence due to the formation of ionic bonds.

B. formed when many amino acids join together in sequence due to the formation of covalent bonds.

C. a polymer constructed of combinations from the same set of 4 amino acids.

D. a molecule identical to a protein.

Question 2

The molecular formula for glucose is sometimes represented as (CH_2O). The molecular formula for a polymer made by linking ten glucose molecules would be

A. $C_{60}H_{102}O_{60}$

B. $C_{60}H_{100}O_{51}$

C. $C_{60}H_{120}O_{50}$

D. $C_{60}H_{102}O_{51}$

Question 3

In a segment of double-stranded DNA, a particular region has the following sequence of nitrogenous bases:

5′ – CCGATCG – 3′

The complementary strand has the sequence

A. 3′ – CCGATCG – 5′

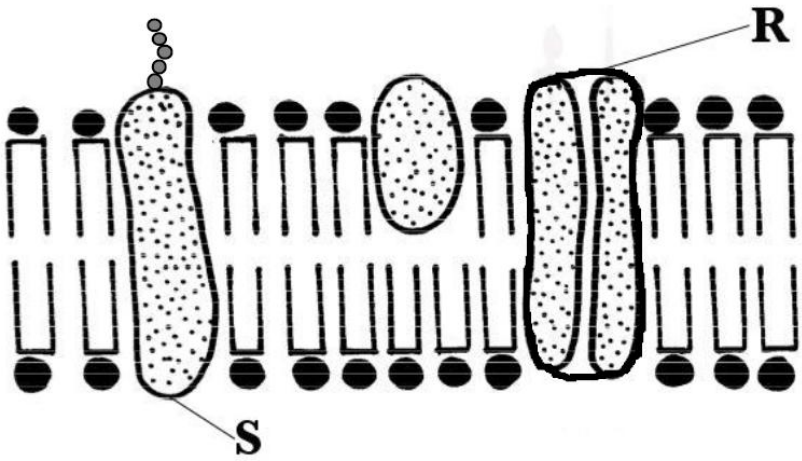
B. 5′ – CCGATCG – 3′

C. 5′ – GGCTAGC – 3′

D. 3′ – GGCTAGC – 5′

The following information relates to Questions 4 and 5.

The diagram below shows a section from a plasma membrane.



Question 4

Molecule R is a

A. globular protein.

B. fibrous protein.

C. glycoprotein.

D. glycolipid.

Question 5

Structure S was synthesised during formation of the plasma membrane and transported to the cell surface. The synthesis of structure S is most likely to have occurred

A. at a ribosome.

B. in the nucleus.

C. in the endoplasmic reticulum.

D. in a lysosome.

Question 6

The enzyme succinate dehydrogenase is involved in the Krebs cycle and the electron transport chain and is inhibited by the chemical malonate. A student hypothesised that malonate is a competitive inhibitor of succinate dehydrogenase. She performed an experiment using succinate dehydrogenase, malonate and the substrate succinate. The result which supports her hypothesis is

	Concentration of succinate	**Rate of Reaction**
A.	**increase**	**speeds up**
B.	increase	slows down
C.	decrease	speeds up
D.	decrease	no reaction

Question 7

Which of the following processes could be described as one that follows a catabolic pathway?

A. $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

B. amino acids → protein

C. ADP + Ⓟi → ATP + H_2O

D. glucose + galactose → lactose

Question 8

A botanist extracted pigments from the leaves of a green plant. The pigments were suspended in an isotonic solution and then white light was passed through the mixture. What effect will the leaf pigments have on the white light?

A. Green wavelengths will be absorbed and red and blue wavelengths will be transmitted.

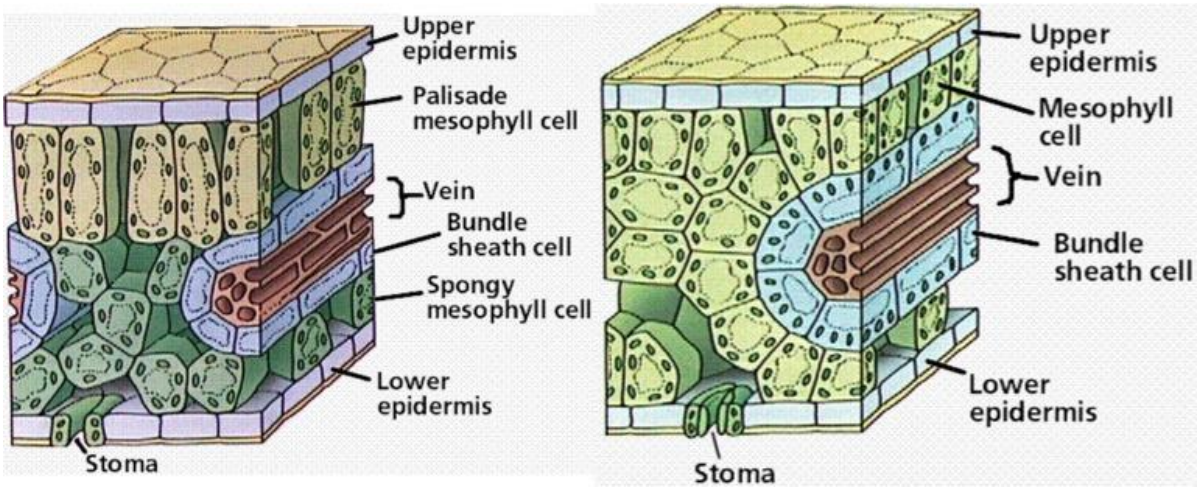
B. Red and blue wavelengths will be absorbed and green wavelengths will be transmitted.

