INSIGHT

YEAR 12 *Trial Exam Paper*

2012

BIOLOGY

Written examination 1

Solutions book

This book presents:

- correct solutions
- explanatory notes
- mark allocations

SECTION A – Multiple-choice questions

Question 1

Which of the following molecules would be **least** soluble in water?

A. nucleotide
B. carbohydrate
C. **cholesterol**
D. amino acid

Answer is C

Explanatory notes

- A is incorrect – nucleotides are charged molecules, hydrophilic and easily soluble in water.
- B is incorrect – carbohydrates carry many hydroxyl groups and, as a result, are readily soluble in water.
- C is correct – cholesterol is a hydrophobic molecule and will, therefore, not dissolve in water.
- D is incorrect – most amino acids are soluble in water.

Question 2

A protein is **NOT**

A. involved in protection against disease.
B. **a principle component of a cell membrane.**
C. associated with transport in blood.
D. a catalyst in metabolic reactions.

Answer is B

Explanatory notes

- A is incorrect – the immune system is comprised of many protein components (e.g. antibodies, enzymes).
- B is correct – the principle components of a cell membrane are phospholipids, NOT proteins.
- C is incorrect – protein comprises 7 per cent of blood plasma and is directly associated with transport in blood.
- D is incorrect – enzymes that catalyse metabolic reactions are proteins.

Question 3

The nuclear membrane encloses the genetic material of eukaryotes. The many nuclear pores that are embedded in the nuclear membrane allow the movement of

A. ribosomal subunits into the nucleus.

B. proteins out of the nucleus.

C. **mRNA out of the nucleus.**

D. DNA out of the nucleus.

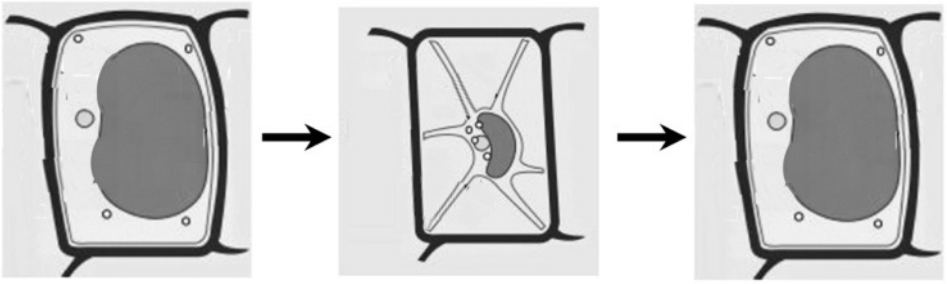
Answer is C

Explanatory notes

- A is incorrect – ribosomal units are assembled in the nucleolus and move out of, not into, the nucleus.
- B is incorrect – proteins are not synthesised in the nucleus and, therefore, will not exit from the nucleus.
- C is correct – mRNA moves out of the nucleus to the ribosomes to begin the process of protein synthesis.
- D is incorrect – DNA remains within the nucleolus of the nucleus; it does not leave the nucleus.

The following information relates to Questions 4 and 5.

A sample of plant cells is placed in an unidentified solution and, once removed, is immediately observed by a botanist under a light microscope. The diagrams below show the observations of the botanist.



time = 0 minutes L *time = 0 minutes*

Source: Wikimedia Commons, *http://en.wikipedia.org/wiki/File:Turgor_pressure_on_plant_cells_diagram.svg*

Question 4

The name of the process occurring at L is

A. cytolysis.

B. **plasmolysis.**

C. hydrolysis.

D. histolysis.

Answer is B

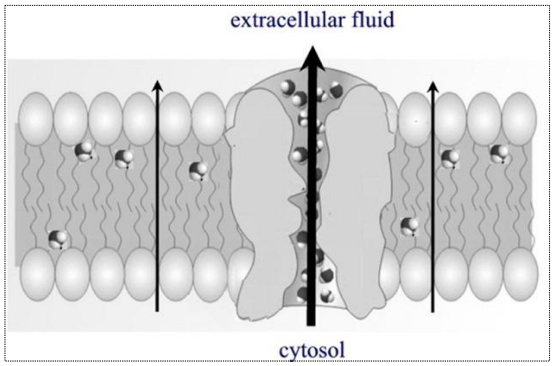
Explanatory notes

- A is incorrect – cytolysis occurs when a cell bursts due to excess water movement into the cell.
- B is correct – plasmolysis occurs in plant cells; the plasma membrane pulls away from the cell wall due to the loss of water through osmosis.
- C is incorrect – hydrolysis is a chemical reaction that involves the splitting of a water molecule.
- D is incorrect – histolysis is the breakdown of body tissues.

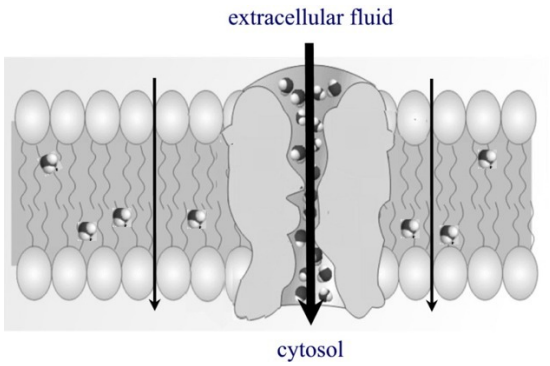
Question 5

Which diagram best shows the pathway of movement taken during the process at L?

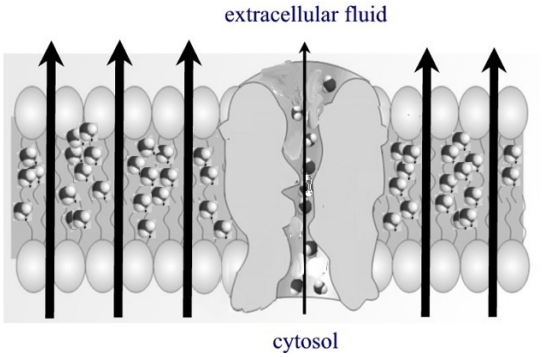
A.



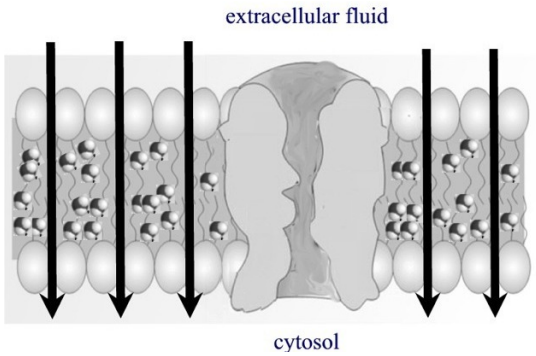
B.



C.



D.



Answer is A

Explanatory notes

The process at L indicates the cell has lost water. Water is a polar molecule and mostly moves across the plasma membrane through aquaporins – proteins that form channels in the lipid bilayer. It can also move through the lipid bilayer, but to a lesser degree. This is shown in **A**.

- A is correct – this shows the principal pathway of water out of the plasma membrane through the aquaporins, with some through the lipid bilayer.
- B is incorrect – this shows the pathway of water into the cell, which does not occur at L.
- C is incorrect – this shows the principle pathway of water out of the plasma membrane through the lipid bilayer, which does not occur at L.
- D is incorrect – this shows the pathway of water into the cell through the lipid bilayer, which does not occur at L.

Question 6

An example of active transport across a plasma membrane is

A. the exchange of oxygen and carbon dioxide by a cell performing aerobic cellular respiration.

B. the uptake of water by red blood cells when they are placed in distilled water.

C. the transport of glucose by glucose transport protein GLUT2 in the β-cells of the pancreas.

D. **the exchange of sodium and potassium ions in the axon of a neuron when the cell is stimulated.**

Answer is D

Explanatory notes

- A is incorrect – this is an example of passive transport (diffusion).
- B is incorrect – this is an example of passive transport (osmosis).
- C is incorrect – this is an example of passive transport (facilitated diffusion).
- D is correct – this is an example of active transport; energy is required for this process to occur.

Question 7

Which of the following colours of light is **least** efficient in driving photosynthesis?

