INSIGHT

Trial Exam Paper

2010

BIOLOGY

Written examination 1

Solutions book

This book presents:

- correct solutions
- explanatory notes
- mark allocations

SECTION A – Multiple-choice questions

Question 1

Organic molecules are comprised of many elements. Three of the six elements most commonly found in organic molecules are carbon, hydrogen and oxygen. Three more elements commonly found in organic molecules include

A. nitrogen, phosphorus, zinc.

B. **nitrogen, sulfur and phosphorus.**

C. nitrogen, phosphorus, calcium.

D. nitrogen, sulfur, magnesium.

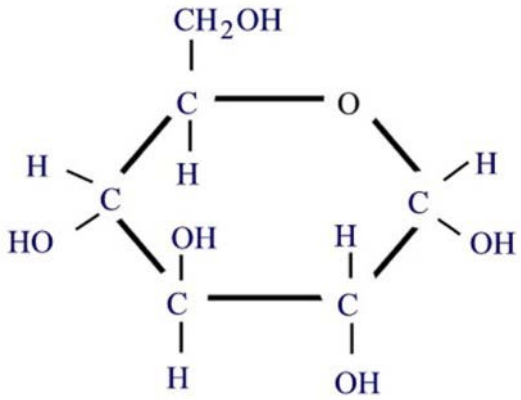
Answer is B

Explanatory notes

- Organic molecules are most commonly comprised of carbon, hydrogen and oxygen. Other elements such as nitrogen, sulfur and phosphorus are also found in organic molecules but less frequently.
- A is incorrect. Zinc is not one of the six elements most commonly found in organic molecules.
- B is correct. Nitrogen, sulfur and phosphorus are three of the six elements most commonly found in organic molecules.
- C is incorrect. Calcium is not one of the three elements most commonly found in organic molecules.
- D is incorrect. Magnesium is not one of the three elements most commonly found in organic molecules.

The following information relates to Questions 2, 3 and 4.

Glucose is the most common monosaccharide. The structural formula for glucose is



Question 2

Glucose molecules can be joined to make macromolecules known as polysaccharides. A polysaccharide commonly found in plants is

A. cellobiose.

B. **cellulose.**

C. chitin.

D. sucrose.

Answer is B

Explanatory notes

- A is incorrect. Cellobiose (or cellose) is a disaccharide molecule produced from hydrolysis of cellulose.
- B is correct. Cellulose is a polysaccharide molecule found in cell walls of plants.
- C is incorrect. Chitin is a polysaccharide found in the cell walls of fungi and the exoskeletons of insects and arthropods.
- D is incorrect. Sucrose is a disaccharide molecule found in plant sap.

Question 3

The name given to the chemical reaction in which glucose molecules are joined together is

A. **condensation.**

B. hydrolysis.

C. polymerisation.

D. glycolysis.

Answer is A

Explanatory notes

- A is correct. A condensation reaction involves the covalent bonding of two molecules, accompanied by the loss of a water molecule.
- B is incorrect. A hydrolysis reaction involves the splitting of two molecules by the addition of water.
- C is incorrect. Polymerisation is the process of adding monomers to form a polymer, however, given option A, it is not the **best** answer to choose.
- D is incorrect. Glycolysis is the splitting of glucose into pyruvate.

Question 4

If five glucose molecules were added together, the molecular formula for the resulting polymer would be

A. $C_{30}H_{60}O_{30}$

B. $C_{30}H_{55}O_{30}$

C. $C_{30}H_{55}O_{25}$

D. $\mathbf{C_{30}H_{52}O_{26}}$

Answer is D

Explanatory notes

When five glucose molecules are added together, 4 molecules of H_20 are released (8 hydrogen, 4 oxygen). If the molecular formula for 1 glucose molecule is $C_6H_{12}O_6$, 5 molecules will contain 30 carbon, 60 hydrogen, 30 oxygen. If 5 molecules of glucose are joined and 4 molecules of water are released, there will be 30 carbon, 52 hydrogen and 26 oxygen. Therefore, the molecular formula for the resulting polymer is $C_{30}H_{52}O_{26}$.

- A is incorrect. $C_{30}H_{60}O_{30}$ does not take into account that 4 molecules of H_20 are released.
- B is incorrect. $C_{30}H_{55}O_{30}$ takes into account that some H is released, but not the correct amount.
- C is incorrect. $C_{30}H_{55}O_{25}$ takes into account that some H and O are released, but not the correct amount.
- D is correct. $C_{30}H_{52}O_{26}$ takes into account that 4 molecules of water are released.

Question 5

In living organisms, proteins

A. are an essential source of energy.
B. store hereditary information.
C. **receive signals from outside a cell.**
D. form steroid hormones.

Answer is C

Explanatory notes

- A is incorrect. Carbohydrates and lipids are the primary sources of energy in living organisms, not proteins.
- B is incorrect. Nucleic acid (DNA) stores all hereditary information, not protein.
- C is correct. Protein receptors found embedded in the phospholipid bilayer receive chemical signals from outside a cell.
- D is incorrect. Steroid hormones are lipid based and not made of protein.

Question 6

Which of the following is **not** found in a prokaryote cell?

A. **mitochondria**
B. plasma membrane
C. ribosome
D. double-stranded DNA

Answer is A

Explanatory notes

- A is the correct response. Mitochondria are **not** found in prokaryote cells.
- B is incorrect. Prokaryote cells have a plasma membrane that encloses the cytoplasm.
- C is incorrect. Prokaryote cells contain ribosomes for protein synthesis.
- D is incorrect. Prokaryotes have plasmids which are single circular molecules of double-stranded DNA.

Question 7

In plant cells, plasmodesmata have a similar function to

A. desmosomes.
B. tight junctions.
C. **gap junctions.**
D. the extracellular matrix.

Answer is C

Explanatory notes

- A plasmodesma is an open channel in the cell wall of a plant through which strands of cytosol connect from adjacent cells.
- A is incorrect. Desmosomes are intercellular junctions in animal cells that function to adhere cells.
- B is incorrect. Tight junctions are intercellular junctions in animal cells that prevent leakage of material between cells.
- C is correct. Gap junctions are intercellular junctions in animal cells that allow the passage of material between cells, thus they are similar in function to plasmodesmata.
- D is incorrect. The extracellular matrix is the substance in which animal tissue cells are embedded.