C. Blue wavelengths will be absorbed and green and red wavelengths will be transmitted.

D. Green and red wavelengths will be absorbed and blue wavelengths will be transmitted.

The following information relates to Questions 9 and 10.

In the leaves of some plants, photosynthesis usually occurs solely in mesophyll cells. These are known as C_3 plants. Some plants that live in hot, dry habitats have a ring of photosynthetic cells that surround the vascular bundles in addition to the mesophyll cells. These are known as C_4 plants. The diagrams below show two leaf cross-sections.



Question 9

An example of a C_4 plant could be

A. rice.

B. maize.

C. wheat.

D. barley.

Question 10

In C_3 plants the Calvin cycle occurs in mesophyll cells whereas in C_4 plants it occurs in the bundle sheath cells deeper in the leaf tissue. C_4 plants are able to pick up and use more carbon dioxide with greater efficiency than C_3 plants because

A. there are potentially fewer photosynthetic cells present in the leaves of C_4 plants.

B. there are potentially more photosynthetic cells present in the leaves of C_3 plants.

C. in comparison to C_3 plants, there is a steeper concentration gradient of carbon dioxide from outside the leaves in C_4 plants to the cells in the leaf where the Calvin cycle occurs.

D. in comparison to C_4 plants, there is a steeper concentration gradient of carbon dioxide from outside the leaves in C_3 plants to the cells in the leaf where the Calvin cycle occurs.

Question 11

A G-protein is

A. a neutrotransmitter.

B. a signalling molecule.

C. a signal transducing molecule.

D. a specific type of membrane-receptor protein.

Question 12

In plants, the growth pattern of a shoot sprouting in darkness to gradually break through the ground is known as etiolation. Once the shoot emerges from the surface, stem elongation slows down, leaves expand, the root system elongates and the production of chlorophyll begins. This latter process, the 'greening' of a plant, is known as de-etiolation. The signal in the process of de-etiolation is most likely to be

A. gravity.

B. light.

C. contact.

D. temperature.

Question 13

Beer is an alcoholic beverage produced by the brewing and fermentation of starches derived from cereal grains such as malted barley. It is possible to accelerate the process of germination by spraying the barley seeds with

A. abscisic acid.

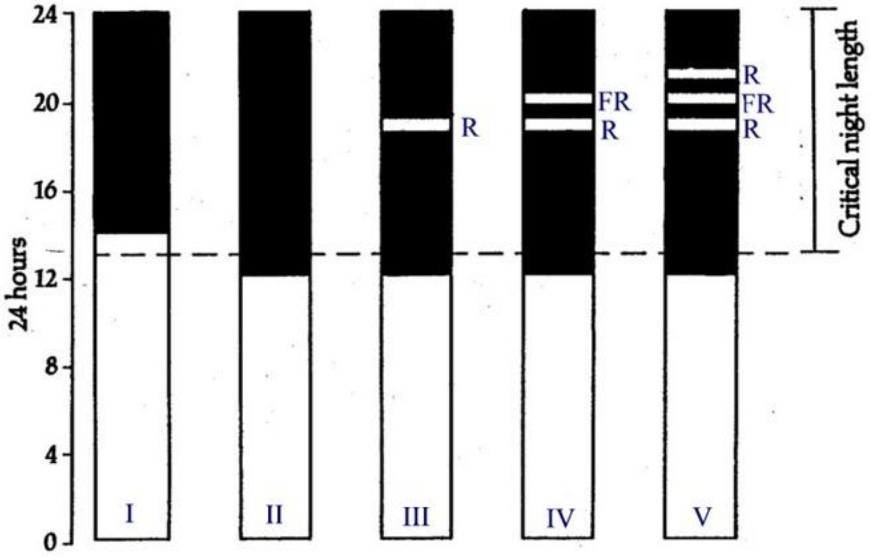
B. auxin.

C. ethylene.

D. gibberellin.

Question 14

In some plants, the relative length of day and night is crucial to flowering. Plants are highly sensitive to light and detect night length very precisely. Some short-day plants will not flower if the period of night is 1 minute shorter than the critical length. It is known that a flash of red light (R) can interrupt a period of darkness; however, if it is followed by a flash of far-red light (FR) then the plant detects no interruption of night length. An experiment was done in which a species of short-day plant and a species of long-day plant were exposed to particular light conditions. The experiment is represented in the diagram below.



Plant 1	Plant 2	Plant 3	Plant4	Plant 5
				

Short-day plants

Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
				

Long-day plants

Which set of results below shows the expected sequence of flowering for the experiment described above?

	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Plant 7	Plant 8	Plant 9	Plant 10
A.	✓	✓	✓	✓	✓	×	×	×	×	×
B.	×	×	×	×	×	✓	✓	✓	✓	✓
C.	×	✓	×	✓	×	✓	×	✓	×	✓
D.	✓	×	✓	×	✓	×	✓	×	✓	×

✓ – flowering × – no flowering

Question 15

An invasion by pathogens in plants can trigger the release of substances which can communicate with the whole plant. Methylsalicylic acid has been identified as one such substance which is transported throughout the plant in the phloem and is converted to salicylic acid in areas quite removed from the initial site of infection. Salicylic acid is most likely to act by