A. red

B. blue

C. **green**

D. orange

Answer is C

Explanatory notes

- A is incorrect – red light is absorbed by chloroplasts and is one of the most effective colours for driving photosynthesis.
- B is incorrect – blue light is absorbed by chloroplasts and is one of the most effective colours for driving photosynthesis.
- C is correct – green light is reflected by chloroplasts and is one of the least effective colours for driving photosynthesis.
- D is incorrect – orange light is absorbed by chloroplasts and is an effective colour for driving photosynthesis.

The following information relates to Questions 8 and 9.

ATP synthase is an enzyme that is found on the inner membrane of the mitochondrion. ATP synthase uses the difference in H^+ concentration on opposite sides of the inner mitochondrial membrane to produce ATP from ADP and inorganic phosphate. The H^+ concentration gradient can also be considered as a pH gradient, given that pH is a measure of H^+ concentration. Due to the electron transport chain, there is a higher concentration of H^+ on the outer side of the inner mitochondrial membrane.

Question 8

Another name for the inner mitochondrial membrane is

A. matrix.

B. thylakoid.

C. granum.

D. **cristae.**

Answer is D

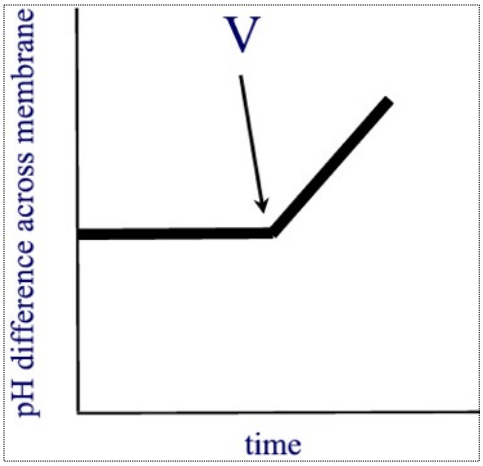
Explanatory notes

- A is incorrect – the matrix is the compartment enclosed by the inner membrane.
- B is incorrect – a thylakoid is part of the inner membrane of a chloroplast.
- C is incorrect – a granum is a stack of thylakoids.
- D is correct – cristae is the name given to the inner mitochondrial membrane.

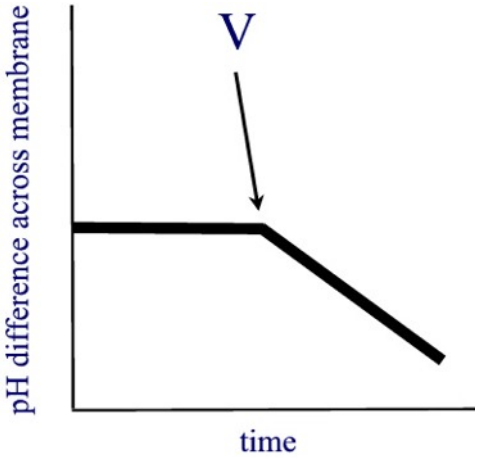
Question 9

It is possible to measure the pH difference across the inner mitochondrial membrane of a living cell. The graphs below show the pH difference over time in an actively respiring cell. A metabolic poison that inhibits the function of mitochondrial ATP synthase is added to a respiring cell at **V**. Which graph shows the expected effect on pH after adding the poison?

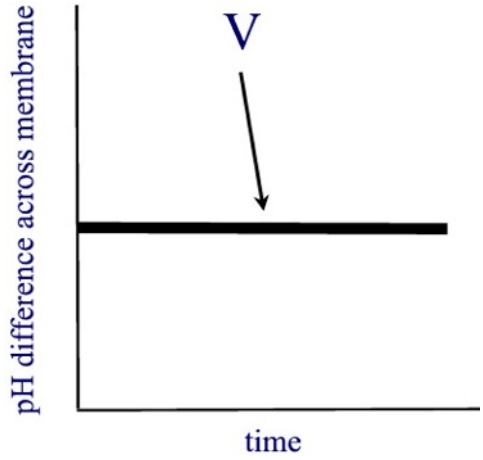
A.



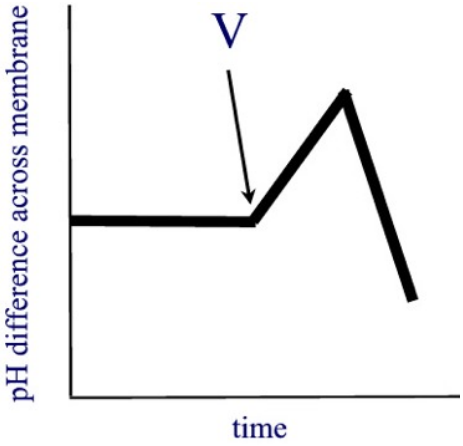
B.



C.



D.



Answer is A

Explanatory notes

- A is correct – the poison denatures the ATP synthase; as a result H^+ ions are not moved across the membrane and the gradient increases.
- B is incorrect – the poison denatures the ATP synthase; as a result H^+ ions are not moved across the membrane. The gradient will not decrease; H^+ ions do not move against the direction of the inner mitochondrial membrane.
- C is incorrect – the poison denatures the ATP synthase; as a result H^+ ions are not moved across the membrane and the gradient increases; it does not remain the same.
- D is incorrect – the poison denatures the ATP synthase; as a result H^+ ions are not moved across the membrane and the gradient increases; it does not increase and then decrease.

Question 10

Whether a glucose molecule undergoes fermentation or cellular respiration, a step in the metabolic pathway will always be

A. **glycolysis.**

B. the electron transport chain.

C. the Krebs cycle.

D. the Calvin cycle.

Answer is A

Explanatory notes

- A is correct – glycolysis is the first step in the process of fermentation and cellular respiration.
- B is incorrect – the electron transport chain does not occur in fermentation.
- C is incorrect – the Krebs (citric acid) cycle only occurs in cellular respiration.
- D is incorrect – the Calvin cycle does not occur in fermentation or cellular respiration.

Question 11

Usually, cellular respiration yields 36 molecules of ATP. However, some tissues are capable of producing 38 molecules of ATP. An example of one such tissue would be found in the

A. xylem of angiosperms.

B. adipose depots around internal organs in humans.

C. extracellular matrix in pig intestines.

D. **kidneys of frogs.**

Answer is D

Explanatory notes

- A is incorrect – xylem is non-living tissue and will not perform cellular respiration.
- B is incorrect – adipose tissue is primarily comprised of fat and the cellular material of which it is comprised does not produce 38 molecules of ATP.
- C is incorrect – the extracellular matrix is made up of non-living tissue and will not perform cellular respiration.
- D is correct – kidneys of frogs produce 38 molecules of ATP (as do heart and liver tissue).

The following information relates to Questions 12 and 13.

Minnows are small freshwater fish of the carp family. If a minnow is injured, a substance is released from its skin and disperses in the water, inducing a response in other nearby fish.

Question 12

The substance released from the skin of the minnow is a

A. neurohormone.

B. neurotransmitter.

C. **pheromone**.

D. hormone.

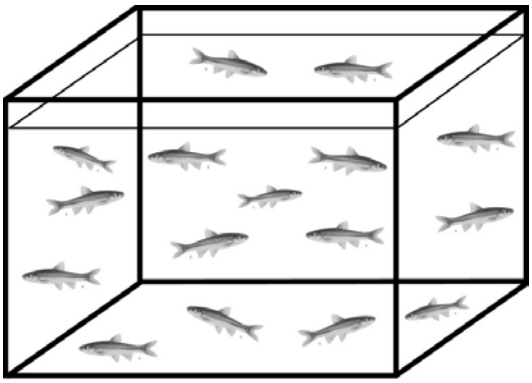
Answer is C

Explanatory notes

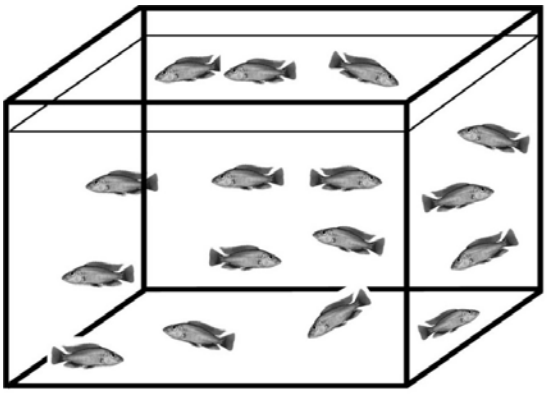
- A is incorrect – neurohormones are released by nerves; this substance is released by the skin.
- B is incorrect – neurotransmitters transmit signals from a neuron to a target cell across a synapse.
- C is correct – pheromones are communication molecules released into the environment.
- D is incorrect – hormones are formed within cells, travel within an organism and act on specific target cells to bring about a change in function.