Question 8

The fluid mosaic model describes plasma membranes as consisting of

A. **a phospholipid bilayer with proteins embedded in and attached to it.**

B. a lipid bilayer with proteins coating the outside of the hydrophobic structure.

C. a cholesterol bilayer with proteins embedded in the hydrophobic centre.

D. a phospholipid bilayer with proteins sandwiched between the layers.

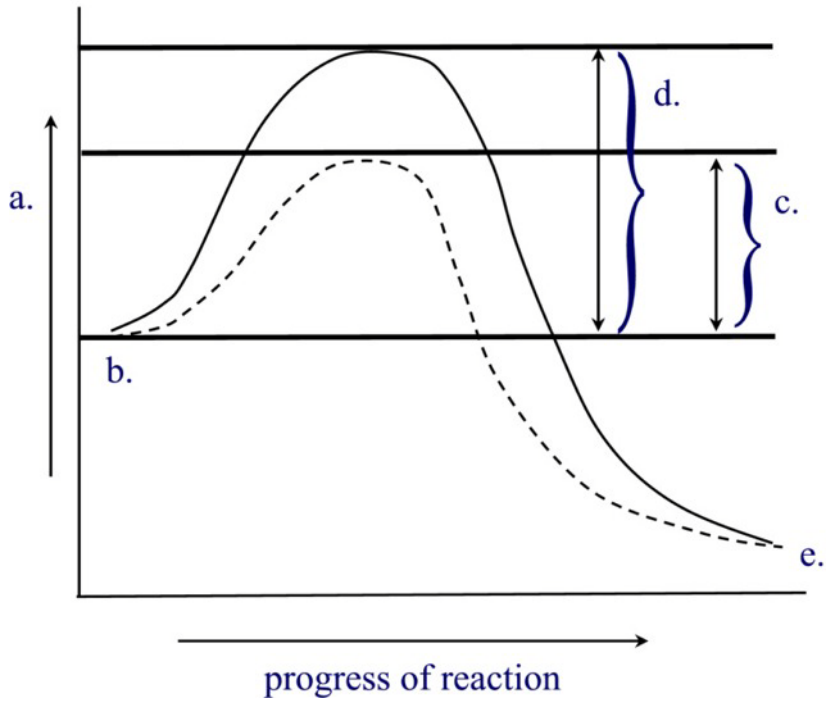
Answer is A

Explanatory notes

- According to the fluid mosaic model, the plasma membrane is a fluid structure with a 'mosaic' of proteins embedded in or attached to the bilayer of phospholipids.
- A is correct. The plasma membrane is a fluid structure with a 'mosaic' of proteins embedded in or attached to the bilayer of phospholipids.
- B is incorrect. The plasma membrane is composed of a phospholipid bilayer, not a lipid bilayer, which demonstrates both hydrophobic (lipid tails) and hydrophilic (phosphate heads) properties. Proteins are found embedded in or attached to the outside of the phospholipid bilayer, which is hydrophilic not hydrophobic.
- C is incorrect. The plasma membrane is comprised of a phospholipid bilayer, **not** a cholesterol bilayer.
- D is incorrect. Proteins are embedded in or attached to the plasma membrane, not sandwiched between the layers.

The following information relates to Questions 9 and 10.

The graph shows the progress of an endergonic reaction with and without an enzyme.



Question 9

An endergonic reaction

A. involves the net release of free energy into the surrounding environment.

B. **involves the absorption of free energy from the surrounding environment.**

C. occurs in cellular respiration.

D. follows a catabolic pathway.

Answer is B

Explanatory notes

- A is incorrect. The net release of free energy into the surrounding environment is associated with an exergonic reaction, not an endergonic reaction.
- B is correct. A endergonic reaction involves the absorption of free energy from the surrounding environment.
- C is incorrect. Cellular respiration is a catabolic process and releases energy by breaking down complex molecules into simple ones, therefore, it is an exergonic (not endergonic) process.
- D is incorrect. Endergonic reactions are anabolic (not catabolic) in nature (consume energy to build complex molecules from simpler ones).

Question 10

On the graph, the correct labels for the parts **a** to **e** are

	a.	b.	c.	d.	e.
A.	reactants	products	activation energy with enzyme	activation energy without enzyme	free energy
B.	products	free energy	activation energy without enzyme	activation energy with enzyme	reactants
C.	reactants	products	activation energy with enzyme	activation energy without enzyme	free energy
D.	**free energy**	**reactants**	**activation energy without enzyme**	**activation energy with enzyme**	**products**

Answer is D

Explanatory notes

The correct labels are as follows

a.	b.	c.	d.	e.
free energy	reactants	activation energy without enzyme	activation energy with enzyme	products

- A is incorrect. None of the labels is in the correct position.
- B is incorrect. Labels **c** and **d** are correct, but **a**, **b** and **e** are incorrect.
- C is incorrect. None of the labels is in the correct position.
- D is correct. All labels are in the correct position.

Question 11

At the conclusion of glycolysis, the net products will be

A. 2 ATP, 2 CO_2, 2 ethanol.

B. **2 ATP, 2 NADH, 2 pyruvate, 2 H_20.**

C. 38 ATP, 2 CO_2, 2 ethanol.

D. 38 ATP, 6 CO_2, 2 pyruvate.

Answer is B

Explanatory notes

- A is incorrect. Whilst at the end of glycolysis 2 ATP is formed, 2 CO_2 and 2 ethanol are not.
- B is correct. 2 ATP, 2 NADH, 2 pyruvate and 2 H_20 are produced as a result of glycolysis.
- C is incorrect. At the end of glycolysis, ATP is not formed in these amounts and CO_2 and ethanol are not formed at all.
- D is incorrect. At the end of glycolysis even though 2 pyruvate is formed, ATP is not formed in these amounts and CO_2 is not formed at all.

Question 12

Which of the following reactions is correctly paired with the location in which it occurs?

A. glycolysis – cristae of mitochondrion only

B. citric acid cycle – cytosol

C. ATP synthesis – matrix of the mitochondrion only

D. **electron transport – cristae of the mitochondrion**

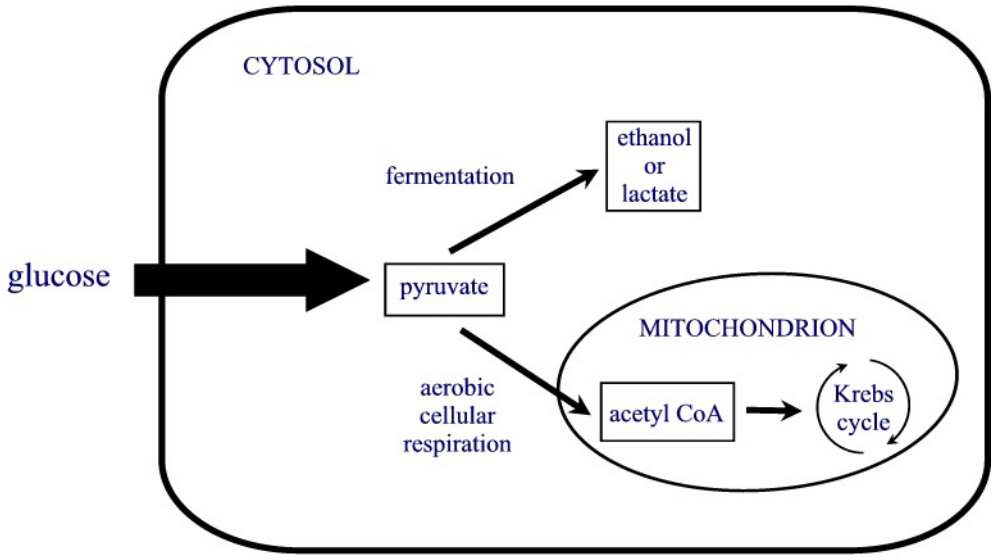
Answer is D

Explanatory notes

- A is incorrect. Glycolysis occurs in the cytosol, not within the mitochondria on the cristae.
- B is incorrect. Krebs cycle (citric acid cycle) occurs in the matrix of the mitochondria, not the cytosol.
- C is incorrect. ATP synthesis occurs in the cytosol and in the mitochondria (in the matrix and on the cristae), not only in the matrix of the mitochondrion.
- D is correct. The correct location for the process of electron transport is on the cristae of the mitochondrion.

Question 13

A process known as alcoholic fermentation has been observed in yeasts and roots cells of certain plants. The diagram shows the possible pathways that can follow glycolysis in a metabolising cell.