A. destroying infected tissues by hydrolysing cells.

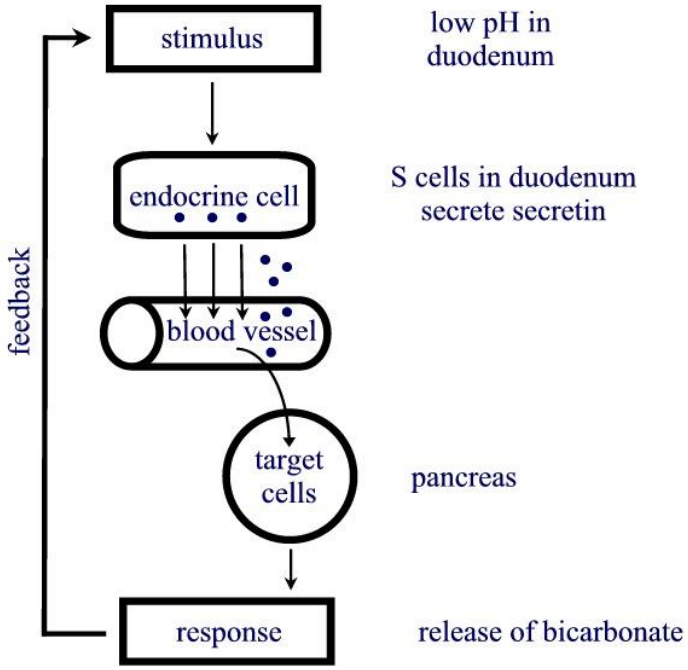
B. closing stomata and thereby preventing the entry of pathogens.

C. destroying pathogens directly.

D. activating defences throughout the plant before infection spreads.

The following information relates to Questions 16, 17 and 18.

Secretin is a hormone that stimulates pancreatic secretions and is produced by S cells in the small intestine (duodenum). Secretin enters the bloodstream and reaches receptors at target cells in the pancreas, triggering signal transduction, inducing them to release bicarbonate which raises the pH in the duodenum. This process is modelled in the diagram below.



Question 16

The kind of chemical signalling shown in the secretin model is

A. endocrine.

B. paracrine.

C. autocrine.

D. synaptic.

Question 17

An example of a stimulus that would trigger S cells to release secretin would be

A. the release of acidic stomach contents into the duodenum.

B. the release of alkaline stomach contents into the duodenum.

C. the release of acidic contents into the large intestine.

D. the release of alkaline contents into the large intestine.

Question 18

This response pathway is an example of a

A. positive feedback loop which serves to reinforce the initial stimulus.

B. positive feedback loop which results in a reduction of the initial stimulus.

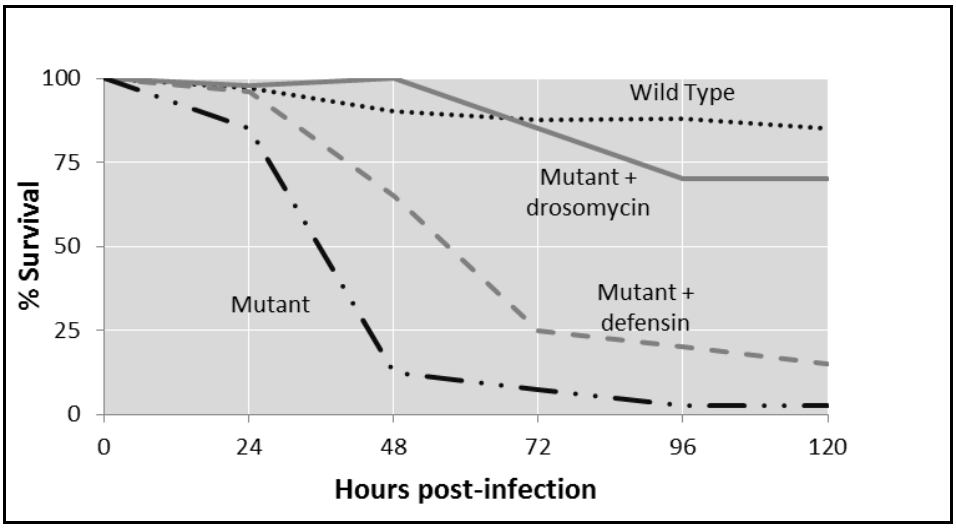
C. negative feedback loop which serves to reinforce the initial stimulus.

D. negative feedback loop which results in a reduction of the initial stimulus.

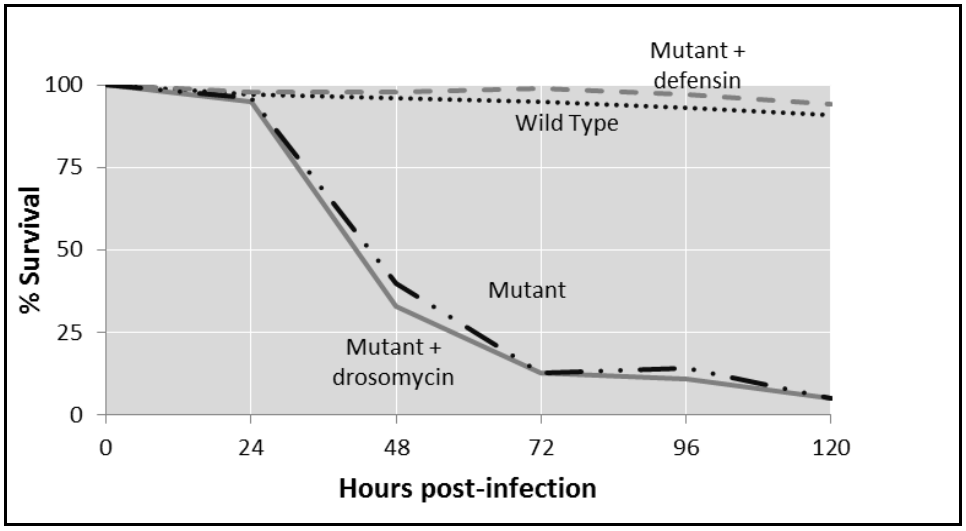
The following information relates to Questions 19, 20 and 21.

