INSIGHT

Trial Exam Paper

2009

BIOLOGY

Written examination 1

Solutions book

This book presents:

- correct solutions
- explanatory notes
- mark allocations

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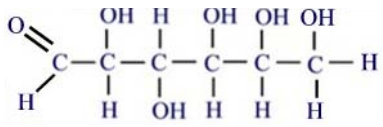
SECTION A – Multiple-choice questions

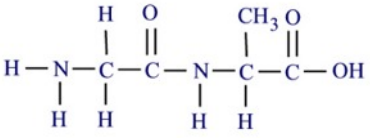
Question 1

A polymer could be represented by

A.



C.



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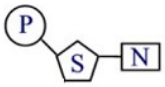

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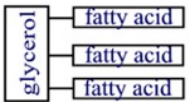


Answer is C

Explanatory notes

- A is incorrect – diagram shows a glucose monomer.
- B is incorrect – diagram shows a nucleotide which is a monomer.
- C is correct – diagram shows two amino acid molecules joined by a peptide bond, i.e. a dipeptide which is a polymer.
- D is incorrect – diagram shows a triglyceride which is a lipid. Lipids are not polymers.

The following information is relevant for Questions 2 and 3.

Proteins are large molecules usually comprised of many amino acids which are joined together by peptide bonds to form a primary structure. The overall structure of a protein can be very complex.

Question 2

The principle difference between the tertiary and quaternary structure in proteins is that a protein with a quaternary structure

A. **always has two or more polypeptide chains bound together.**

B. shows greater tolerance of heavy metals.

C. will show either α-helices or β-pleated sheets, but not both.

D. will only display hydrogen and peptide bonding.

Answer is A

Explanatory notes

- A is correct – proteins with quaternary structure always have two or more polypeptide chains bound together.
- B is incorrect – heavy metals can disrupt ionic bonds, bind with carboxyl groups of the R-groups and cause precipitation of the protein; proteins with tertiary and quaternary structure are equally susceptible.
- C is incorrect – both α-helices and β-pleated sheets are present in proteins with a quaternary structure.
- D is incorrect – proteins with quaternary structure display peptide, hydrogen, disulfide and ionic bonding.

Question 3

Some proteins, such as haemoglobin, incorporate other chemical groups within the amino acid chains. These proteins are known as

A. complementary.

B. **conjugated.**

C. dysfunctional.

D. defective.

Answer is B

Explanatory notes

- A is incorrect – a complementary protein is a protein that needs to be associated with other proteins in a diet to provide an organism with a balanced nutrient intake.
- B is correct – conjugated proteins have amino acids and other chemical groups.
- C is incorrect – normally conjugated proteins are highly functional.
- D is incorrect – normally conjugated proteins are not defective.

Question 4

Animal cells contain many organelles, all of which perform specific functions. The sac-like, membrane-bound organelle which contains dissolved digestive enzymes for the destruction of substances no longer needed by a cell is the

A. endosome.

B. peroxisome.

C. melanosome.

D. **lysosome.**

Answer is D

Explanatory notes

- A is incorrect – an endosome is a membrane-bound organelle that transfers newly ingested material to a lysosome for enzymatic breakdown.
- B is incorrect – a peroxisome is a membrane-bound organelle that contains the enzyme catalase which is responsible for the breakdown of hydrogen peroxide which is toxic to cells.
- C is incorrect – a melanosome is a membrane-bound organelle that contains the pigment melanin.
- D is correct – a lysosome is a membrane-bound organelle that contains enzymes which are capable of digesting unwanted or damaged substances from inside or outside the cell.

Question 5

There are three types of junction that are found in animal cells. Which of the following is NOT a junction found in animal cells?