The principle outcome of alcoholic fermentation is the

A. **regeneration of the oxidising agent NAD^+, enabling glycolysis to continue in the absence of oxygen.**

B. production of beer.

C. production of lactic acid during exercise.

D. significant increase in the amount of ATP produced in cellular respiration.

Answer is A

Explanatory notes

In alcoholic fermentation, the absence of oxygen inhibits Krebs cycle. Instead of entering the Krebs cycle, pyruvate is converted to ethanol. Even though Krebs cycle and oxidative phosphorylation no longer occurs, ATP production can continue (in small amounts) if NAD^+ is present to convert glucose to pyruvate.

- A is correct. The principle outcome of alcoholic fermentation is regeneration of NAD^+ so glycolysis can continue.
- B is incorrect. Alcoholic fermentation is applied to the production of beer; however, production of beer is not the principle outcome.
- C is incorrect. Lactic acid is produced in skeletal cells of mammals in the absence of oxygen. It is not produced in yeasts or plant root cells.
- D is incorrect. Oxidative phosphorylation (electron transport and chemiosmosis) is the process which produces the greatest number of ATP. Alcoholic fermentation only produces 2 ATP and therefore cannot significantly increase the amount of ATP produced in cellular respiration.

Question 14

During paracrine signalling, chemical signals are

A. **released from a cell and act upon other cells within the immediate vicinity of their origin.**

B. produced within a cell, diffuse locally and trigger a response in the cells that have released them.

C. diffused into the bloodstream and trigger responses in target cells all around the body.

D. released into the external environment where they can have an effect on the physiology or behaviour of other animals.

Answer is A

Explanatory notes

- A is correct. In paracrine signalling a cell secretes chemical signals which act on nearby target cells.
- B is incorrect. This is a description of autocrine signalling.
- C is incorrect. This is a general definition of endocrine signalling and not specific to paracrine signalling.
- D is incorrect. This is a description of communication associated with pheromone action, not paracrine signalling.

Question 15

The most accurate description of the difference between hormones and pheromones is

A. pheromones are small, volatile molecules whereas hormones are not.

B. **pheromones are signals that function between organisms, whereas hormones communicate within an organism.**

C. pheromones use neurons as their means of transmission, whereas hormones use chemicals as their means of transmission.

D. pheromones are involved in reproduction, whereas hormones are not.

Answer is B

Explanatory notes

- A is incorrect. Both pheromones and hormones are small molecules.
- B is correct. Pheromones are signals that function intraspecifically, whereas hormones communicate within an organism.
- C is incorrect. Pheromones are released into the external environment and interact chemically; they do not use neurons as their means of transmission.
- D is incorrect. Both pheromones and hormones are involved in reproduction.

Question 16

Epinephrine is a hormone produced in humans. When it binds to the muscle cells of the small intestine, contraction of the muscles is inhibited. In contrast, when it binds to heart muscle, it speeds up the contraction. Epinephrine can have different effects on muscle cells because

A. small intestine muscle is not as strong as heart muscle and has a weaker response to epinephrine.

B. **the cells in small intestine muscle and heart muscle have different signal transduction pathways for epinephrine, producing different cellular responses.**

C. there are more receptors for epinephrine in heart muscle cells than there are in small intestine muscle cells.

D. epinephrine circulates to the heart first and the higher concentration around heart muscle cells results in a stronger response.

Answer is B

Explanatory notes

- A is incorrect. The contraction of muscle cells in the small intestine and the heart is a response to the signal transduction pathway of epinephrine, it is not related to the strength or weakness of the muscle.
- B is correct. Cellular responses to hormones can be different depending on the nature of the signal transduction pathway in the cell.
- C is incorrect. The contraction of muscle cells in the small intestine and the heart is a response to the signal transduction pathway of epinephrine. It is not related to the number of receptors in the plasma membrane of the cells.
- D is incorrect. The contraction of muscle cells in the small intestine and the heart is a response to the signal transduction pathway of epinephrine. It is not related to the order of circulation of epinephrine around the body.

Question 17

A signal molecule that binds to a plasma membrane protein functions as a

A. protein kinase.
B. receptor protein.
C. second messenger.
D. **ligand.**

Answer is D

Explanatory notes

- A is incorrect. A protein kinase is an enzyme that transfers phosphate groups from ATP to a protein. It does not bind to a plasma membrane protein.
- B is incorrect. A receptor protein is found embedded in the plasma membrane. Signal molecules are not incorporated in the plasma membrane; they are produced in endocrine cells and travel in the bloodstream.
- C is incorrect. A second messenger is a small, non-protein, water-soluble molecule or ion that relays a signal within a cell in response to a signalling molecule; it does not bind to a plasma membrane protein.
- D is correct. A ligand is a molecule that specifically binds to another molecule. Ligand binding causes a receptor protein to undergo a change in shape, and is what occurs when a signal molecule binds to a plasma membrane protein.

Question 18

The bracken *Pteridium aquilinum* is an herbaceous plant which produces hormones that are capable of disrupting the development of insect predators as part of its passive defence mechanism.

Another example of passive defence in *Pteridium aquilinum* could be the

A. **production of a carcinogen that is toxic to rodents and livestock.**
B. secretion of antibiotic-like substances to kill pathogens.
C. sealing off infected areas with cork cells.
D. increasing of reactive oxygen levels to kill microorganisms.

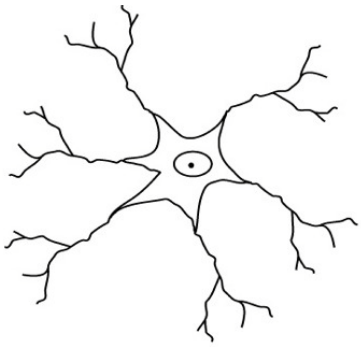
Answer is A

Explanatory notes

- A is correct. Passive defences are always present in a plant: carcinogens are always produced by *P. aquilinum.*
- B is incorrect. Secretion of antibiotic-like substances to kill pathogens is an active response to a pathogenic attack and therefore not an example of passive defence.
- C is incorrect. Sealing off infected areas with cork cells is an active response to a pathogenic attack and therefore not an example of passive defence.
- D is incorrect. Increasing of reactive oxygen levels to kill microorganisms is an active response to a pathogenic attack and therefore not an example of passive defence.

Question 19

The diagram below shows a representation of an interneuron.



In the nervous system, interneurons

A. do not have cell bodies.

B. are found only in the peripheral nervous system.

C. have electrical synapses between neurons.

D. **may connect affector and effector neurons.**

Answer is D

Explanatory notes

- A is incorrect. All interneurons have cell bodies.
- B is incorrect. Interneurons are found within the central nervous system, not the peripheral nervous system.
- C is incorrect. Synapses are found between neurones, communication across a synapse is via neurotransmitters (chemical) and not electrical.
- D is correct. Interneurons are found within the central nervous system and form synapses with affector and effector neurons.

Question 20

Sexually transmissible infections (STIs) are usually spread between humans when sexual contact is made between an individual who is infected with a disease and one who is not. An STI usually occurs in organs associated with the reproductive system but can also involve other systems of the body. Which of the following agents would **not** cause an STI?

A. **prion**

B. virus

C. bacteria

D. fungus

Answer is A

Explanatory notes

- A is the correct response. To date, prions have not been shown to cause STIs, therefore this is the correct answer.
- B is incorrect. Viruses cause STIs (for example, AIDS and genital herpes), therefore this is the not the correct answer.
- C is incorrect. Bacteria cause STIs (for example, syphilis and gonorrhoea), therefore this is the not the correct answer.
- D is incorrect. Fungi cause STIs (for example, candidiasis), therefore this is the not the correct answer.