Terrestrial and aquatic habitats support a diverse population of microbes. The success of insects despite these microbes has been attributed to their effective innate immune system, the first line of which is the exoskeleton, composed principally of chitin. If a pathogen breaks through the first line of defence, immune cells called haemocytes which circulate within the haemolymph (the insect equivalent of blood) perform phagocytosis. Other haemocytes will trigger the production of chemicals that kill microbes and trap multicellular parasites. Following encounters with specific pathogens, haemocytes also secrete substances known as antimicrobial peptides which circulate around the body of the insect. Once encountering the bacteria or fungi, they disrupt their plasma membranes inactivating or killing them.

In 2002, geneticist Bruno Lemaître and colleagues reprogrammed the immune system of a population of the fruit fly *Drosophila* to test the function of a single antimicrobial peptide in response to a pathogen. The signalling that would normally trigger innate immune response in a mutant strain of *Drosophila* was blocked. Genetic engineering was then used to make some of the mutant fruit flies express significant amounts of a single antimicrobial protein (either drosomycin or defensin). The fruit flies were first infected with the fungus *Neurospora crassa*. The experiment was repeated, infecting the fruit flies with the bacterium *Micrococcus luteus*. The results are shown in the graphs below.



Fruit fly survival after infection by *N. crassa* fungi



Fruit fly survival after infection by *M. luteus* bacteria

Question 19

The exoskeleton of insects is composed primarily of chitin which is a

A. protein.

B. lipid.

C. polysaccharide.

D. polypeptide.

Question 20

Like insects, vertebrates also display a non-specific immune response to pathogens. Internal components of non-specific immune defence in vertebrates are

A. mucous membranes.

B. natural killer cells.

C. antibodies.

D. cytotoxic lymphocytes.

Question 21

The results of the experiment show that

A. the control has no protective immune response when infected by *N. crassa* and *M. luteus*.

B. the mutant strain shows a protective immune response when infected by *N. crassa* and *M. luteus*.

C. both of the antimicrobial peptides enable a protective immune response, with drosomycin being effective against *M. luteus* and defensin being effective against *N. crassa*.

D. both of the antimicrobial peptides enable a protective immune response, with drosomycin being effective against *N. crassa* and defensin being effective against *M. luteus*.

Question 22

The specific immune system relies entirely on the coordination of the humoral and cell-mediated responses. The cell-mediated immune response

A. involves the activation of B cells.

B. uses toxic gene products to kill infected cells.

C. involves the clonal expansion of B cells.

D. is also known as the antibody-mediated response.

Question 23

Myasthenia gravis is a condition in humans in which circulating antibodies bind to and block the acetylcholine receptors at the post-synaptic neuromuscular junctions, preventing muscle contractions. This condition would best be described as an

A. immunodeficiency disorder.

B. allergic response.

C. autoimmune disorder.

D. immune rejection.

The following information relates to Questions 24 and 25.

In Australia, rotavirus is the most common cause of severe gastroenteritis in infants and young children. It is caused by group A rotaviruses. The live, weakened vaccine is administered orally (by mouth) to infants at the age of 2 months, 4 months and 6 months. There is still a small chance of catching a rotavirus infection even after receiving the vaccine. However, it is usually a much milder illness than if immunisation had not occurred.

Question 24

Following oral administration, rotavirus vaccination stimulates production of antibodies which protect against gastroenteritis. This response should provide the immunised infant with

A. induced passive immunity.

B. induced active immunity.

C. natural passive immunity.

D. natural active immunity.

Question 25

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

A. immunity is usually not acquired until the third administration.

B. the immature immune system cannot produce antibodies until the third administration of toxoids.

C. at this early stage of life, the toxoids are naturally reabsorbed from the infant bloodstream.

D. the antibodies provided in the vaccination have a short lifespan.

END OF SECTION A

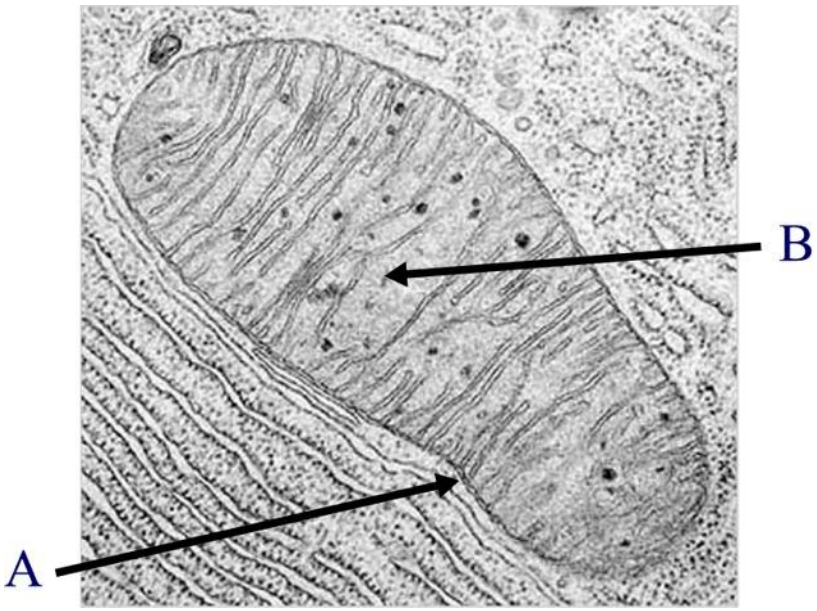
SECTION B – Short-answer questions

Instructions for Section B

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

Question 1

From 1933 to 1938, a drug called 2,4-dinitrophenol (DNP) was used extensively in diet pills due to its ability, in large doses, to significantly increase metabolic rate and assist in weight loss. DNP allows protons to leak across the inner mitochondrial membrane bypassing the protein complex ATP synthase which makes ATP from ADP and inorganic phosphate. Bypassing ATP synthase makes energy production less efficient because part of the energy that is normally produced from cellular respiration is released as heat. The amount of heat released is proportional to the dose of DNP taken. As the dose of DNP increases, energy production becomes increasingly inefficient, metabolic rate increases in order to compensate for the inefficiency and to meet energy demands. The diagram below shows a mitochondrion.