Question 13

In a class experiment students were required to observe the effects of introducing Substance M, a chemical released from the skin of minnows, into two experimental groups, one with minnows (Aquarium A) and the other with cichlids (Aquarium B). Before the experiment began, the students were asked to observe the fish in Aquarium A and Aquarium B, and to make predictions about what they expected to see in each aquarium once Substance M was released into the water.



Aquarium A (minnows)



Aquarium B (cichlids)

Which student's predictions are correct?

		Aquarium A	Aquarium B
A.	**Student A**	**Minnows will respond by grouping tightly together at a point as far away as possible from Substance M.**	**Cichlids will not respond to the introduction of Substance M. They will continue to show the same behaviour.**
B.	Student B	Minnows will not respond to the introduction of Substance M. They will continue to show the same behaviour.	Cichlids will respond by grouping tightly together at a point as far away as possible from Substance M.
C.	Student C	Minnows will respond by grouping tightly together and swimming directly towards Substance M.	Cichlids will not respond to the introduction of Substance M. They will continue to show the same behaviour.
D.	Student D	Minnows will not respond to the introduction of Substance M. They will continue to show the same behaviour.	Cichlids will respond by grouping tightly together and swimming directly towards Substance M.

Answer is A

Explanatory notes

- A is correct – release of Substance M causes minnows to become more vigilant and form tightly packed schools away from its source; cichlids will not respond because they do not have a receptor that recognises the pheromone.
- B is incorrect – release of Substance M causes a response in the minnows; cichlids do not respond because they do not have a receptor that recognises the pheromone.
- C is incorrect – release of Substance M causes minnows to move away from its source, cichlids will not respond because they do not have a receptor that recognises the pheromone.
- D is incorrect – release of Substance M causes a response in the minnows; cichlids will not respond because they do not have a receptor that recognises the pheromone.

Question 14

Broadly speaking, every aspect of plant growth and development is under hormonal control. A single plant hormone is capable of initiating a range of cellular and developmental processes, and multiple hormones can influence a single process. Which of the following is a known interaction between a growth hormone and a plant?

A. ethylene – retards leaf abscission

B. **cytokinin – stimulates seed germination**

C. gibberellin – retards seed development

D. auxin – promotes leaf abscission

Answer is B

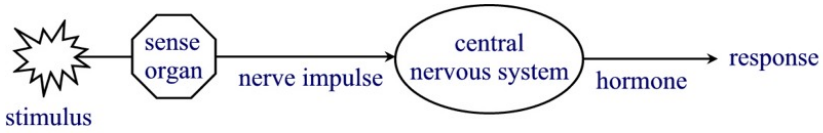
Explanatory notes

- A is incorrect – ethylene promotes leaf abscission
- B is correct – cytokinin stimulates seed germination
- C is incorrect – gibberellin stimulates seed development
- D is incorrect – auxin retards leaf abscission

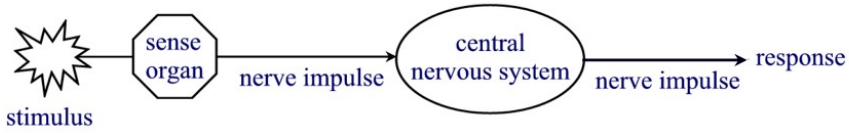
Question 15

After a sumptuous meal, Louis experiences a rise in his blood glucose level, which stabilises after around five hours. A model of this event is best represented by

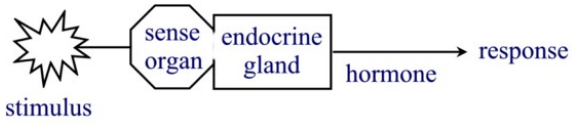
A.



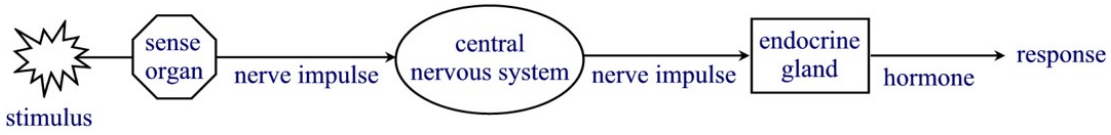
B.



C.



D.



Answer is C

Explanatory notes

- A is incorrect – the rise in blood glucose that Louis experiences is an endocrine response; A shows a nervous response, not an endocrine response.
- B is incorrect – the rise in blood glucose that Louis experiences is an endocrine response; B shows a nervous response, not an endocrine response.
- **C is correct – the rise in blood glucose that Louis experiences is an endocrine response.**
- D is incorrect – the rise in blood glucose that Louis experiences is an endocrine response; D shows a nervous response, not an endocrine response.

Question 16

The blinking action of eyelids is essential to moisten the eye, wash away debris and provide a smooth surface for optimal focusing. When a nerve signal reaches the axon terminal at the junction between the neuron and the orbicularis oculi muscle, which helps to close the eyelid, the next action in the pathway would involve

A. the neurotransmitter binding to a receptor molecule on the muscle cell membrane.

B. an enzyme being released to deactivate the neurotransmitter.

C. **the release of a neurotransmitter from the neuron.**

D. the contraction of the muscle cell.

Answer is C

Explanatory notes

- A is incorrect – the neurotransmitter needs to be released from the axon terminal before it can bind with the receptor molecule.
- B is incorrect – the neurotransmitter needs to be released from the axon terminal before it can be deactivated.
- C is correct – only when a nerve impulse reaches an axon terminal, does the vesicle in the axon terminal release a neurotransmitter.
- D is incorrect – the muscle cell will not contract until the neurotransmitter is released from the axon terminal.

Question 17

A traveller returning from overseas was thought to have contracted an infection caused by a non-cellular agent. Such agents could include

A. fungi.

B. bacteria.

C. yeasts.

D. **prions.**

Answer is D

Explanatory notes

- A is incorrect – fungi are cellular agents that can infect humans.
- B is incorrect – bacteria are cellular agents that can infect humans.
- C is incorrect – yeasts are cellular agents that can infect humans.
- D is correct – prions are non-cellular agents that can infect humans.

Question 18

Anoxic habitats, such as the muddy bottom of a river, are usually hosts to primitive living organisms that respire anaerobically. Anaerobic respiration is a process that

A. **mammals can sustain only over a short period of time.**

B. produces carbon dioxide and water in yeasts.

C. occurs in reptiles, and produces ethanol and water.

D. requires oxygen to proceed.

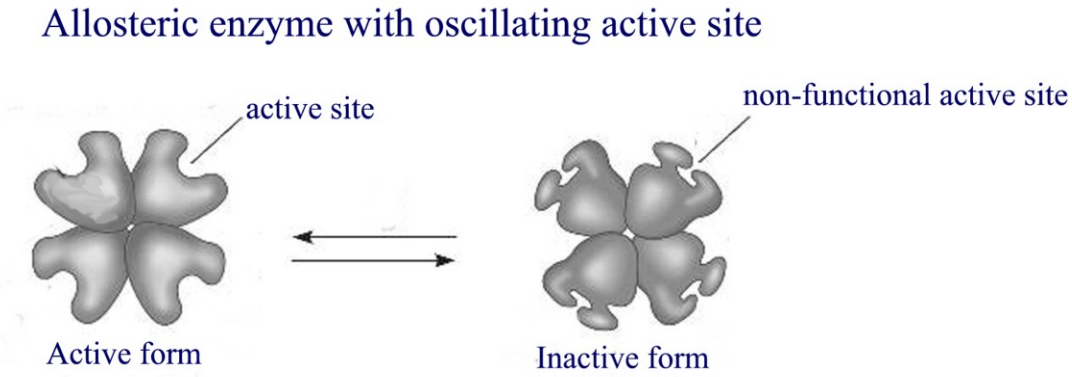
Answer is A

Explanatory notes

- A is correct – anaerobic respiration can be sustained only over a short period in mammals.
- B is incorrect – anaerobic respiration does not produce carbon dioxide and water in yeasts; it produces them in aerobic respiration.
- C is incorrect – anaerobic respiration in reptiles would not produce ethanol and water, rather lactic acid and water.
- D is incorrect – anaerobic respiration can proceed only in the absence of oxygen.