Question 21

There are three known classes of interferons. Interferons are proteins and can be released by

A. helper T cells that bind to antigen presenting cells.

B. macrophages that have become antigen-presenting cells.

C. **cells infected by viruses.**

D. mast cells that bind to antigens.

Answer is C

Explanatory notes

- A is incorrect. When helper T cells bind to antigen-presenting cells they release cytokines (if they have already encountered the antigen being presented); they do not release interferons.
- B is incorrect. Macrophages that have become antigen-presenting cells release cytokines; they do not release interferons.
- C is correct. When cells are infected by viruses, they release interferons.
- D is incorrect. When mast cells bind to antigens they release cytokines and histamines; they do not release interferons.

Question 22

The ability of the immune system to distinguish self from non-self limits the success of blood transfusion. As shown in the table below, in the ABO blood group system, there are four groups A, B, AB and O. People are classified into one of these groups on the basis of the antigen found on their red blood cells and the antibodies present in their blood plasma.

Blood group	Antigen on plasma membrane	Antibody in plasma
A	A	anti-B
B	B	anti-A
AB	A and B	neither anti-A nor anti-B
O	neither A nor B	anti-A and anti-B

A transfusion of Type B blood was given to a person who has Type A blood. As a result of the transfusion

A. there would be no reaction because Type B is a universal donor blood type.

B. **the recipient's anti-B antibodies reacted with the donated red blood cells.**

C. the recipient formed anti-A and anti-B antibodies.

D. the recipient's B antigens reacted with the donated anti-B antibodies.

Answer is B

Explanatory notes

- A is incorrect. The universal donor blood type is Type O, not Type B and B antigens on surface of donor red blood cells will trigger a reaction with the anti-B antibodies in the recipient's plasma.
- B is correct. Recipient will have anti-B antibodies in their plasma, and these will react with donor blood cells causing them to clump and lyse.
- C is incorrect. Anti-A antibodies would not be formed as this would result in a reaction against the recipient's own red blood cells.
- D is incorrect. The recipient's red blood cells only carry A antigens (not B antigens) and the donor plasma only has anti-A antibodies (not anti-B antibodies), therefore the scenario is not possible.

Question 23

Phagocytosis is the process in which large substances are taken up by a cell. A target cell is most likely phagocytosed by a

A. plasma cell.

B. **neutrophil.**

C. natural killer cell.

D. cytotoxic T cell.

Answer is B

Explanatory notes

- A is incorrect. A plasma cell is an antibody-secreting cell, not a leucocyte (white blood cell) which is associated with phagocytosis.

- B is correct. A neutrophil is a leucocyte and is associated with phagocytosis.
- C is incorrect. Natural killer cells are leucocytes that kill target cells by releasing proteins that cause apoptosis; they do not phagocytose them.
- D is incorrect. Cytotoxic T cells are lymphocytes that kill infected cells by releasing proteins that cause apoptosis; they do not phagocytose them.

Question 24

In 1955 Sir Macfarlane Burnet first proposed the clonal selection theory. Clonal selection is responsible for

A. rearrangement of antibody genes.

B. recognition of Class I MHC markers by cytotoxic T cells.

C. formation of cell cultures in the commercial production of monoclonal antibodies.

D. **proliferation of clones of plasma and memory cells specific for an antigen that has been encountered.**

Answer is D

Explanatory notes

- A is incorrect. The process of clonal selection is not capable of triggering gene rearrangement.
- B is incorrect. Whilst cytotoxic T cells do recognise Class I MHC markers, clonal selection is associated with the proliferation of a lymphocyte into a clone of cells.
- C is incorrect. Clonal selection occurs naturally within an immune system and results in the production of cells. Commercial production of monoclonal antibodies results in the production of identical antibodies.
- D is correct. In clonal selection an antigen 'selects' the lymphocyte (B cell) that will proliferate into a large clone of cells (plasma and memory) with the same genetic material and the same antibodies.

Question 25

In some individuals, when there is an interruption of the normal ability to distinguish self from non-self, an autoimmune disease occurs. Which of the following would **not** be considered an autoimmune condition?

A. insulin-dependent diabetes (Type 1).

B. **non-insulin dependent diabetes (Type 2).**

C. multiple sclerosis.

D. rheumatoid arthritis.

Answer is B

Explanatory notes

- A is incorrect. Insulin-dependent diabetes *is* an autoimmune condition, so this is not the correct answer.
- B is the correct response. Non-insulin dependent diabetes is not an autoimmune condition and its onset is associated with lifestyle (diet, body weight and exercise), therefore this is the **correct** answer.
- C is incorrect. Multiple sclerosis *is* an autoimmune condition, so this is not the correct answer.
- D is incorrect. Rheumatoid arthritis *is* an autoimmune condition, so this is not the correct answer.

END OF SECTION A

SECTION B – Short-answer questions

Question 1

In humans, sickle cell disease is an inherited blood disorder caused by a mutation in the sixth DNA triplet of the HBB gene (the gene that codes for the beta haemoglobin chain). The mutation, where an A is replaced by a T, occurs at nucleotide 17, producing the triplet GTG. The normal DNA triplet in the sequence is GAG.

1a. In GAG, what does the letter A represent?

1 mark

Solution

Adenine

Explanatory notes

- A is the letter used to represent the nucleotide adenine which is one of the four nucleotides found in DNA.

	SECOND BASE				
FIRST BASE	T	C	A	G	THIRD BASE
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
	met/stop		lys	arg	A
					G
G	val	ala	asp	gly	T
					C
			glu		A
					G

1b. Use the information in the table above to indicate how the normal beta haemoglobin chain differs from the sickle cell haemoglobin chain.

1 mark

Solution

The normal beta haemoglobin chain has the amino acid glu (glutamine) at position 6. The sickle cell haemoglobin chain has the amino acid val (valine) at position 6.

Explanatory notes

- The substitution of T for A results in a change of DNA triplet from GAG to GTG. This change leads to a change in the amino acid brought to the protein in the formation of haemoglobin. Instead of adding glutamine, valine is added. This changes the primary structure of the protein.

1c. Apart from DNA, identify one other molecule that plays a significant role in the production of a polypeptide and briefly outline its function.

1 mark

Solution

mRNA is produced by translation of the DNA and interacts with tRNA to direct the production of polypeptide.

OR

tRNA is the molecule which carries the correct/specific/corresponding/matching amino acid to the ribosome.

Explanatory notes

- DNA is transcribed and a complementary mRNA is produced. This contains the coding sequence which is translated at the ribosome into a polypeptide chain. The tRNA carries the correct amino acids to the ribosome where it is added to the polypeptide chain.

Haemoglobin is a protein that carries oxygen in red blood cells. It is a molecule made up of four haemoglobin chains, two alpha chains and two beta chains, and four haem (iron containing) groups attached at the centre of each chain. A representation of a molecule of adult haemoglobin is shown below.

1d. What type of protein is haemoglobin?

1 mark

Solution

Transport protein OR globular protein OR conjugated protein.

Explanatory notes

- Haemoglobin is a globular protein and is responsible for transport. It is water soluble and its structure is critical to its function. The inclusion of the four non-protein haem (iron containing) groups makes haemoglobin a conjugated protein.

1e. What level of structure is found in the haemoglobin molecule?