1a. **i.** What is the principle constituent of the membrane of the mitochondrion?

_____

1 mark

1a. ii. Identify a property of DNP that enables it to pass through the mitochondrial membrane.

_____

1 mark

Total 1 + 1 = 2 marks

1b. Identify the structures and their associated function by completing the following table.

Solution

	Structure	**Function**
A		
B		

2 marks

DNP is probably the best-known agent for uncoupling oxidative phosphorylation.

1c. What processes are normally coupled in oxidative phosphorylation?

_____

_____

1 mark

Following the deaths of several patients who had been prescribed DNP, its use as a weight-loss medication was stopped.

1d. Explain what was most likely to have caused death in patients who used DNP for weight loss.

_____

_____

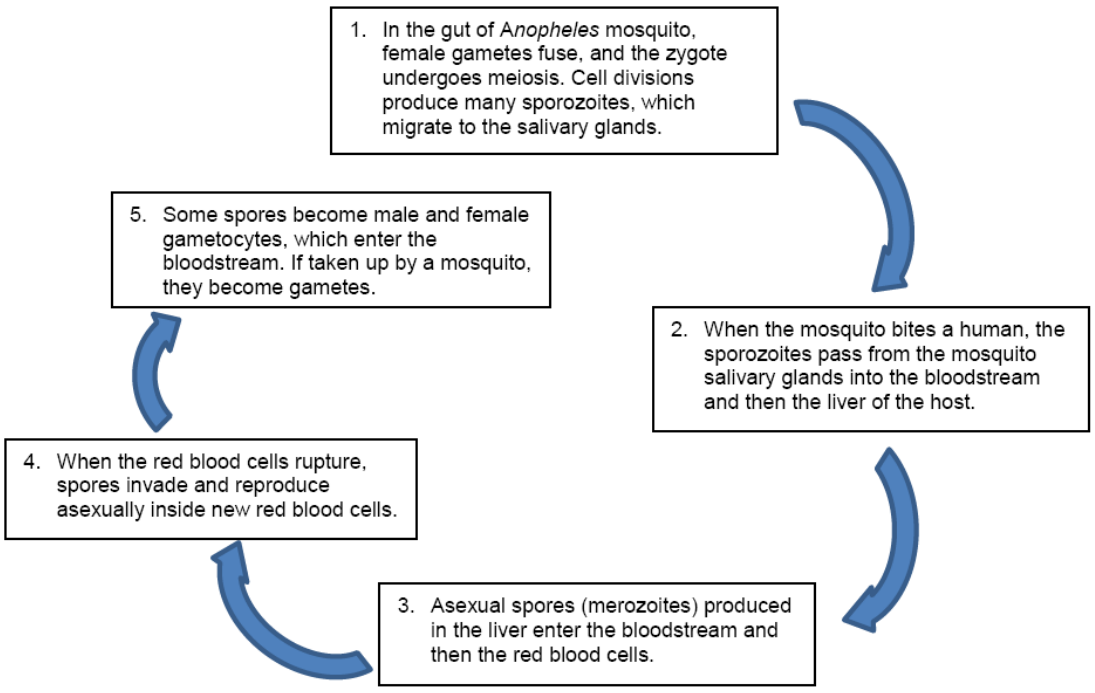
_____

2 marks

Total 2 + 2 + 1 + 2 = 7 marks

Question 2

Malaria is an infection of the blood that kills over one million people globally each year. It is caused by a protist of the genus *Plasmodium*. The control of malaria is hindered by anti-malarial drug resistance. The lifecycle of the malarial parasite is shown in the diagram below.



2a. What is the vector in this lifecycle?

_____

1 mark

Red blood cells contain haemoglobin, a protein responsible for the transport of oxygen. Haemoglobin A (HbA) is found in normal red blood cells. The parasite infects red blood cells that contain HbA but cannot survive in red blood cells containing haemoglobin S (HbS). The mutation which produces HbS is usually benign and has no apparent effects under conditions of normal oxygen concentration. However, at low oxygen levels, hydrophobic interactions cause HbS molecules to cluster which causes the haemoglobin molecules to crystallise. As a result, red blood cells show sickling, are fragile and become susceptible to breaking within capillaries.

Consider the information in Tables A and B.

Table A – Selection of the Hbb sequence in adult haemoglobin

	DNA nucleotide sequence	Amino acid sequence
Hbb sequence in normal adult haemoglobin (Hb A)	CCT GAG GAG	pro - glu - glu
Hbb sequence in affected adult haemoglobin (Hb S)	CCT GTG GAG	

Table B – Selection of the genetic code

FIRST BASE	SECOND BASE					THIRD BASE
	T	C	A	G		
T	phe	ser	tyr	cys	T	
					C	
	leu		stop	stop	A	
			stop	trp	G	
C	leu	pro	his	arg	T	
					C	
			gln		A	
					G	
A	ile	thr	asn	ser	T	
					C	
			lys	arg	A	
	met/stop				G	
G	val	ala	asp	gly	T	
					C	
			glu		A	
					G	

2b. **i.** What is the mutation that produces HbS?