Question 19

The activity of an enzyme can be regulated by molecules known as allosteric activators and inhibitors, which bind to a site on the enzyme. As a result, the shape of the enzyme and the functioning of the active site change. When the function of a protein at one site is affected by the binding of a regulatory molecule at another site, enzyme activity can either be inhibited or stimulated. This process is known as allosteric regulation. The diagram below shows the oscillation that occurs between the active and inactive forms of an enzyme.



Source: College of DuPage: Principles of Biological Science BIO1151, 2010

It would be true to say that

A. there is only one active site in the stabilised active form of the enzyme.

B. **allosteric enzymes are constructed from two or more subunits, each with their own active site.**

C. if an enzyme is inhibited by an allosteric inhibitor, it cannot become active again.

D. allosteric activators work effectively to stabilise the inactive form of the enzyme.

Answer is B

Explanatory notes

- A is incorrect – there are four active sites in the stabilised active form of the enzyme, not just one.
- B is correct – allosteric enzymes are constructed from two or more subunits, each with their own active site.
- C is incorrect – once the enzyme has been inhibited by the allosteric inhibitor, it can become active again.
- D is incorrect – allosteric activators work effectively to stabilise the active, not the inactive, form of the enzyme.

Question 20

A student performed an experiment in which she added an enzyme to a solution in which the substrate and products were in equilibrium. What is she likely to observe?

A. an increase in the temperature of the solution

B. the formation of more products

C. the formation of more substrate

D. **nothing would happen; the solution is at equilibrium.**

Answer is D

Explanatory notes

- A is incorrect – the solution is at equilibrium; the temperature of the solution will not change.
- B is incorrect – the solution is at equilibrium; no more product is formed.
- C is incorrect – the solution is at equilibrium; no more substrate is formed.
- D is correct – the solution is at equilibrium; nothing happens.

Question 21

An autoimmune disease occurs when the body produces antibodies against substances and tissues that are normally present. An example of an autoimmune disease is

A. **pernicious anaemia.**

B. tuberculosis.

C. type 2 diabetes.

D. malaria.

Answer is A

Explanatory notes

- A is correct – pernicious anaemia is an autoimmune disease.
- B is incorrect – tuberculosis is a disease caused by various strains of mycobacteria; it is not an autoimmune disease.
- C is incorrect – type 2 diabetes is a metabolic disorder; it is not an autoimmune disease.
- D is incorrect – malaria is a disease caused by a parasite from the genus *Plasmodium*; it is not an autoimmune disease.

Question 22

Inflammasomes are clusters of proteins found inside certain cells. Inflammasomes respond to stresses, such as infection or injury, by releasing immune cell signalling proteins called cytokines. Inflammasomes are a component of the non-specific immune system, along with

A. **macrophages.**

B. lymphocytes.

C. cytotoxic T cells.

D. plasma cells.

Answer is A

Explanatory notes

- A is correct – macrophages are a component of the non-specific immune system.
- B is incorrect – lymphocytes are a component of the specific immune system.
- C is incorrect – cytotoxic T cells are a component of the specific immune system.
- D is incorrect – plasma cells are a component of the specific immune system.

The following information relates to Questions 23 and 24.

An adjuvant is a substance that has been added to a vaccine to help stimulate the immune system and make the vaccine more effective. Many microbial compounds function as adjuvants by stimulating Toll-like receptors (TLRs). An example of a TLR is shown in the image below.

Source: Wikimedia Commons, *http://en.wikipedia.org/wiki/File:TLR3_structure.png*

Question 23

From the image, it can be deduced that a TLR is a

A. triglyceride.

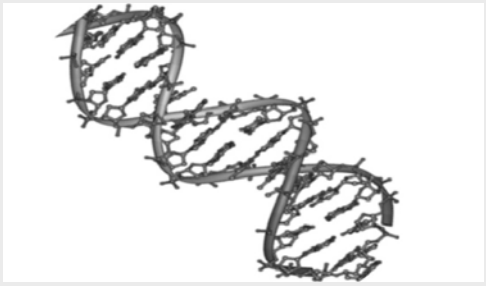
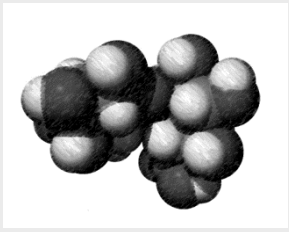
B. **protein.**

C. nucleic acid.

D. disaccharide.

Answer is B

Explanatory notes

A is incorrect – a triglyceride could be represented as such  Source: Healthy tips and guides, *http://abouthighbloodpressuresymptoms.com/what-is-triglycerides*	B is correct.
C is incorrect – a nucleic acid could be represented as such  Source: Wikimedia commons, Author Jerome Walker *http://commons.wikimedia.org/wiki/File:DNA_double_helix_45.PNG*	D is incorrect – a disaccharide could be represented as such 

Question 24

TLRs occur in vertebrates and invertebrates,

A. and act as catalytic receptors.

B. and play a significant role in the phagocytosis of microorganisms.

C. and recognise microbes before they have breached physical barriers, such as the skin or intestinal tract mucosa.

D. **and are found spanning membranes.**

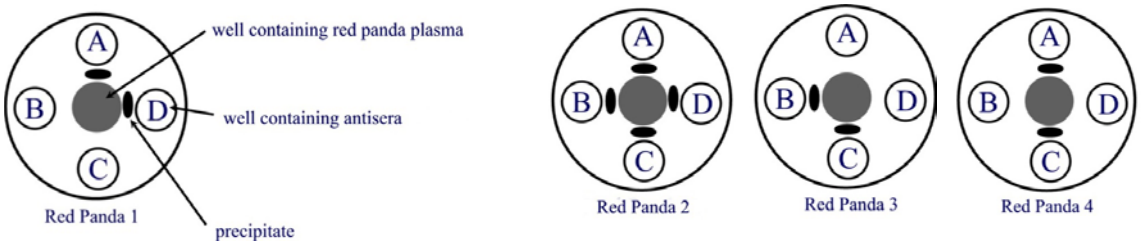
Answer is D

Explanatory notes

- A is incorrect – TLRs act as non-catalytic receptors
- B is incorrect – TLRs do not play a significant role in the adhesion and phagocytosis of microorganisms; instead they seem to be involved in cytokine production and cellular activation in response to microbes.
- C is incorrect – TLRs recognise microbes after (not before) they have breached physical barriers, such as the skin or intestinal tract mucosa.
- D is correct – TLRs do span membranes

Question 25

Researchers conducted an observation of four different proteins in four different red pandas. A sample of plasma from each panda was placed in the centre of an agar plate. Four different antisera were placed in wells located around the central well of each plate. If there was a reaction between a protein and its antiserum, a visible precipitate would form on the agar plate. The results of the observation are shown in the diagrams below. From the results, which observation is correct?



A. All four red pandas share at least one common protein.

B. All four red pandas share at least two proteins with one other red panda.

C. **The plasma of red panda 2 contains at least four different proteins.**

D. Each protein is found in at least three red pandas.

Answer is C

Explanatory notes

- A is incorrect – there is no single protein common to all red pandas.
- B is incorrect – there is no single protein common to all red pandas.
- C is correct – there are four different proteins present in the plasma of red panda 2.
- D is incorrect – only one red panda has all four proteins.

END OF SECTION A

END OF SECTION A

SECTION B – Short-answer questions

Question 1

The Mason-Pfizer monkey virus (M-PMV) is a lentivirus (a member of the retrovirus family). It is similar to the human immunodeficiency virus (HIV) and causes acquired immunodeficiency syndrome (AIDS) in monkeys and apes.