1 mark

Solution

Quaternary structure

Explanatory notes

- A polypeptide with two or more chains that interact to form a functional protein have an arrangement known as a quaternary structure. Incorporated in this structure are the primary structure (amino acid sequence), secondary structure (α – helix or β –pleated sheet) and tertiary structure (folding).

1f. i. What is the function of the haem group associated with each of the polypeptide chains in the molecule?

1 mark

Solution

The haem group binds oxygen.

1f. ii. What is the name given to the non-protein component of haemoglobin?

1 mark

Solution

The non-protein component of haemoglobin is the prosthetic group.

Explanatory notes

- When the haem (non-protein or prosthetic) group comes into contact with oxygen, each iron atom is capable of forming a bond with one oxygen atom as a result of ion induced dipole forces.

Total 1+1+1+1+1+1+1=7 marks

Question 2

The principle source of energy for all living organisms comes from the sun. Radiant energy is transformed into chemical energy which is then incorporated into energy available in food chains.

2a. i. What is the name of the process that transforms radiant energy into chemical energy?

1 mark

Solution

Photosynthesis

2a. ii. Write the balanced chemical equation for this process.

2 marks

Solution

$$6CO_2 + 12H_2O \xrightarrow[\text{chlorophyll}]{\text{radiant energy}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

Explanatory notes

Photosynthesis is the process associated with the transformation of radiant energy to chemical energy. It is best described in the formula given above – with water being shown on both sides of the equation because as a result of the process, reactant water molecules are split and new water molecules are formed.

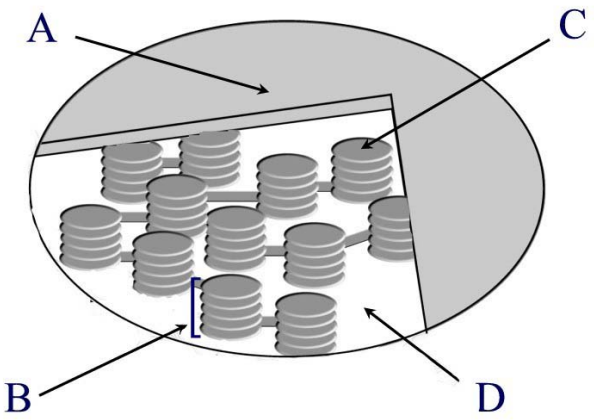
VCAA (2002) also accepts the equation

$$6CO_2 + 6H_2O \xrightarrow[\text{chlorophyll}]{\text{radiant energy}} C_6H_{12}O_6 + 6O_2$$

Mark allocation

- 1 mark – reactants and products ALL correct
- 1 mark – coefficients ALL correct

The diagram below shows an organelle typically associated with the process described in part **2ai**.



2b. Identify the structures and their associated function by completing the following table.

4 marks

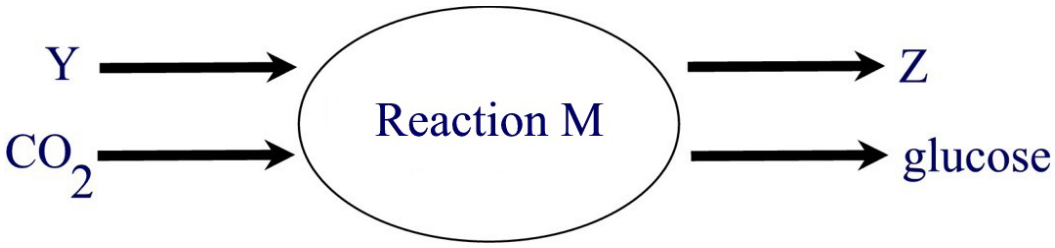
Solution

	Structure	**Function**
A	outer membrane	encloses the stroma, maintains integrity of chloroplast
B	granum	contain chlorophyll and site of light dependent reaction
C	thylakoid	site of light dependent reaction
D	stroma	site of light independent reaction (Calvin cycle)

Explanatory notes

- Chloroplasts are found in mesophyll cells in plants. There are usually about 30–40 chloroplasts per cell. An envelope of two membranes bounds the chloroplast, inside of which is the liquid stroma in which the light independent reaction of photosynthesis occurs. Populating the stroma is a network of interconnected membranous sacs called thylakoids which are organised into stacks known as grana. The thylakoid membranes contain the pigment chlorophyll which is essential for the light dependent reaction to occur.

The diagram below shows a symbolic representation of Reaction M which occurs as part of the process described in part **2ai**.



2c. i. Suggest what input Y might represent.

1 mark

Solution

ATP **OR** NADPH

2c. ii. Suggest what output Z might represent.

1 mark

Solution

ADP + P_i **OR** $NADP^+$

Explanatory notes

- The principle input to the light independent reaction in photosynthesis is carbon dioxide, while the major output is sugar (or PGAL). The process would not occur, however, without the involvement and transfer of ATP and NADPH (from the light dependent reaction). In addition, the light independent reaction always produces ADP + P_i and $NADP^+$.

Total 1+2+4+1+1= 9 marks

Question 3

There are more than 100 different types of naturally occurring gibberellins in plants. The major events in the discovery of gibberellins are summarised in the table.

Time	Event
Early-20th century	Farmers in Asia noticed that some rice seedlings in their rice paddies were hyperelongated causing them to fall over before they could reach maturation and flowering.
1926	Ewiti Kurosawa (plant pathologist) discovers that a fungus of the genus *Gibberella* causes hyperelongation in plants.
1930s	A fungus causes hyperelongation by secreting a chemical; the chemical is subsequently named gibberellin.

Gibberellins belong to a group of chemicals known as hormones or plant growth regulators. Hormones are produced by plants and animals.

3a. Identify one similarity and one difference shown by hormones produced in plants and hormones produced in animals.

2 marks

Solution

Similarity: Both are signalling molecules which bind to a specific receptor and trigger a response in target cells and/or tissue.

Difference: In animals hormones are usually transported in the circulatory system; in plants there is no circulatory system for the transport of hormones.

Explanatory notes

- A hormone is a signalling molecule produced in small amounts in one part of an organism and transported to other parts where it binds to a specific receptor and triggers a response in a target cell or tissue. In animals hormones are most often transported via the circulatory system. Plant physiologists adopted the hormone concept, however, the absence of a circulatory system to transport signalling molecules, the fact that some signalling molecules in plants act only locally and that some signalling molecules (for example, sucrose) occur at concentrations significantly higher than typical hormones have caused the classification to be called into question. Despite these objections, they are transported through plants and induce signal transduction pathways, and are therefore considered to be acting as hormones.

Mark allocation

- 1 mark for similarity (only if both plants and animals are considered).
- 1 mark for difference (only if both plants and animals are considered).

3b. What other plant hormone is capable of stimulating cell elongation in plants?