A. occluding

B. **bridging**

C. communicating

D. anchoring

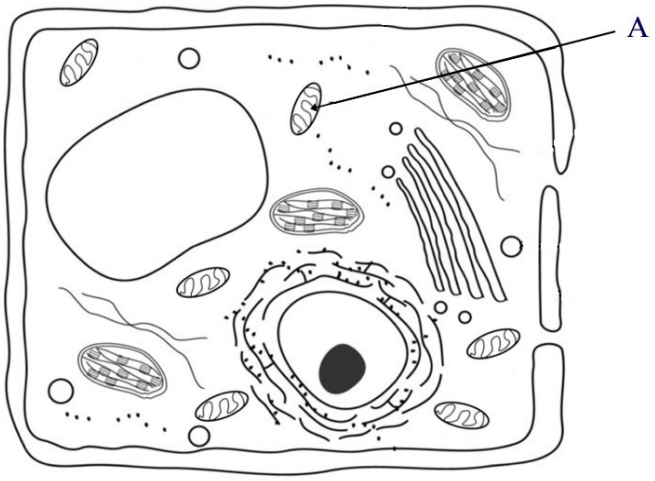
Answer is B

Explanatory notes

- A is incorrect – occluding junctions bring membranes into contact with each other and prevent movement of material between animal cells.
- B is correct – there are no bridging junctions found in animal cells, therefore this is NOT a junction from an animal cell.
- C is incorrect – communicating junctions are protein lined pores in animal cell membranes which allow the passage of salt ions, sugars and amino acids.
- D is incorrect – anchoring junctions (also known as desmosomes) are protein adhesions found on animal cell membranes with fine filaments which project into the cytosol, providing significant tensile strength.

Question 6

The diagram shows a 'typical' plant cell. Structure **A** is directly associated with



A. the conversion of radiant energy to chemical energy.

B. the breakdown of glucose to pyruvate.

C. the production of glucose.

D. **the production of ATP.**

Answer is D

Explanatory notes

- Structure **A** is the cristae, the inner membrane of a mitochondrion. The cristae is the site of electron transport and is associated with the production of ATP.
- A is incorrect – conversion of radiant energy to chemical energy (photosynthesis) occurs in the chloroplasts, not in the mitochondria.
- B is incorrect – breakdown of glucose to pyruvate occurs in the cytosol, not in the mitochondria.
- C is incorrect – the production of glucose occurs through photosynthesis in chloroplasts, not in the mitochondria.
- D is correct – ATP is produced in electron transport and this occurs on the cristae within the mitochondria.

Question 7

Anaerobic respiration in yeast is known as

A. condensation.

B. **fermentation.**

C. hydrolysis.

D. glycolysis.

Answer is B

Explanatory notes

- A is incorrect – condensation occurs when a peptide bond forms between two amino acids and water is released.
- B is correct – fermentation is the process of anaerobic respiration in yeasts which produces alcohol.
- C is incorrect – hydrolysis is the process in which in the presence of water, peptide bonds are broken and two amino acids are produced.
- D is incorrect – glycolysis is the first stage of cellular respiration which results in the production of two 3C compounds from one 6C compound.

Question 8

In living organisms metabolic reactions cannot take place efficiently without the involvement of enzymes. The rate of an enzyme reaction is NOT influenced by

A. pH.

B. temperature.

C. concentration of enzyme and substrate.

D. **the position of the active site in the substrate.**

Answer is D

Explanatory notes

- A is incorrect – enzymes operate best at an optimal pH, as the rate of an enzymatic reaction is affected by pH.
- B is incorrect – enzymes operate best at an optimal temperature, as the rate of an enzymatic reaction is affected by temperature (high temperatures denature, low temperatures will slow a reaction).
- C is incorrect – concentration of enzyme and substrate impact on the rate of enzyme reaction.
- D is correct – an active site is found in an enzyme, NOT in a substrate.

Question 9

Cyanide is a chemical that is known to inhibit the activity of *cytochrome c oxidase,* an enzyme involved in electron transport in aerobic respiration. Enzyme inhibition occurs when other molecules

A. **compete with the normal substrate for the active site of the enzyme.**

B. compete with the normal enzyme for the active site of the substrate.

C. alter the tertiary structure of the enzyme.

D. alter the tertiary structure of the substrate.

Answer is A

Explanatory notes

- A is correct – enzyme inhibition occurs when enzyme inhibitors compete with the normal substrate for the active site of an enzyme. This can involve binding permanently with the active site.
- B is incorrect – enzyme inhibition occurs when enzyme inhibitors compete with the normal substrate for the active site of an enzyme, NOT the substrate (substrates do not have an active site).
- C is incorrect – enzyme inhibition does not alter the tertiary structure of the enzyme.
- D is incorrect – enzyme inhibition does not alter the tertiary structure of the substrate.