1a. Identify one characteristic of a retrovirus.

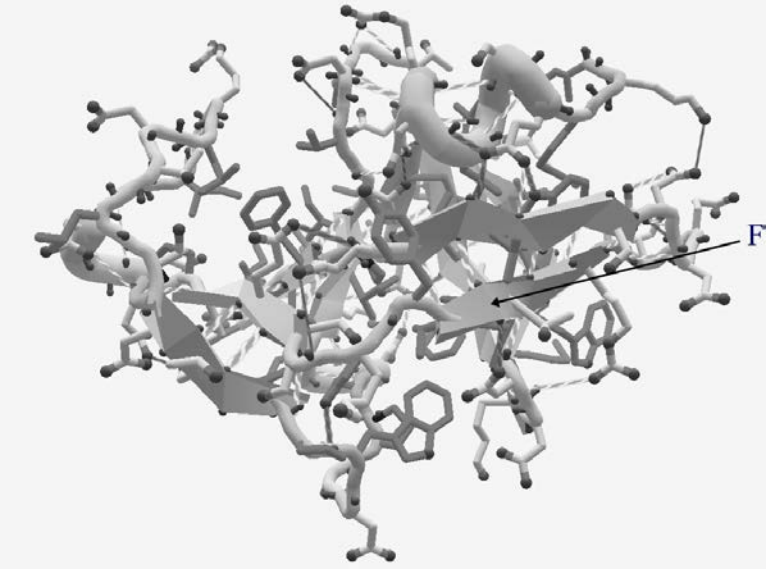
1 mark

Solution
A virus whose genetic material is RNA
or
It is duplicated in a living cell using reverse transcriptase to produce DNA
or
It has an envelope made of phospholipid, protein and glycoproteins.

'Foldit' is an online game that allows players to collaborate and compete in predicting the structure of protein molecules. In September 2011, online gamers solved the crystal structure of the M-PMV retroviral protease (PR), the protein whose configuration had stumped scientists for more than a decade. The diagram below shows the crystal structure of the Mason-Pfizer monkey virus (M-PMV) retroviral protease.

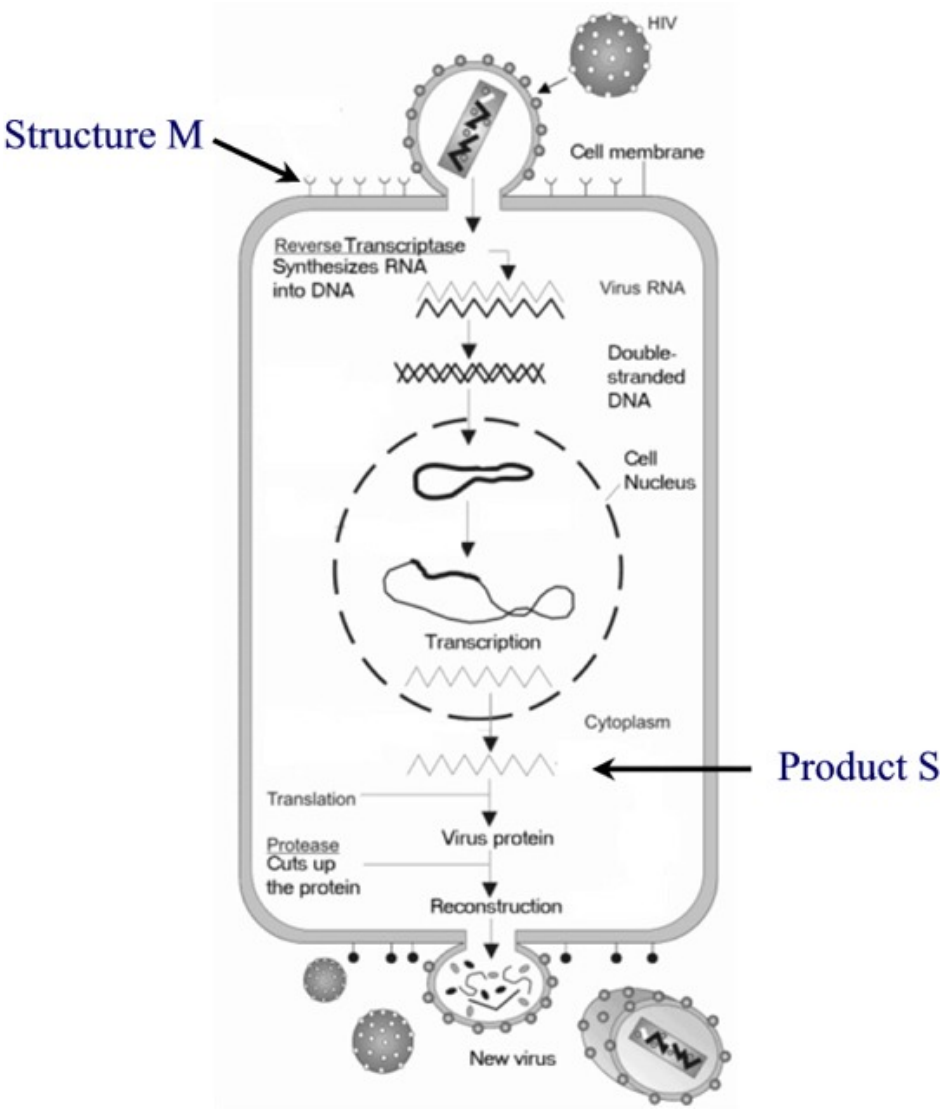
1b. What is the name given to the type of secondary protein structure labelled **F**?

1 mark



Source: David Baker, Washington University

Solution
Beta (β) pleated sheet



Source: Wikimedia Commons,
http://upload.wikimedia.org/wikipedia/commons/thumb/3/35/HIV_gross_cycle_only.png/300px-HIV_gross_cycle_only.png

1c. In the diagram above, what is the name given to structure **M**?

1 mark

Solution

Receptor

1d. What process is occurring in the nucleus of the cell?

1 mark

Solution

Integration, combining or joining of viral and host DNA

There are two families of nitrogenous bases found in DNA and RNA. They are shown in the table below.

Purines	**Pyrimidines**
adenine, guanine	cytosine, thymine, uracil

1e. What nitrogenous bases would be found in Product S?

1 mark

Solution

Adenine, cytosine, guanine, uracil

Mark allocation

- 1 mark – four correct nitrogenous bases must be given to gain the mark.

Retroviral proteases play a critical role in the maturation and proliferation of HIV.

1f. How could understanding the exact structure of the retroviral protease assist in the development of antiretroviral drugs that can fight HIV?

3 marks

Solution

Knowing the chemical structure would enable identification of the active site of the protease enzyme. A molecule that acts as an inhibitor and binds to the active site could be developed. This molecule would block the ability of the protease to cleave viral polypeptides into functional enzymes.

Mark allocation

- 1 mark – enable identification of the active site of the protease enzyme.
- 1 mark – development of molecule that acts as an inhibitor and binds to the active site.
- 1 mark – molecule blocks protease from cutting viral polypeptides into functional enzymes.

Total 8 marks

Question 2

Plants are subject to attack by plant-eating animals (herbivores). Plants are capable of defending themselves against herbivores through the use of mechanical defences.

2a. Identify one mechanical defence against a herbivore. Explain how this defence protects the plant.

1 mark

Solution

Mechanical defence: either thorns, needles, resins, lignins, silica, wax or sap.

Depending on choice of defence mechanism, answers will include:

- reduce feeding by larger herbivores;
- cover the epidermis of terrestrial plants and alter the texture of the plant tissue making feeding more difficult;
- trap the herbivore and prevent it from eating the plant.

The jack bean (*Canavalia ensiformis*) produces an amino acid called canavavine. Canavavine closely resembles arginine, one of the 20 amino acids that organisms incorporate into their proteins. If an insect eats a plant that has produced canavavine it will die.

2b. Explain why the insect dies after eating the plant.