1 mark

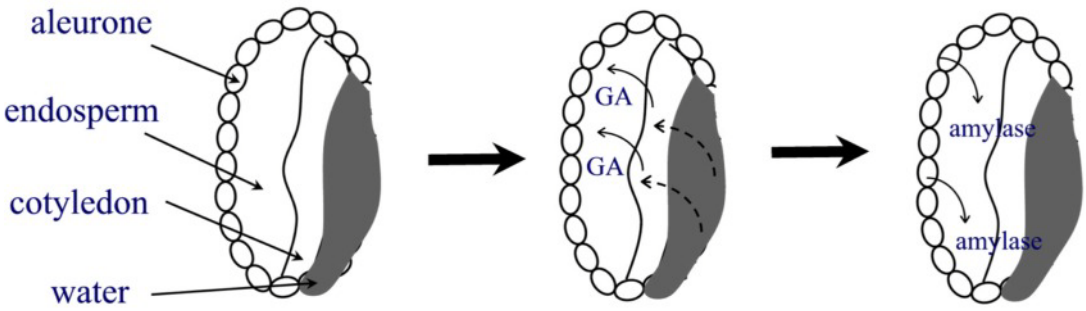
Solution

Auxin

Explanatory notes

- When present in low concentration, auxins act to trigger the elongation of young developing shoots in plants. Auxins are also associated with the formation of lateral and adventitious roots, regulating the development of fruit, the enhancement of apical dominance, the promotion of vascular differentiation and slowing of leaf abscission.

The seeds of the barley plant *Hordeum vulgare* store nutrients in the endosperm, tissue which provides nourishment to the developing embryo (cotyledon). After planting and watering, a seed absorbs water, which causes the cotyledon to release gibberellins (GA). This signals the seed to break dormancy and commence germination. In addition, gibberellin triggers the release of amylase from the aleurone. Amylase hydrolyses starch in the endosperm to sugar. This process is described in the diagram.



3c. What is amylase and what is the relationship between amylase and starch?

2 marks

Solution

Amylase is an enzyme and starch is the substrate upon which amylase acts.

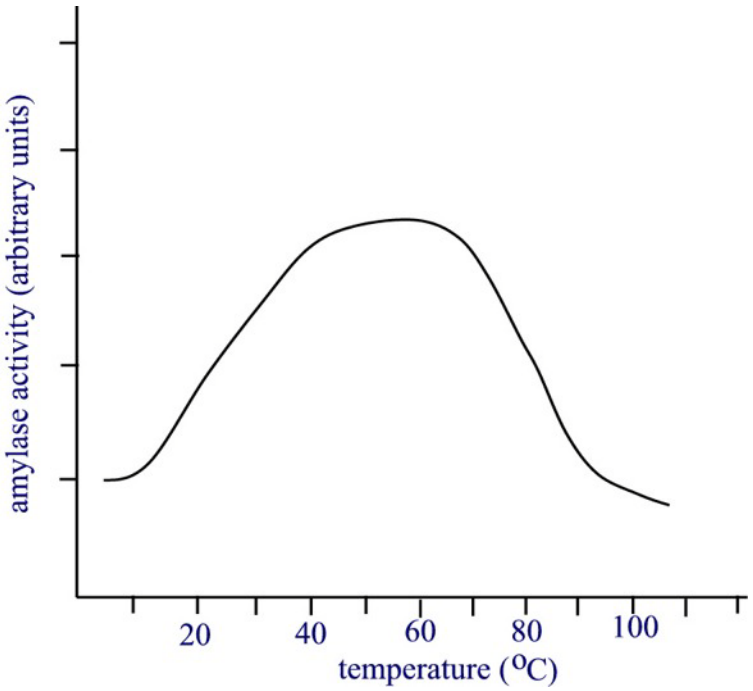
Explanatory notes

- In an enzymatic reaction, the enzyme acts as a biological catalyst upon a substrate (usually found on the left of a chemical equation) to produce a product (found on the right of a chemical equation). In this example, amylase is the enzyme that acts upon the substrate (starch) to produce the product (sugar).

Mark allocation

- 1 mark for enzyme.
- 1 mark for substrate.

Amylase is also produced by the salivary glands in humans and begins the process of carbohydrate digestion in the mouth. The graph shows the activity of amylase across a range of temperatures.



3d. Explain the effect on amylase activity as the temperature approaches 100°C.

2 marks

Solution

A temperature approaching 100°C will alter the molecular structure of the active site of the enzyme. Enzyme is denatured and any further enzyme activity ceases because a bond between enzyme and substrate cannot be formed.

Explanatory notes

- High temperatures cause atoms to move with greater energy than at lower temperatures. Increased energy places greater stress on bonds formed between the atoms within the enzyme. If the bonds break, the molecular structure alters and consequently the shape of the active site changes irreversibly – denaturation. No bond forms between the active site of the enzyme and the substrate and enzyme activity ceases.

Mark allocation

- 1 mark – molecular structure of active site changes with increased temperature.
- 1 mark – enzyme denatures AND no bond interaction occurs between active site and substrate.

Total 2+1+2+2=7 marks

Question 4

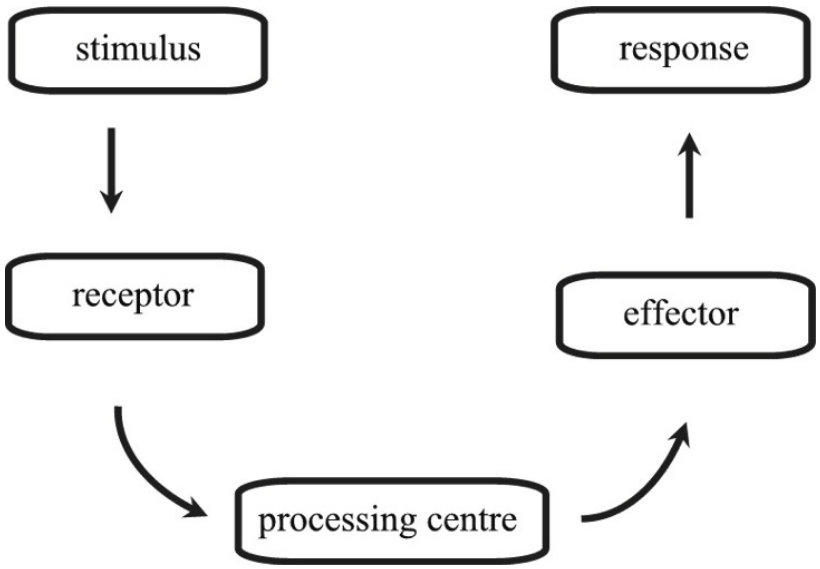
4a. Select a homeostatic system you have studied in Unit 3 Biology and use **all** the components in the box below to present a labelled diagram explaining how the specific system operates. You can also include your own components to explain the model.

response	stimulus	receptor	effector	processing centre

2 marks

Solution

Response could be any suitable example but it must be explained with a diagram such as



Mark allocation

- 1 mark – using **all** the terms in the box.
- 1 mark – clear identification of the specific receptor, specific effector and specific response in the **correct** order.

4b. Explain whether this is an example of a positive or negative feedback mechanism.

1 mark

Solution

- This is a negative feedback mechanism because the components in the box only allow for an example in which a change in a physiological variable triggers a response that counteracts the initial fluctuation.

Huntington disease (HD) is an inherited disorder that results in progressive neurological deterioration and in humans is controlled by a gene on the number 4 chromosome. Normally the gene produces a protein called huntingtin, however, a mutation leads to the production of an abnormal protein. By aggregating or clumping together inside neurons, the abnormal protein initiates a process that kills the neurons in a region of the brain known as the *corpus striatum*. This causes tremors, loss of motor function and eventually death. Mice also show the gene mutation for HD. A scientist hypothesised that a drug, cystamine, may alleviate the symptoms and prolong life expectancy for mice with HD.

4c. Design an experiment to test the scientist's hypothesis. You may use diagrams.

Your experimental design should

- clearly outline the experimental design that will be followed.
- identify the results that would support the hypothesis.