Question 10

Single gene defects can cause genetic diseases in humans. Gene therapy is a biomedical process that can correct some gene defects. Which of the following would NOT be used in gene therapy?

A. Treatment of Parkinson's disease by introducing liposomes.

B. Treatment of severe combined immunodeficiency (SCID) using retroviruses.

C. **Treatment of PKU by reducing intake of phenylalanine.**

D. Treatment of cystic fibrosis by applying adenoviruses into the lungs.

Answer is C

Explanatory notes

- A is incorrect – liposomes (vesicles with lipid membranes) are a vector for gene therapy.
- B is incorrect – retroviruses (viruses containing RNA) are a vector for gene therapy.
- C is correct – reducing intake of phenylalanine manages genetic disease through diet, not through gene therapy.
- D is incorrect – adenoviruses (viruses containing RNA) are a vector for gene therapy.

The following information is relevant for Questions 11 to 13.

The influenza virus has two proteins on its surface. The first, haemagglutinin, is used by the virus to gain entry to a cell and the other, neuraminidase, enables newly formed viruses to leave a host cell by severing the attachment between host cell and newly formed virus. Efforts to find a treatment that would block viral entry to a cell failed, however, a strategy which prevented viral particles from leaving a host cell was successful.

Question 11

The technique used to find the treatment for influenza is known as

A. **rational drug design.**

B. trial and error.

C. chorionic villus sampling.

D. screening.

Answer is A

Explanatory notes

- A is correct – the process of finding out how an infective agent impacts on a cell and then using that information to design a drug that prevents the infective agent from having its effect.
- B is incorrect – trial and error is a random process and does not implement a directed strategy.
- C is incorrect – chorionic villus sampling involves sampling of chorion tissue for prenatal diagnosis.
- D is incorrect – screening is the name given to the process of checking whether an individual has a condition when signs and symptoms may not be evident.

Question 12

Neuraminidase is

A. **an enzyme.**

B. a glycoprotein.

C. an antibody.

D. a microfibril.

Answer is A

Explanatory notes

- A is correct – neuraminidase is the enzyme that enables newly formed viruses to leave a host cell.
- B is incorrect – a glycoprotein is a membrane protein with a carbohydrate group attached.
- C is incorrect – an antibody is a protein produced by B plasma cells in response to antigens.
- D is incorrect – a microfibril is a basic structural unit of a plant cell wall.

Question 13

An anti-influenza virus drug has been developed with the generic name Zanamivir. When Zanamivir is present in the body of a host it will bind to

A. the haemagglutinin protein on the plasma membrane of the host.

B. the neuraminidase protein on the plasma membrane of the host.

C. the haemagglutinin protein on the outer layer of the influenza virus.

D. the neuraminidase protein on the outer layer of the influenza virus.

Answer is D

Explanatory notes

- Zanamivir binds with the neuraminidase protein which is found on the outer layer of the virus.
- A is incorrect – the haemagglutinin protein is found on the outer layer of the virus, not the plasma membrane of the host.
- B is incorrect – the neuraminidase protein is found on the outer layer of the virus, not the plasma membrane of the host.
- C is incorrect – Zanamivir does not bind with the haemagglutinin protein. The haemagglutinin protein is used by the virus to gain entry to a cell and efforts to find a treatment that would block viral entry failed.
- D is correct – Zanamivir binds with the neuraminidase protein, which is found on the outer layer of the virus.

Question 14

Exteroceptors are highly specialised cells that receive information from the external environment of an organism. Information is received and converted to a chemical signal which is then transferred through body cells. The exteroceptor that responds to pressure, tension and sound vibrations is a

A. thermoreceptor.

B. photoreceptor.

C. chemoreceptor.

D. mechanoreceptor.

Answer is D

Explanatory notes

- A is incorrect – thermoreceptors respond to temperature.
- B is incorrect – photoreceptors respond to light.
- C is incorrect – chemoreceptors respond to molecules of substances associated with smell and taste.
- D is correct – mechanoreceptors respond to pressure, touch, tension, position and posture of the body and sound vibrations.