_____

1 mark

2b. ii. Draw a diagram of the DNA nucleotide that causes the mutation found in HbS.

1 mark

Total 1 + 1 = 2 marks

2c. i. What is the amino acid sequence for an adult with HbS?

_____

1 mark

2c. ii. Explain how changing a single amino acid in the haemoglobin polypeptide chain can cause it to behave so adversely at low oxygen concentrations.

_____

_____

_____

_____

2 marks

Total 1 + 2 = 3 marks

The most common form of malaria is caused by the parasite burrowing into red blood cells where it quickly multiplies leading to severe disease and often death. Currently, all treatments for malaria function by blocking the development of the parasite from within the red blood cell. Antimalarial drug resistance is a major public health problem which hinders the control of malaria. In 2010, a research group presented a new technique for prevention of malaria. The malarial parasite displays a surface protein MSP1 which is essential in the attachment of the parasite to the red blood cell. The study shows that when heparin-like carbohydrates are present, the malarial parasite is unable to infect the red blood cells. In humans, heparin is stored in mast cells in relatively small amounts. Pharmaceutical-grade heparin is derived from porcine and bovine mucosal tissue for its medical use as an anticoagulant.

2d. What is the general term given to a surface protein such as MSP1?

_____

1 mark

2e. Explain the likely role of heparin in the human body.

_____

_____

_____

1 mark

2f. Describe how heparin-like carbohydrates may be able to prevent malarial parasites from infecting red blood cells.

_____

_____

_____

_____

2 marks

2g. Give one reason why is it necessary to use heparin-like carbohydrates, rather than heparin itself, in the development of new anti-malarial drugs.

_____

_____

1 mark

2h. What is a significant advantage of discovering the new treatment for malaria?

_____

_____

1 mark

Total 1 + 2 + 3 + 1 + 1 + 2 + 1 + 1 = 12 marks

Question 3

The process of sex determination in mammals is under hormonal control. Scientists investigating the role of hormones in sex determination performed an experiment using rabbit embryos still living inside the uterus of the mother. At a stage of embryonic development before sex differences are visible, the part of the embryo that would form the gonads (ovaries or testes) was surgically removed. When the baby rabbits were born, the chromosome sex and the sexual differentiation of the genital structure was recorded. The results are shown in the table below.

Chromosomal sex	Genital structure	
	No surgery	Embryonic gonad removed
XX (female)	female	female
XY (male)	male	female

3a. What conclusion can be drawn from this study?

_____

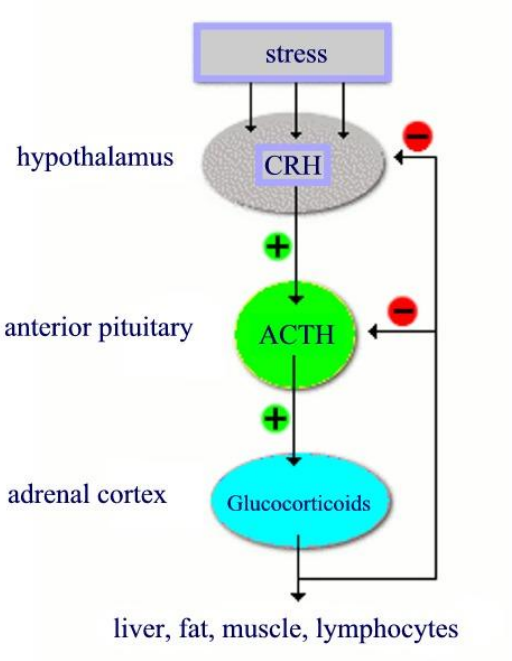
_____

_____

_____

2 marks

Cushing's syndrome is a condition in which prolonged exposure to high levels of the group of hormones known as glucocorticoids can cause severe fatigue, weak muscles, high blood pressure and depression. Glucocorticoids are released as a response to physical or mental stress. Normal effects of glucocorticoids are associated with the breakdown and conversion of proteins (from skeletal muscle) and fats to glucose. Glucocorticoids are secreted in response to a single stimulator: adrenocorticotropic hormone (ACTH). The diagram outlines the hormonal control of glucocorticoid production.

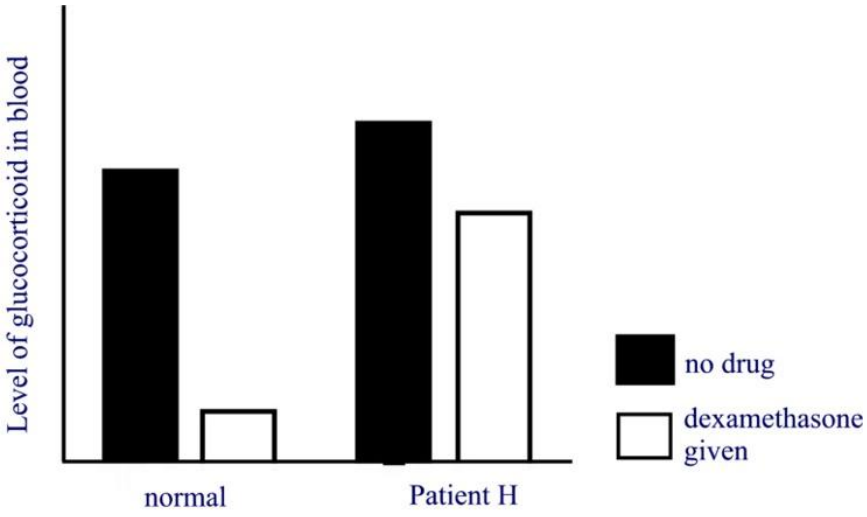


3b. Using the information in the diagram shown above, identify the two glands in which overactivity could directly cause excessive production of glucocorticoids. Circle your choices below.

hypothalamus anterior pituitary adrenal cortex

1 mark

In order to determine which gland is overactive, dexamethasone, a synthetic glucocorticoid which decreases the release of ACTH is administered to a patient in a test known as a dexamethasone suppression test. The result of the test is shown below.