4 marks

Solution

Response could be any suitable experimental design but it must contain **all** components listed above, i.e. experimental procedure and results that would support the hypothesis.

Experimental design:

Have one group of genetically identical mice with HD (large number – around 50 to 100 is reasonable). Randomly divide the mice into two equal groups. Give cystamine in a regular regime to **all** the mice in one group and give a placebo drug (also in a regular regime) to **all** the mice in the other group. Ensure that mice are kept in controlled conditions (same temperature, surrounding, food, etc.). Make observations of mice and record results. Repeat the experiment if necessary.

Results that support hypothesis:

Mice with HD that are treated with cystamine will show a reduction in tremors, improved (or a halt to loss of) motor function and extended life expectancy. Mice with HD receiving placebo will not show relief from symptoms and will show continued deterioration.

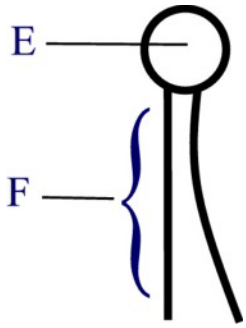
Mark allocation

- 1 mark – one large group of genetically identical mice (large number – around 50 to 100) OR smaller groups of mice (around 5 to 10) AND repeat the experiment MANY times (e.g. 5 repetitions).
- 1 mark – random division of mice into two groups; give one group cystamine, the other group should receive a placebo.
- 1 mark – controlled conditions (same temperature, surrounding, food, etc.); record observations.
- 1 mark – description of results that support hypothesis.

Total 2+1+4=7 marks

Question 5

Cell membranes are found in all organisms. The primary constituent of a cell membrane is a phospholipid, the structure of which is shown in the diagram below.



5a. Identify the structures and describe their behavioural properties in water by completing the following table.

3 marks

Solution

	Structure	**Behaviour in water**
E	phosphate head	hydrophilic – shows an affinity for water
F	lipid tails	hydrophobic – excluded from/repelled by water

Mark allocation

- 1 mark – correct identification of phosphate head and lipid tails.
- 1 mark – hydrophilic: shows an affinity for water.
- 1 mark – hydrophobic: excluded from/repelled by water.

Two students were having a discussion about biological molecules. Student A was insistent that lipids should be grouped with carbohydrates, proteins and nucleic acids, whilst Student B disagreed vehemently, stating instead that lipids were the 'odd group out' and should be grouped independently.

5b. State which student is correct and clearly explain your reasoning.

2 marks

Solution

Student B is correct. Lipids are not true polymers and they do not form structures large enough to be considered macromolecules.

Explanatory notes

- A polymer is a long molecule consisting of many similar or identical building blocks (monomers) linked by covalent bonds. A macromolecule is a chain-like molecule known as a polymer.

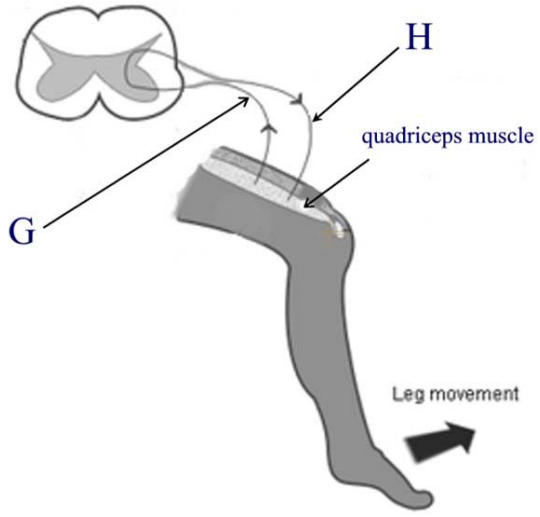
Mark allocation

- 1 mark – correctly naming which student is correct.
- 1 mark – correctly identifying that lipids are not true polymers as they do not form macromolecules.

Total 3+2=5 marks

Question 6

The diagram below shows a nerve pathway in humans which becomes activated automatically if the tendon connected to the quadriceps muscle in the leg is stimulated.



6a. Name and explain the characteristics associated with this particular type of nerve pathway.

1 mark

Solution

This is a reflex arc and is not mediated directly by the brain but by a processing point (the spinal cord or brain stem) in the central nervous system.

Explanatory notes

- The nerve pathway is a reflex arc. A reflex arc enables rapid responses to stimuli. They are an automatic reaction to a stimulus which is mediated by a processing point in the central nervous system (the spinal cord or brain stem), rather than directly by the brain itself.

6b. Using the letters shown, indicate which part of the diagram represents a sensory neuron.

1 mark

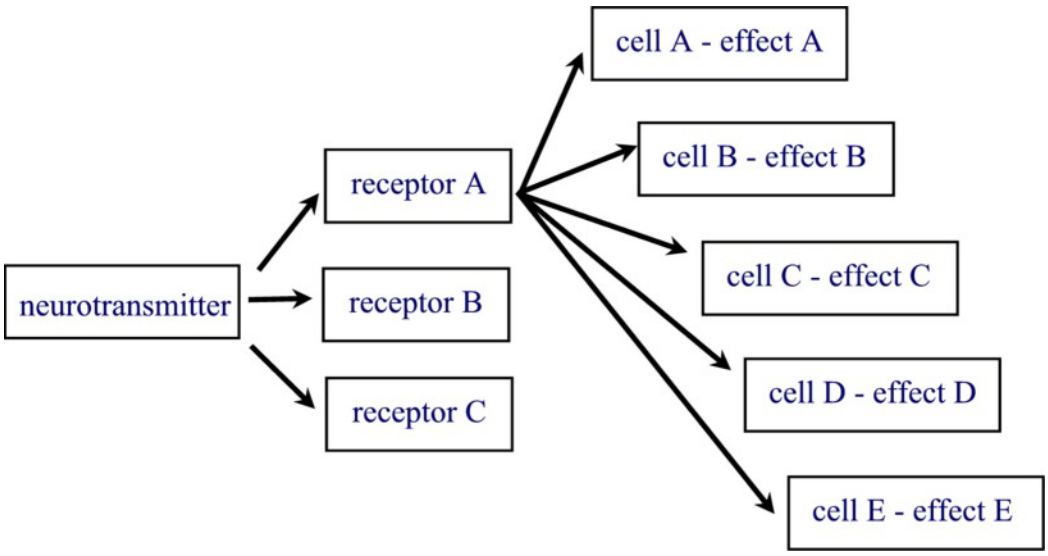
Solution

G

Explanatory notes

- A sensory neuron receives information from the external and internal environment and transmits the information to the central nervous system for processing.

There are over 100 known neurotransmitters which are classified into five groups based on chemical structure. The diagram models a potential neurotransmitter–receptor–effect interaction in a human nervous system.



6c. i. What is a neurotransmitter?

1 mark

Solution

A molecule released from the synaptic terminal of a neuron at a chemical synapse which diffuses across the synaptic cleft, binds to the postsynaptic cell and triggers a response.

6c. ii. Explain why this model of neurotransmitter-receptor-effect interaction could have implications in the development of drugs that are used to manage brain function or treat nervous system diseases.

2 marks

Solution

A single neurotransmitter can act on multiple receptors. Furthermore, a single specific receptor for a particular neurotransmitter can trigger a wide range of effects depending on the postsynaptic cell with which it is associated. Drug design must target the specific receptor associated with the condition rather than the neurotransmitters.