Question 15

The development of a tadpole into an adult frog (metamorphosis) is controlled by the hormone thyroxine. Instead of thyroxine concentrations being maintained within a set range, the levels rise and trigger metamorphosis. This is an example of

A. negative feedback.

B. **positive feedback.**

C. metabolism.

D. homeostasis.

Answer is B

Explanatory notes

- A is incorrect – negative feedback ensures that when a change of variable occurs, the response is to reverse the direction of change. This does not happen in the metamorphosis of frogs.
- B is correct – positive feedback ensures that when a change of variable occurs, the response is to reinforce the change. This is what happens in the metamorphosis of frogs.
- C is incorrect – metabolism describes all the chemical reactions that occur in an organism, while this example refers to a developmental process.
- D is incorrect – this is an example of positive feedback which is not considered to be part of homeostasis because it does not return the variable to its 'normal' range, which should occur in homeostasis.

Question 16

Thyroxine is a hormone which is released from the thyroid gland into the bloodstream. It is transported through the circulatory system until reaching target cell receptors around the body. Thyroxine is synthesised from the amino acid tyrosine and

A. **can move through the plasma membrane of the cell because it is small and hydrophobic.**

B. can move through the plasma membrane of the cell because it is small and hydrophilic.

C. binds with a receptor protein on the plasma membrane.

D. binds with a target protein on the plasma membrane.

Answer is A

Explanatory notes

- A is correct – for an amine-based molecule, thyroxine is small and also hydrophobic so can therefore move through the plasma membrane.
- B is incorrect – thyroxine is not hydrophilic, it is hydrophobic.
- C is incorrect – thyroxine is a small amine-based hormone and does not bind with receptor proteins on the membrane because it can move through the plasma membrane.
- D is incorrect – there are no target proteins on the plasma membrane: the target protein is the protein affected by the hormone (signalling protein).

Question 17

Ethylene is a gas produced by some but not all ripening plants. The petals of the chrysanthemum *Chrysanthemum morifolium* also produce ethylene which leads to the death of the flower. The graph shows levels of ethylene produced by *Chrysanthemum morifolium* flowers after cutting.

The increase in ethylene level at Day 4 is most likely due to

A. decreased rate of cellular respiration in the cells of the petals.

B. decreased rate of photosynthesis in the cells of the petals.

C. **increased rate of cellular respiration in the cells of the petals.**

D. increased rate of photosynthesis in the cells of the petals.

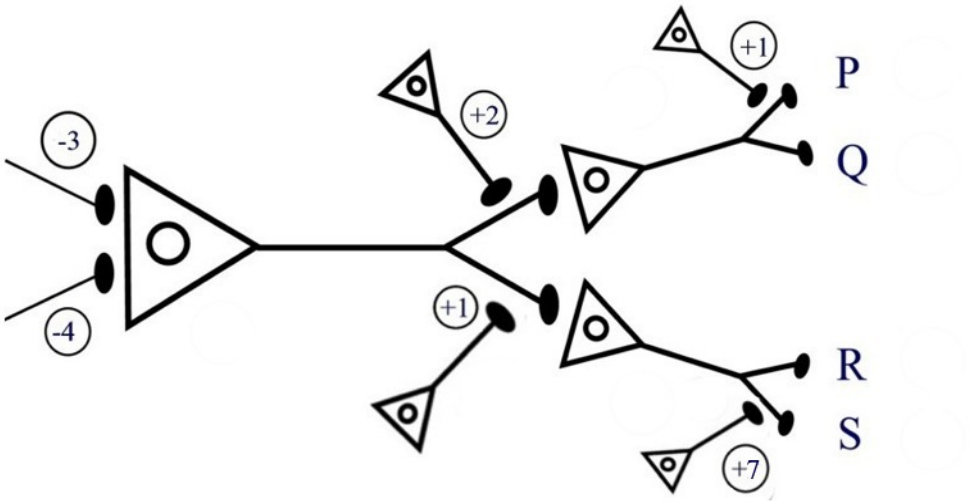
Answer is C

Explanatory notes

- A is incorrect – the rate of cellular respiration will be increasing due to the increased production of ethylene.
- B is incorrect – the rate of photosynthesis in the cells does not influence the ethylene levels in the flowers.
- C is correct – metabolising cells produce ethylene which increases the rate of cellular respiration; an increase in cellular respiration will lead to an increase in the rate of ethylene.
- D is incorrect – the rate of photosynthesis in the cells does not influence the ethylene levels in the flowers.