2 marks

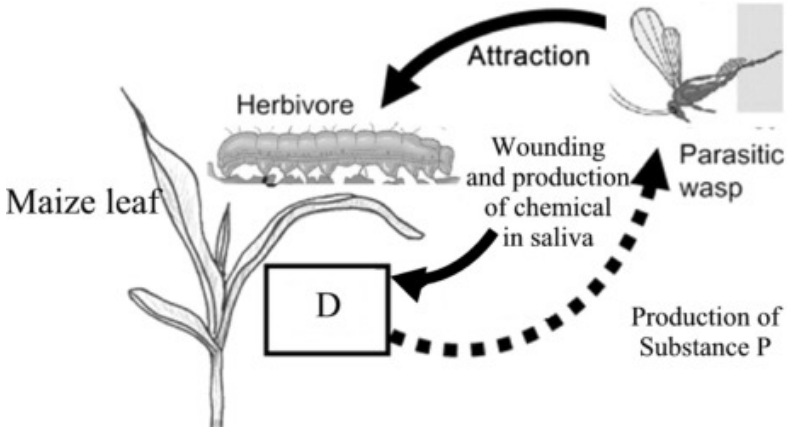
Solution

The insect has ingested the canavavine and, due to the similar molecular nature of canavavine, it replaces the arginine in the insect's proteins. The canavavine adversely changes the shape and function of the protein molecule.

Mark allocation

- 1 mark – insect has ingested the canavavine, which replaces arginine in the insect's proteins.
- 1 mark – canavavine adversely changes the shape and function of the protein molecule.

Plants are also known to ‘recruit’ predatory animals as a defensive response. Consider the following diagram.



2c. Identify and explain the process occurring at **D**.

2 marks

Solution

Process: signal transduction

Physical damage caused by the caterpillar eating the plant and a chemical compound in caterpillar saliva trigger a signal transduction pathway.

Mark allocation

- 1 mark – signal transduction
- 1 mark – damage caused by caterpillar triggers a signal transduction pathway.

2d. i. What is the general name given to Substance **P**?

1 mark

Solution

Volatile compounds, chemical attractants or similar.

2d. ii. Suggest how the wasp might assist in the defence of the maize plant.

2 marks

Solution

The wasp lays eggs in the caterpillar, which hatch to produce larvae. The larvae feed on the internal organs and tissue of the caterpillar and the caterpillar dies.

Mark allocation

- 1 mark – wasp lays eggs in caterpillar; eggs hatch to produce larvae.
- 1 mark – larvae feed on internal organs and tissue of the caterpillar; caterpillar dies.

Total 8 marks

Question 3

Lyme disease is a condition caused by species of bacteria from the genus *Borrelia* and is one of the most common tick-borne diseases in the northern hemisphere. *Borrelia* is transmitted to humans through the bite of infected ticks, one of which is classified in the genus *Ixodes scapularis*. The table below identifies the geographical areas in which three species of *Borrelia* are found.

Species	Location
Borrelia burgdorferi sensu strict	United States
Borrelia afzelii	Europe
Borrelia garinii	Europe

3a. Identify the vector associated with Lyme disease.

1 mark

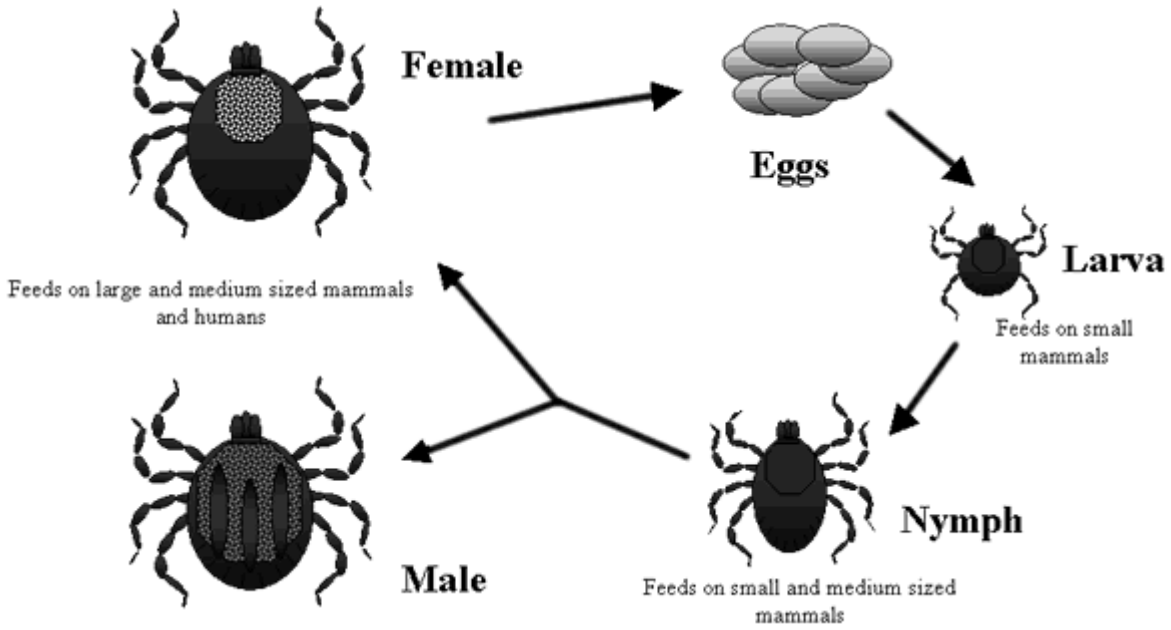
Solution

Ixodes scapularis

Mark allocation

- 1 mark – actual scientific name must be given
- (Note: 0 marks if answer gives the common name)

The life cycle of *Ixodes scapularis* is shown in the diagram below.



Source: Centre for Disease Control and Prevention

3b. i. Identify the stages in the life of *I. scapularis*.

1 mark

Solution

There are four stages in the life cycle of *I. scapularis* – egg, larva, nymph, adult.

Mark allocation

- 1 mark – correct identification of all stages in life cycle

Borrelia inhabits the digestive tract of *I. scapularis*. Lyme disease is transmitted to humans from a tick bite.

3b. ii. Explain how the disease can be transmitted through the tick bite.

1 mark

Solution

The bacteria (*Borrelia*) migrates up to the salivary glands of *I. scapularis* and passes into the human through the opening created by the tick.

The western fence lizard (*Sceloporus occidentalis*) is found in California, a southern state on the west coast of the United States. Research on the role of the western fence lizard in the occurrence of Lyme disease has produced divergent results.

Result A: Lyme disease is reduced when western fence lizards are found in an area.

Result B: Lyme disease is reduced when western fence lizards are removed from an area.

3c. What might be a possible explanation for result **A**?

2 marks

Solution

The western fence lizard produces a substance (protein) that kills the bacterium (*Borrelia burgdorferi sensu stricto*) that causes Lyme disease. This is passed on when the ticks bite the western fence lizard.

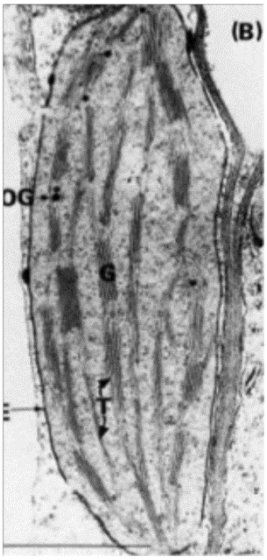
Mark allocation

- 1 mark – western fence lizard produces a substance that kills the bacterium
- 1 mark – passed on when the ticks bite the western fence lizard.

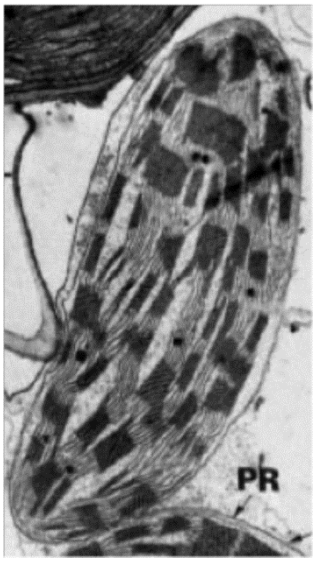
Total 5 marks

Question 4

Chloroplasts were taken from the leaves of a maize plant and a bean plant and examined under a microscope. The maize plant was grown under normal diurnal illumination. The bean plant was grown for 14 days in the dark and then transferred to continuous illumination.