Explanatory notes

- A specific neurotransmitter can have multiple receptors and furthermore, the receptors for a particular neurotransmitter can show significant variation in their effects on postsynaptic cells. Consequently molecular biologists must focus their research on targeting the specific receptor associated with the condition rather than the neurotransmitters. Otherwise if neurotransmitters are targeted, their interaction with some receptors will be interrupted unnecessarily and perhaps even to the detriment of certain neuronal functions.

Mark allocation

- 1 mark – explain interaction in the relationship between neurotransmitter–receptor–effect.
- 1 mark – drug design must target the specific receptor, not the neurotransmitter.

Total 1+1+1+2=5 marks

Question 7

In the middle of 2009, a new influenza A (H1N1) virus circulated amongst humans around the globe. The human population demonstrated little or no immunity to the virus and due to its highly contagious nature it spread rapidly, particularly among people between the ages of 10 to 45. Typical symptoms of the disease include fever, cough, headache, muscle and joint pain, sore throat and runny nose, and sometimes vomiting and diarrhoea.

7a. Identify one mode of transmission for influenza A (H1N1) virus.

1 mark

Solution

Person to person via infected droplets of saliva (such as coughing, sneezing, contamination of skin or surfaces).

During the early stages of the pandemic, the only treatment available for influenza A (H1N1) was an antiviral medication (oseltamivir or zanamivir); there were no vaccinations. In a desperate effort to control and contain the spread of the virus, antiviral medication was administered, in many cases only on the basis of symptoms. Serious concerns were expressed over this approach to the management of the disease.

7b. Identify a problem that could occur from the widespread use of antiviral medication.

1 mark

Solution

Influenza A (H1N1) virus may become resistant to the antiviral treatment.

Explanatory notes

- Variant strains of influenza A (H1N1) exist which may not be susceptible to oseltamivir or zanamivir. If susceptible strains are eliminated by the antiviral treatment, only highly resistant strains would remain and in the absence of vaccinations or further treatment, this could cause a serious health issue.

In September 2009, the Therapeutic Goods Administration (TGA) approved an influenza A (H1N1) vaccine for use in Australia. With many immunisation programs it is necessary to administer the vaccination at intervals over several months. With influenza A (H1N1) vaccine only a single dose is required and is recommended for all individuals who are 'most at risk of exposure'.

7c. Why is the vaccination for influenza A (H1N1) recommended for those at 'most risk of exposure' to the virus, even if they have taken a course of the influenza A (H1N1) antiviral treatment?

2 marks

Solution

The antivirals treat the infection and help prevent its spread within the individual and from the individual to others. There is no active immunity associated with the antiviral treatment. The vaccination introduces an attenuated form of the virus which triggers B lymphocytes to proliferate into plasma cells (which produce antibodies) and memory cells, hence immunity is acquired.

Explanatory notes

- Individuals who take antiviral treatment have already been infected by the virus and the treatment assists in halting the spread of infection within the individual and from the individual to others. There is no long-term protection against influenza A (H1N1) from an antiviral as it does not involve a humoral response, no clonal selection, no memory. The vaccination however introduces an attenuated form of the virus to the immune system, clonal selection occurs and antibodies and memory cells are made, thus conferring long-term protection against the virus.

Mark allocation

- 1 mark – antivirals treat the infection, no active immunity acquired.
- 1 mark – vaccination activates immune system, producing antibodies and memory cells, immunity is acquired.

Total 1+1+2=4 marks

Question 8

In humans, acquired immunity can provide significant protection against a vast array of pathogens; however, if a disruption occurs within the immune system, disease can occur or become exacerbated.

8a. What is acquired immunity?

2 marks

Solution

Defence against pathogenic agents is mediated by B-lymphocytes and T-lymphocytes. It is specific, has memory and self–non-self recognition.

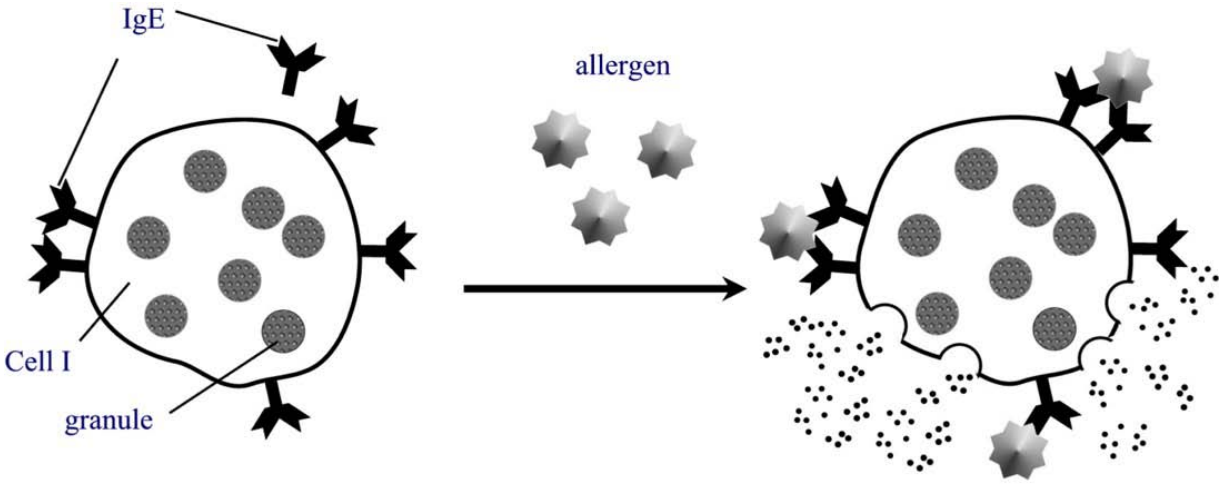
Explanatory notes

- Acquired immunity is only found in vertebrates and is also known as adaptive immunity. Acquired immune responses develop slowly after innate immune responses take effect. For an acquired immune response to be initiated, exposure to an infecting pathogen must occur.

Mark allocation

- 1 mark – defence mediated by B-lymphocytes and T-lymphocytes.
- 1 mark – has specificity, memory, ability to recognize self and non-self.

Allergies are considered disruptions to the immune system and are described as hypersensitive responses to particular antigens known as allergens. The most common allergies are associated with antibodies of the IgE class. The diagram describes the events that take place in an allergic response.



8b. What is the name given to Cell I?

1 mark

Solution

Mast cell

Explanatory notes

- A mast cell is a somatic cell of a vertebrate that produces histamine and other inflammatory molecules in response to infection and allergic reactions.

8c. Outline the sequence of events which lead to the binding of IgE molecules to Cell I.

3 marks

Solution

- immune system encounters allergen for the first time, plasma cells secrete IgE antibodies specific for the antigens on the surface of the allergen, some of which attach to Cell I;
- immune system encounters allergen on a second (or subsequent) occasion, antibody-antigen complex forms, crosslinks form between adjacent antibodies;
- (degranulation occurs and) cells release histamine, causing dilation and increased permeability of capillaries.

Mark allocation

- 1 mark – immune system encounters allergen for the first time, plasma cells secrete IgE antibodies specific for the antigens on the surface of the allergen, some of which attach to the cell.
- 1 mark – immune system encounters allergen on a second (or subsequent) occasion, antibody-antigen complex forms, crosslinks form between adjacent antibodies.
- 1 mark – (degranulation occurs and) cells release histamine, causing dilation and increased permeability of capillaries.

Total 2+1+3=6 marks

END OF SOLUTIONS BOOK