Question 18

Neurons interact in networks to enable the functioning of an organism. Signals can either excite (+) or inhibit (-) processes. If an excitation signal and an inhibition signal are given to the same neuron at the same time, they will cancel each other out. The diagram shows a network of neurons associated with a muscle fibre. Which of the four target cells P, Q, R or S will receive a signal from the neurons?



A. Target cells P and Q

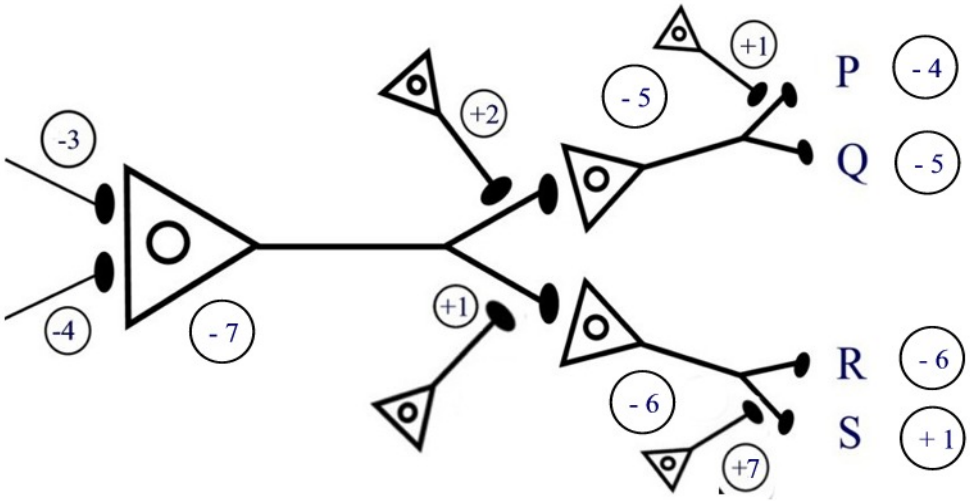
B. Target cells R and S

C. Target cell P only

D. **Target cell S only**

Answer is D

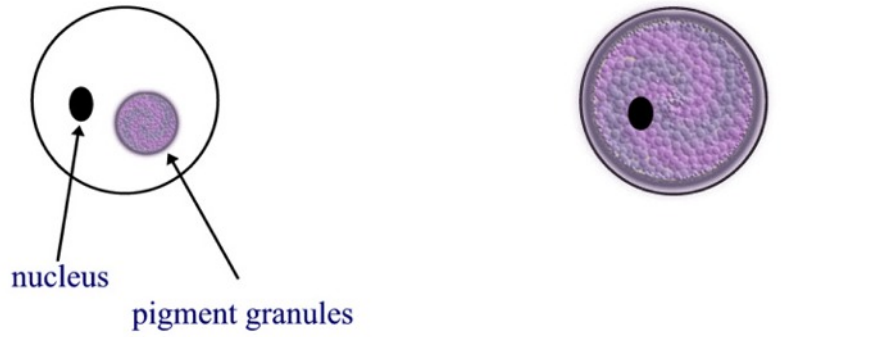
Explanatory notes



- A is incorrect – Target cells **P** and **Q** do not receive incoming excitatory signals.
- B is incorrect – Target cell **S** does receive an incoming excitatory signal (+1), however Target cell **R** does not receive an incoming excitatory signal.
- C is incorrect – Target cell **P** does not receive an incoming excitatory signal.
- D is correct – Target cell **S** does receive an incoming excitatory signal (-7 + 1 + 7 = +1).

Question 19

Vertebrates gain their colours from pigments which are found in pigment cells or structures which have differentiated from these cells. Pigment cells have a fixed shape; however, the distribution of pigment within the cells is changeable.



A - concentrated pigment granules B - dispersed pigment granules

When threatened, octopuses are capable of expressing colour change within seconds. In contrast, *Lepus americanus,* the snowshoe hare, changes coat colour over a period of weeks from white in winter to brown in summer. The change in coat colour of snowshoe hares is controlled

A. mainly by the nervous system.

B. entirely by the nervous system.

C. **mainly by the endocrine system.**

D. entirely by the endocrine system.

Answer is C

Explanatory notes

- A is incorrect – the nervous system is associated with rapid colour change, not slow gradual colour change.
- B is incorrect – the nervous system is associated with rapid colour change, not slow gradual colour change.
- C is correct – slow and gradual colour change is controlled mainly by the endocrine system but also in part by the nervous system.
- D is incorrect – slow and gradual colour change is controlled mainly by the endocrine system but not entirely.