Plant A



Plant B

4a. Explain which plant is most likely to be the maize plant.

2 marks

Solution

Plant B – it shows a higher number of grana compared with Plant A. A plant exposed to normal diurnal illumination would show a normal concentration of grana and hence chlorophyll in a chloroplast. This would enable the plant to photosynthesise at normal optimal levels.

Mark allocation

- 1 mark – plant B, which shows a higher number of grana.
- 1 mark – plant exposed to normal diurnal illumination shows normal concentration of grana and chlorophyll; plant can photosynthesise at normal levels.

The production of ATP in photosynthesis is dependent on the existence of a pH gradient across the thylakoid membrane. A group of chloroplasts from the maize plant was placed in a solution with all the necessary components to perform ATP synthesis. A solution (Solution K) that makes membranes permeable to hydrogen ions was also added to the solution. This is shown in the diagram below.

4b. What reaction of photosynthesis occurs on the thylakoid membrane?

1 mark

Solution

Light-dependent stage of photosynthesis.

4c. Explain what is likely to happen to the rate of ATP synthesis following the addition of solution K.

2 marks

Solution

The rate of ATP synthesis would slow down and eventually stop because a pH/proton/hydrogen gradient would not have a chance to build up.

Mark allocation

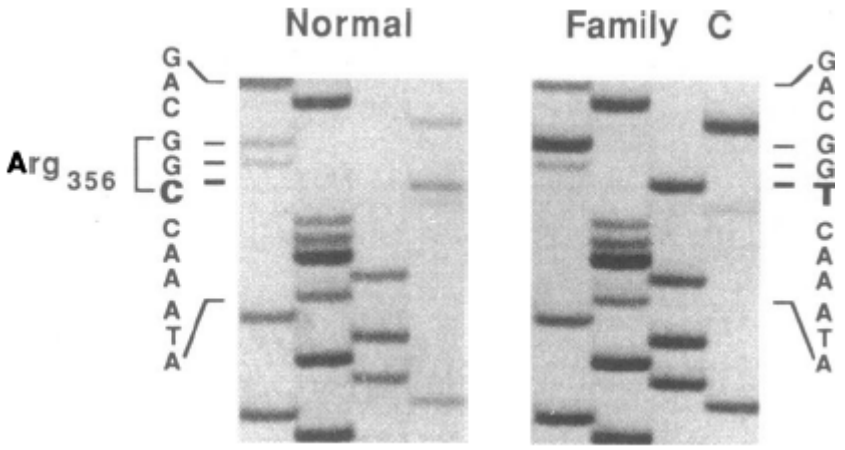
- 1 mark – rate of ATP synthesis would slow down and eventually stop
- 1 mark – stating a pH/proton/hydrogen gradient would not have a chance to build up

Total 5 marks

Question 5

The enzyme, alpha galactosidase A (alpha-A), is normally responsible for the breakdown of the fatty substance, globotriaosylceramide (GL-3). Faulty production of alpha-A results in Fabry disease, in which abnormal deposits of GL-3 accumulate in blood vessel walls throughout the body. Fabry disease can be caused by a range of genetic mutations.

The images below show a comparison of template DNA sequences for individuals from two families.



Source: Harold Bernstein, University of California, San Francisco

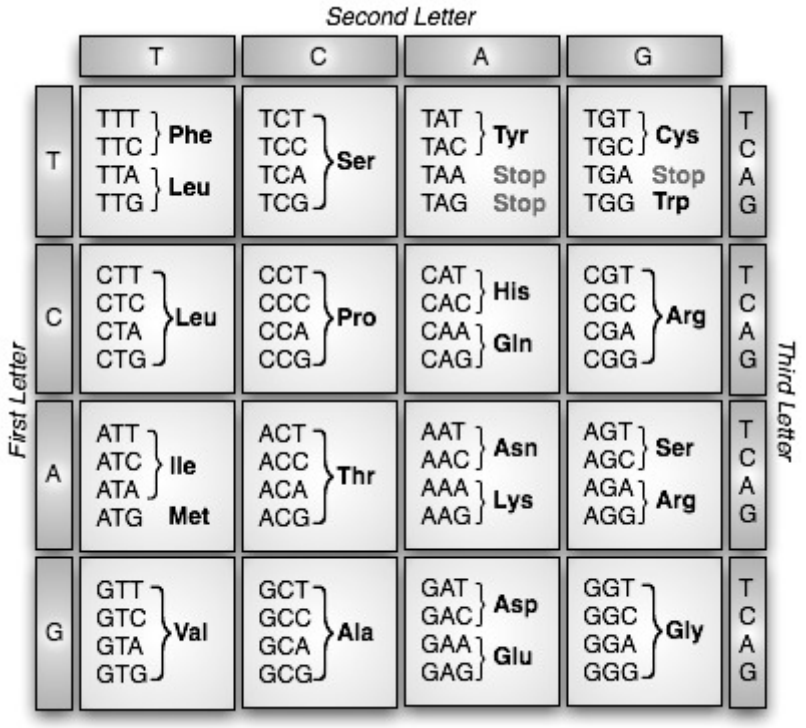
5a. What is the difference in nucleotide sequence for the normal case and the individual in family C?

1 mark

Solution

A substitution of T for C, or C is replaced by T

The table below shows the genetic code.



5b. i. What is the amino acid sequence for the individual in family C?

1 mark

Solution

ile – asn – trp – gln

5b. ii. Use the available information to explain how changing a single amino acid in a polypeptide chain may adversely affect the function of that specific protein.

2 marks

Solution

Changing the amino acid will change the primary structure and, therefore, the shape of the protein. It will not be able to bond or interact with other molecules in the expected manner.

Mark allocation

- 1 mark – changing amino acid leads to changed primary structure and hence shape.
- 1 mark – protein will not be able to bond with or interact in the expected manner.

Currently, enzyme replacement therapy (ERT) is used to treat individuals with Fabry disease. However, ERT requires a complicated and expensive process to purify and replace the damaged alpha-A enzyme, and it must be performed by a medical professional. Researchers are considering an alternative strategy called pharmacological chaperone (PC) therapy, which uses smaller molecules, taken orally, to ensure that the correct enzyme proteins are produced.

5c. What advantages could PC have over ERT?

2 marks

Solution

Individuals with Fabry disease would no longer require complicated, expensive medical treatments and there is the strong likelihood that PC could be applied to the treatment of other faulty enzyme conditions.

Mark allocation

- 1 mark – individuals with Fabry disease no longer require expensive medical treatments
- 1 mark – likelihood that PC could be applied to the treatment of other faulty enzyme conditions.

Total 6 marks

Question 6

Exosomes are small vesicles secreted by most cell types, including B lymphocytes and dendritic cells, and measure around 150 nm in diameter. They are formed within the cell in compartments known as multivesicular endosomes (MVE), which take up parts of the cytoplasm and its contents.

6a. What is the outer layer of an exosome vesicle made of?

1 mark

Solution

Phospholipid bilayer (it is a plasma membrane).

Exosomes contain cell-specific proteins, lipids and mRNA. It has been shown that B lymphocytes secrete measurable numbers of exosomes only when stimulated by the binding of a cell-surface receptor.

6b. Identify one possible role of an exosome and explain your reasoning.

2 marks

Solution

Possible role in mediating specific immune responses to pathogens. Exosomes are released when a cell-surface receptor binds to the B lymphocyte; B lymphocytes are associated with specific immune responses.

Mark allocation

- 1 mark – specific immunity or specific immune responses
- 1 mark – exosomes are released by the B lymphocyte after the cell-surface receptor binds to it.

The proteins released by exosomes differ from the proteins contained in the vesicles released by apoptotic cells. Apoptotic vesicles contain a number of nuclear, cytosolic and endoplasmic reticulum-derived proteins, all of which are cellular components that have been broken down.

6c. Outline the three steps that are likely to occur in apoptosis after cellular proteins are broken down into their components.

3 marks

Solution

Step 1: Enzymes break down the cell nucleus; cell releases signals to attract macrophages.

Step 2: Cell breaks into many smaller pieces of cell components and destroyed nucleus.

Step 3: Macrophages recognise cell components and remove them from the body.