3c. Explain which gland is affected in patient H.

_____

_____

_____

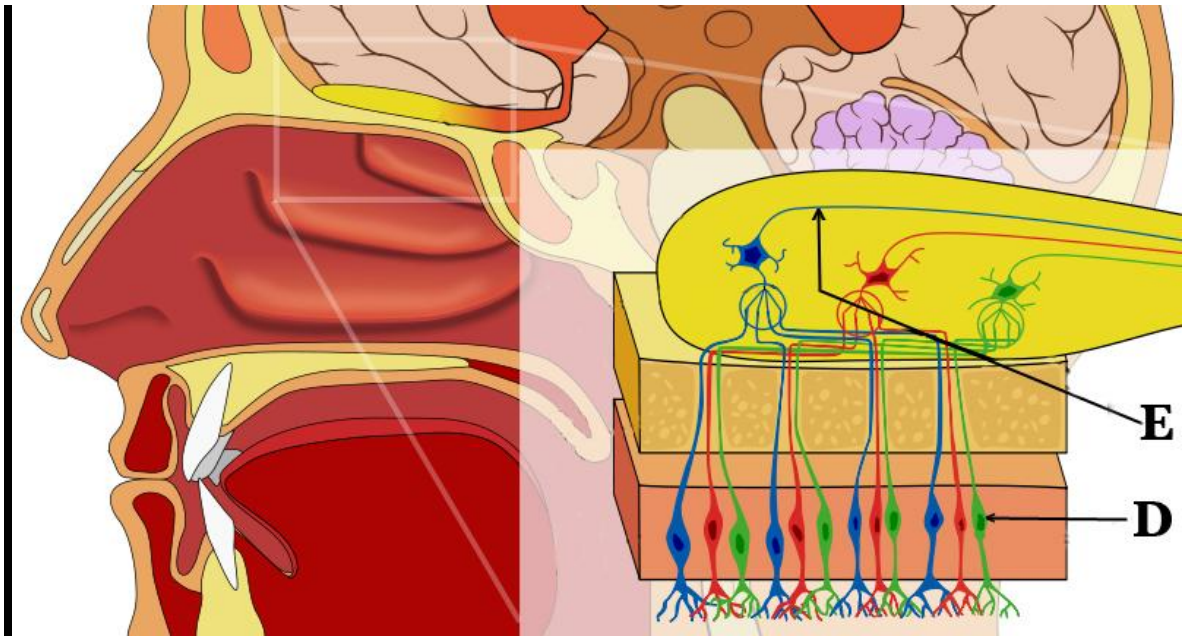
_____

2 marks

Total 2 + 1 + 2 = 5 marks

Question 4

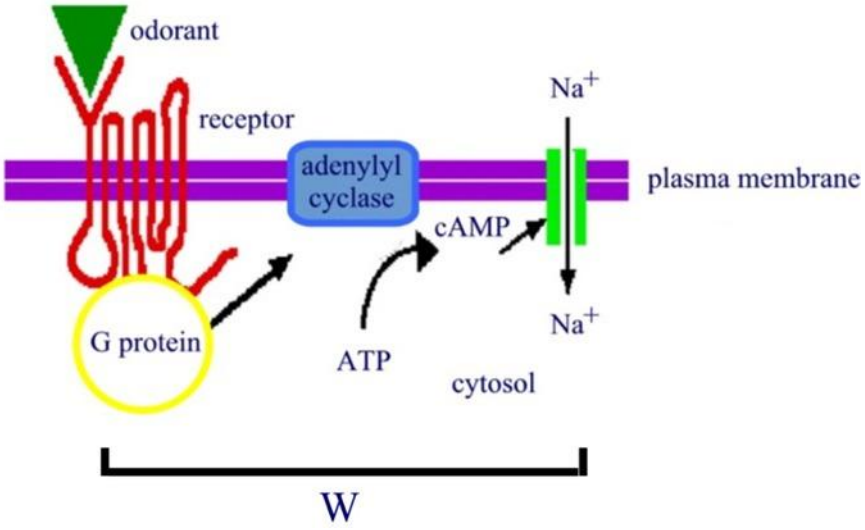
The ability to detect smell in humans relies on sensory receptors in the body that respond to airborne molecules. The receptors for smell are located in the nasal cavity in a small area of tissue known as the olfactory epithelium. The image below shows a sequence of stages in the process of olfaction (smell).



4a. Identify and describe the function of structures D and E.

	Name	**Function**
Structure D		
Structure E		

2 marks



4b. Identify the cell signalling process occurring at W.

_____

1 mark

Cell signalling pathways that involve G-proteins are associated with an increase in signal strength, also known as amplification.

4c. Explain one advantage gained from amplifying the strength of an olfactory signal.

_____

_____

_____

2 marks

Chemicals are used for communication within organisms and between organisms.

4d. What is the name given to the group of chemicals used by organisms within a species to communicate with each other?