The following information is relevant for Questions 20 and 21.

Severe acute respiratory syndrome (SARS) is caused by a corona virus which is spread by respiratory droplets from infected individuals.

Question 20

When a person is infected with the SARS virus, the virally infected cells are most likely to be ingested by a kind of phagocyte known as a

A. **macrophage.**

B. bacteriophage.

C. viroid.

D. lymphocyte.

Answer is A

Explanatory notes

- A is correct – a macrophage is a large amoeboid cell that phagocytoses bacteria and virally infected or dead cells.
- B is incorrect – a bacteriophage is a virus that infects bacteria.
- C is incorrect – a viroid is a small piece of RNA that can cause disease in plants.
- D is incorrect – a lymphocyte is a white blood cell that plays a role in specific immunity.

Question 21

Following ingestion, viral peptides are displayed on the surface of the phagocyte. The appearance of the viral peptides activates an immune response mediated by

A. B plasma cells.

B. mast cells.

C. suppressor T cells.

D. **helper T cells.**

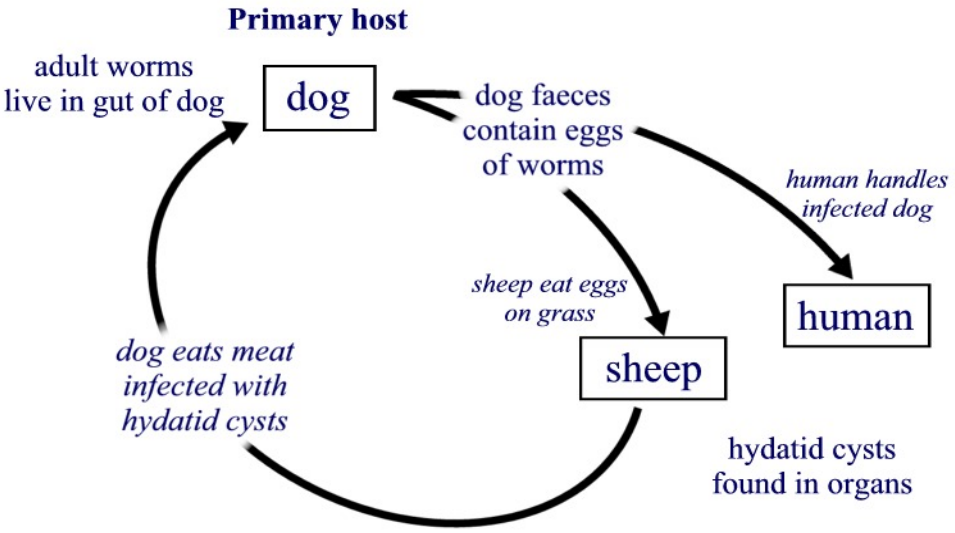
Answer is D

Explanatory notes

- A is incorrect – B plasma cells are B cells which are associated with the secretion of antibodies.
- B is incorrect – mast cells are associated with the production of histamines.
- C is incorrect – suppressor T cells cause B cells to ignore antigens.
- D is correct – helper T cells stimulate B cells to produce antibodies or enable other T cells to respond to antigens or secrete lymphokines or interleukins.

Question 22

The adult hydatid tapeworm *Echinococcus granulosus* lives in the intestine of a dog. The lifecycle of *E. granulosus* is described in the diagram. Which of the following statements is NOT true?



A. The human and the sheep are intermediate hosts in this lifecycle.

B. **Dogs produce faeces containing hydatid cysts which can be transferred to humans and sheep.**

C. Hydatid cysts contain large numbers of tapeworm heads that can develop into worms.

D. Hydatid cysts are typically found in organs such as the liver, brain and lungs.

Answer is B

Explanatory notes

- A is incorrect – both humans and sheep are intermediate hosts in the tapeworm lifecycle.
- B is correct – dog faeces contain eggs of the tapeworm, not hydatid cysts. This statement is NOT true.
- C is incorrect – hydatid cysts contain many tapeworm heads that can develop into worms.
- D is incorrect – hydatid cysts migrate from the intestine of the intermediate host and can be found in organs such as the liver, brain and lungs.