Mark allocation

- 1 mark – each correct step

Total 6 marks

Question 7

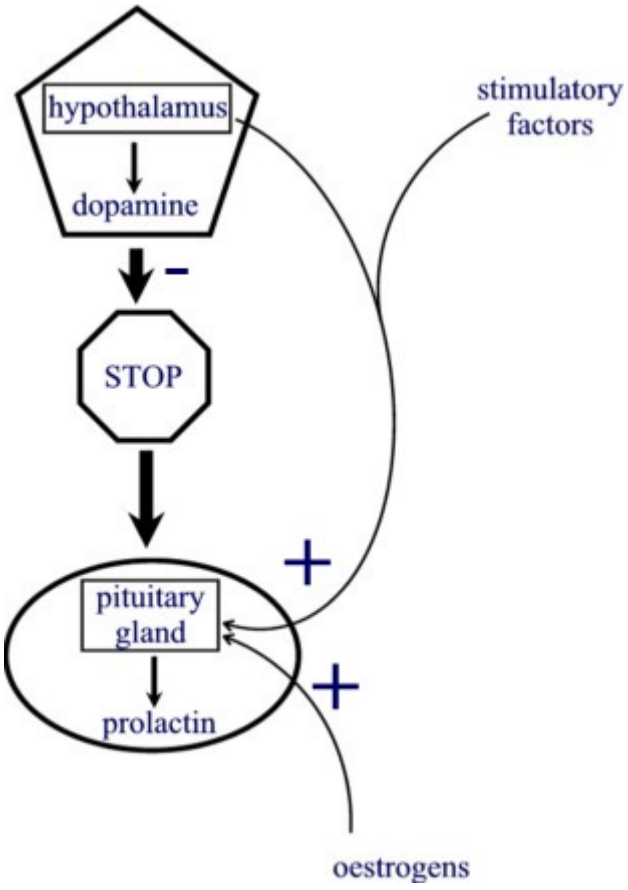
Parkinson's disease (PD) is a degenerative condition that affects the central nervous system in humans. In its early stages, it is characterised by movement-related symptoms, such as shaking, rigidity and slowness of movement, and then progresses to cognitive and behavioural problems, and commonly dementia. PD is caused by the death of dopamine-producing cells in the midbrain; the reason for cell death is unknown.

After synthesis, dopamine is packaged into vesicles, which are then released into the synapse in response to a presynaptic action potential.

a. What is the function of dopamine?

Solution
Dopamine is a neurotransmitter and is released by nerve cells to send signals to other nerve cells.

Dopamine is also released into the bloodstream by neurons in the hypothalamus and binds to receptors on lactotrophs. Lactotrophs are cells in the anterior pituitary that produce prolactin. The diagram below outlines the control of prolactin production.



b. Explain what class of endocrine molecule dopamine would be acting as.

2 marks

Solution

Dopamine is acting as a neurohormone because it is being released into the bloodstream to reach its target cell. It is not released into a synapse as a neurotransmitter would be.

Mark allocation

- 1 mark – neurohormone
- 1 mark – because it is being released into the bloodstream to reach its target cell.

In mammals, young are nourished postnatally with milk that is produced by the mammary glands. In response to changes in oestrogens and suckling by the newborn, the hypothalamus releases thyrotropin-releasing hormone (TRH), which sends a signal to the pituitary gland. In response, prolactin is secreted and the mammary glands are stimulated to release milk.

c. Explain what kind of feedback is associated with lactation.

2 marks

Solution

Lactation is an example of positive feedback. The more suckling that occurs, the more milk is produced, due to the release of TRH from the hypothalamus, which in turn results in a surge in prolactin secretion and more milk.

Mark allocation

- 1 mark – positive feedback; the more breastfeeding, the more milk is produced.
- 1 mark – feeding triggers release of TRH from the hypothalamus, which in turn results in a surge in prolactin secretion.

Total 5 marks

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Question 8

Pertussis (whooping cough) is a highly contagious condition caused by the many strains of the bacterium *Bordetella pertussis*. From 1880 to the 1940s, the incidence of pertussis was recorded in the hundreds of thousands. After the 1940s, the incidence declined almost completely until the early 1990s.

a. What is most likely to have caused such a significant decline in the incidence of pertussis from 1940 to late 1980?

1 mark

Solution

The implementation of an immunisation program to control the spread of the disease.

A child with pertussis has spasms of coughing, with a characteristic whoop upon inhalation. However, this is less common in older children and adults. Some of the tests that can be used to confirm a diagnosis of pertussis include

- bacterial culture
- serological testing to detect rises in immunoglobulin IgA or IgG antigens
- lymphocyte count.

After a two-week course of broad-spectrum antibiotics, a woman who still has a persistent cough visits a medical clinic. Concerned that she might have whooping cough, the doctor decides to perform a series of serological tests to detect the levels of IgA and IgG antibodies specific to *B. pertussis* antigens.

b. Explain why the doctor chooses serological testing over the other tests available.

3 marks

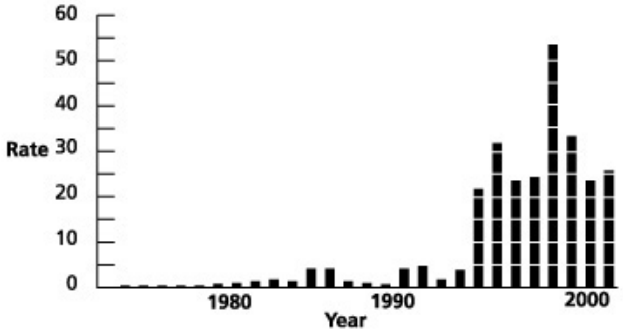
Solution

Serological testing will detect the rise in levels of immunoglobulin IgA or IgG in response to *B. pertussis* antigens, which will be higher than normal if the woman has pertussis. Raised lymphocyte counts are a non-specific indicator of infection and will not necessarily confirm the presence of *B. pertussis*. The woman has been on a two-week course of antibiotics. As a result, a bacterial culture is unlikely to be conclusive about the presence of *B. pertussis* because the bacteria will have most likely been eradicated by the antibiotics.

Mark allocation

- 1 mark – serological testing is reliant on an immune response.
- 1 mark – raised lymphocyte counts are a non-specific indicator of infection.
- 1 mark – bacterial culture is unlikely to be conclusive about the presence of *B. pertussis* because the bacteria has been eradicated by the antibiotics.

Currently in Australia, epidemics of pertussis occur every three to four years. The following graph shows the rates of pertussis in Australia from 1970–2000.



Australia's pertussis rate (per 100,000 population)

Up until the late 1990s, children were given a broad-acting whole-cell vaccine. However, concerns over the potential side effects resulted in the development of a more targeted acellular vaccine. The acellular vaccine contains a pertussis toxin that has either been inactivated or genetically detoxified.

	Whole cell vaccine	**Acellular vaccine**
Period of use	prior and up to 1997	after 1997
number of different antigens against pertussis	hundreds	3-5

More than 200 samples of the bacterium collected over the past 40 years in Australia were compared with samples from Japan, Canada, the United States and Finland. An analysis showed that the vaccine currently in use is effective against some of the strains circulating in Australia. However, it may no longer offer protection against two strains, MT27 and MT70.

c. Identify two possible explanations for the dramatic rise in the incidence of pertussis in vaccinated Australians since the mid-1990s.

2 marks

Solution

Explanation 1: Diminished immunity – there are no longer sufficient antibodies or B-memory cells present in vaccinated individuals to respond to the introduction of *B. pertussis* antigens.

Explanation 2: Promotion of resistant strains, such as MT27 and MT70, as a result of the use of targeted acellular vaccine.

Mark allocation

- 1 mark – diminished immunity.
- 1 mark – promotion of resistant strains due to use of narrower focus vaccine.

Researchers have analysed particular sequences in the DNA of strains of *B. pertussis* that make the three to five antigens. Strains MT27 and MT70 have different gene sequences.

d. What is the likely outcome of strains MT27 and MT70 having different gene sequences?

1 mark

Solution

The gene will produce a different antigen, which means the mutated strains are unlikely to react to an immune response arising from the vaccine.

Total 7 marks

END OF SECTION B

END OF SOLUTIONS BOOK