_____

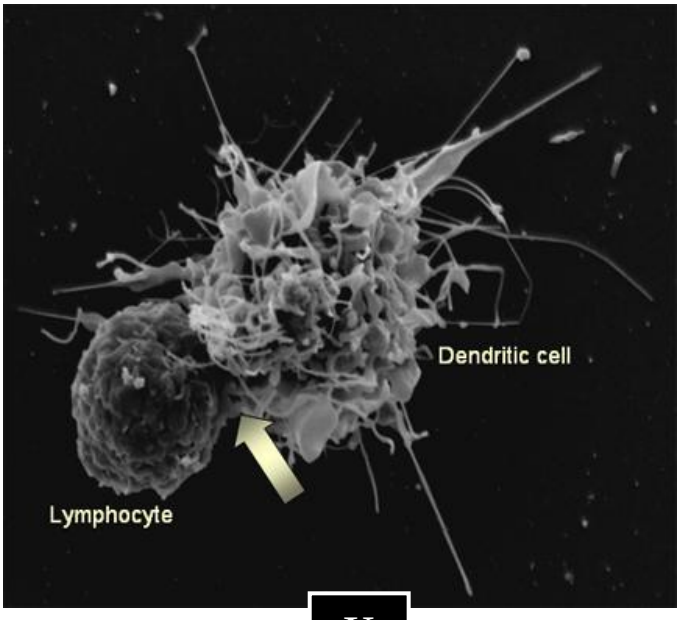
1 mark

Total 2 + 1 + 2 + 1 = 6 marks

Question 5

Cancer is a disease that affects people globally and is caused by abnormal and uncontrolled proliferation of cells. It can be eliminated by the immune system before it turns into a detectable cancer. Sometimes cancer cells are identified as normal healthy cells and escape detection by the immune system. Clinical trials using immunotherapy are currently underway in the search for a new treatment for cancer. Known as Human Initiated Therapeutic Vaccine (HITV) the immunotherapy uses the natural defence system of the body to fight the disease. It involves harvesting the patient's dendritic cells for culturing in the laboratory, before reintroducing them to the patient's body. Dendritic cells are antigen presenting cells and are found in small quantities in tissues that have contact with the external environment such as the skin and the lining of the respiratory system and gastrointestinal tract.

The image below shows a dendritic cell and a lymphocyte.



5a. Indicate whether dendritic cells are associated with the non-specific or specific immunity and clearly explain their role in the immune system. Circle your choice below.

non-specific immune system specific immune system

Explanation: _____

_____

_____

_____

3 marks

5b. Explain what is occurring at X.

_____

_____

_____

1 mark

5c. Identify another two cells that would normally be involved in an immune response against cancerous cells.

Type of immunity	**Name of cell**
non-specific	
specific	

1 mark

Until recently it was unclear whether dendritic cells existed in non-mammalian vertebrates. Scientists now know that zebrafish share many of the cellular elements of the specific immune system, including T and B lymphocytes and dendritic cells. Zebrafish are translucent, reproduce rapidly and are easy to handle.

5d. Explain why zebrafish might offer practical research advantages over some other animal models.

_____

_____

_____

1 mark

Total 3 + 1 + 1 + 1 = 6 marks

Question 6

A circadian rhythm is a physiological cycle which continues, in the absence of cues, over what is close to a 24-hour period in all eukaryotes. In hamsters, it is controlled by a group of neurons in the hypothalamus called the suprachiasmatic nucleus (SCN). The eyes transmit sensory information to the SCN which acts as regulator and synchronises the biological clock in body cells to the natural cycles of day length.

A genetic mutation, known as the tau ($\boldsymbol{\tau}$) mutation, alters the period of circadian rhythm in hamsters from the normal 24-hour cycle to one of around 20 hours.

Using the space provided below, outline an experiment that would enable you to determine whether circadian rhythms originate in the SCN.

In your answer you should

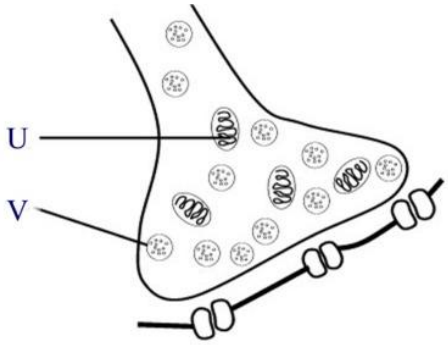
- state the hypothesis you are testing
- outline the experimental procedure
- describe ALL the results that would support or negate your hypothesis
- present a graph which summarises the results (use the next page to draw your graph)

Draw your graph for Question 6 in the space below:

6 marks

Question 7

The diagram below shows a junction between two neurons.



7a. Name and describe the function of structures **U** and **V**.

	Name	**Function**
Structure U		
Structure V		

4 marks

Multiple sclerosis is a condition in which myelin sheaths harden and deteriorate over time.

7b. Explain the effect that multiple sclerosis would have on the functioning of the nervous system.

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1 mark

Total 4 + 1 = 5 marks

Question 8

Haemolytic disease of the newborn (HDN) is caused by an incompatibility between the rhesus blood group of the mother and baby. D antigens are found on the surface of red blood cells of a rhesus positive (Rh^+) individual, whilst there are no D antigens present on the surface of red blood cells of an individual who is rhesus negative (Rh^-). An Rh^- mother can receive Rh^+ red blood cells if the blood of the baby enters her bloodstream, via the placenta, during birth.

8a. How would an Rh^- mother's immune system respond to the introduction of Rh^+ blood from her baby?

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1 mark

In a second pregnancy with an Rh^+ baby, HDN takes effect and red blood cells are attacked and broken down. The condition can be mild but can also lead to jaundice, cause brain damage or even the death of the child.

8b. Explain how the mother's immune system will respond to a second Rh^+ baby.

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2 marks

Total 1 + 2 = 3 marks

END OF SECTION B
END OF SOLUTIONS BOOK