The following information is relevant for Questions 23 and 24.

The egg in which a chicken embryo develops is comprised of amniotic fluid (the white) and the yolk which is a source of nutrition. Immunoglobulins are transferred from a mother hen into the developing egg.

Question 23

An immunoglobulin is best described as

A. a group of proteins associated with building resistance against viral infection.

B. a group of blood proteins involved in the body's second line of defence.

C. a protein molecule capable of initiating antibody production.

D. **an antibody molecule found in body fluid and on the surface of B cells.**

Answer is D

Explanatory notes

- A is incorrect – describes interferons.
- B is incorrect – describes complement proteins.
- C is incorrect – describes an antigen.
- D is correct – describes an immunoglobulin.

Question 24

The immunoglobulins present in the newly hatched chick will give

A. long-lasting passive immunity.

B. long-lasting active immunity.

C. **temporary passive immunity.**

D. temporary active immunity.

Answer is C

Explanatory notes

- A is incorrect – whilst passive (immunoglobulins have been passed from mother through the yolk), not long-lasting (no memory cells for these immunoglobulins).
- B is incorrect – not active (no exposure to antigen to trigger production of antibodies), not long-lasting (no memory cells for these immunoglobulins).
- C is correct – passive (immunoglobulins have been passed from mother through the yolk), temporary (immunoglobulins will break down and no memory cells have been made for these immunoglobulins).
- D is incorrect – temporary (immunoglobulins will break down and no memory cells have been made for these immunoglobulins), not active (no exposure to antigen to trigger production of antibodies).

Question 25

Diabetes mellitus is an autoimmune condition in which the body is unable to regulate blood glucose levels, resulting in excessively high levels of glucose in the blood. Which of the following statements does NOT apply to autoimmune disease?

A. Failure of the body's self-recognition system

B. **Disease of the immune system, like AIDS**

C. Immune system reacts against its own tissues

D. No distinction made between self cells and invading micro-organisms

Answer is B

Explanatory notes

- A is incorrect – autoimmune disease is the failure of the body's self-recognition system.
- B is correct – disease of the immune system is an immunodeficiency disease, not an autoimmune disease.
- C is incorrect – autoimmune disease occurs when the immune system reacts against its own tissues.
- D is incorrect – the inability of the immune system to distinguish between self cells and invading micro-organisms is a characteristic of autoimmune disease.

END OF SECTION A

SECTION B – Short-answer questions

Question 1

In humans, metabolism is dependent on the intake of organic molecules. Particular organic molecules are consumed and processed during digestion. Once digested, organic material can be broken down and reorganised into molecules that have specific functions throughout the body.

1a. Complete the table.

Molecule	Function	Example
W	regulates blood glucose levels	
X		glycogen
Y		DNA
Z	stimulates development of female reproductive system	

Solution

Molecule	Function	Example
W	regulates blood glucose levels	**insulin OR glucagon**
X	**storage material**	glycogen
Y	**controls all functions within cells**	DNA
Z	stimulates development of female reproductive system	**oestrogen OR steroid**

2 marks

Explanatory notes

In addition to being aware of the biomacromolecules (carbohydrates, lipids, protein and nucleic acid), students should also be aware of the specific examples of biomacromolecules and have a general understanding of the various functions they perform.

Mark allocation

- 4 correct = 2 marks
- 3 or 2 correct = 1 mark
- 1 or 0 correct = 0 marks

1b. What type of organic molecule is Molecule **Z**?

1 mark

Solution

lipid

Explanatory notes

- A steroid is a class of lipid possessing a carbon skeleton consisting of four fused rings to which different functional groups are attached.

1c. In terms of function, what is the plant equivalent of Molecule **X**?

1 mark

Solution

Starch (or inulin)

Explanatory notes

- Plants produce a 3C compound known as PGAL during photosynthesis. PGAL is converted to various sugars including glucose, fructose and sucrose. Carbohydrates are transported through a plant in the form of sucrose. Sucrose is converted to starch or inulin.

The following information applies to Question 1d.

The nucleotide base sequence of a strand of DNA which codes for a specific amino acid is shown below.

G G A A T G C T C G A C A T G

1d i. What is the base sequence of the complementary strand?

1 mark

Solution

C C T T A C G A G C T G T A C

1d ii. How many amino acids are coded for by this strand of DNA?

1 mark

Solution

5

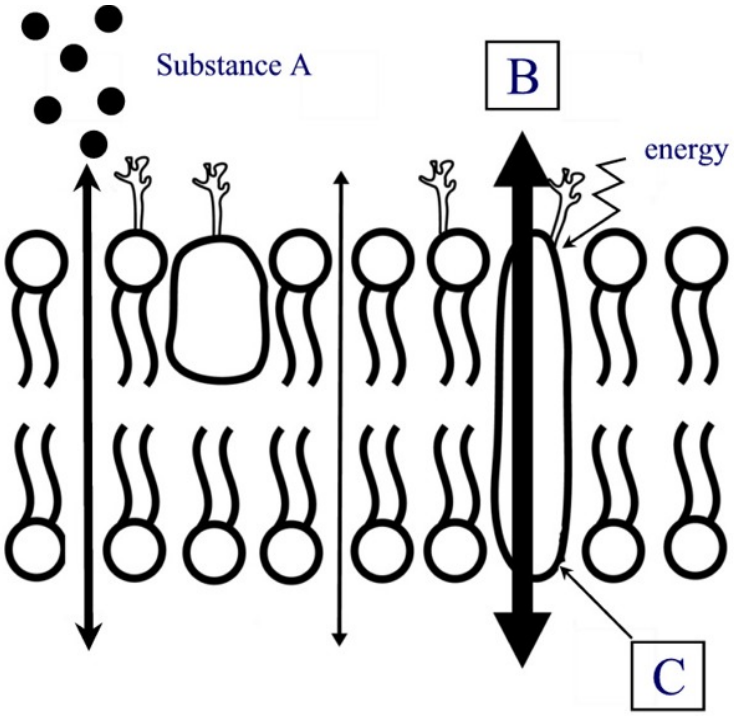
Explanatory notes

- The nucleotide bases in DNA bind in a complementary manner (A with T; C with G). In order to determine the sequence of a complementary strand it is necessary to build a chain of matching bases. An amino acid is coded for by a sequence of three nucleotide bases. There are 15 nucleotides in this sequence, therefore the sequence codes for 5 amino acids.

Total 2 + 1 + 1 + 1 + 1 = 6 marks

Question 2

The plasma membrane encloses a cell and is involved in the selective regulation of the movement of substances in and out of the cell. A cross-sectional representation of part of a plasma membrane from a eukaryotic cell is shown in the diagram.



2a i. Suggest a name for Substance **A**.

1 mark

Solution

ONE of alcohol/ethanol OR chloroform OR glycerol OR water OR urea OR oxygen OR carbon dioxide OR nitrogen

2a ii. Name one characteristic that would be demonstrated by Substance **A**.

1 mark

Solution

Substance **A** could be a small hydrophobic or lipid-soluble molecule which can dissolve into the phospholipid bilayer and pass easily through the plasma membrane.

OR

Substance **A** could be a small uncharged (non-polar) molecule which can pass easily through the plasma membrane.

Explanatory notes

- The phospholipid bilayer of the plasma membrane is permeable to small hydrophobic molecules (oxygen, carbon dioxide, nitrogen) and small uncharged polar molecules (water, ethanol, glycerol, urea).

Mark allocation

- 1 mark (Note: answer must be consistent with answer provided for Question **2ai** to gain mark

2b. Explain the process that would occur at **B**.

2 marks

Solution

Active transport occurs at **B**. A transport protein moves substances across the membrane against their concentration gradient. Energy is required for this process and it is supplied by ATP.

Explanatory notes

- Active transport requires energy (provided by ATP) because it is the net movement of dissolved substances into or out of cells against a concentration gradient.

Mark allocation

- 1 mark – active transport OR energy is used
- 1 mark – substances are moved across the membrane against the concentration gradient

2c i. What is Structure **C**?

1 mark

Solution

Protein channel OR carrier protein

2c ii. Apart from using Structure **C**, by what other means could a large, lipid-insoluble molecule gain entry to a cell?

1 mark

Solution

Through the process of endocytosis (phagocytosis OR pinocytosis), which is a form of bulk transport.

Explanatory notes

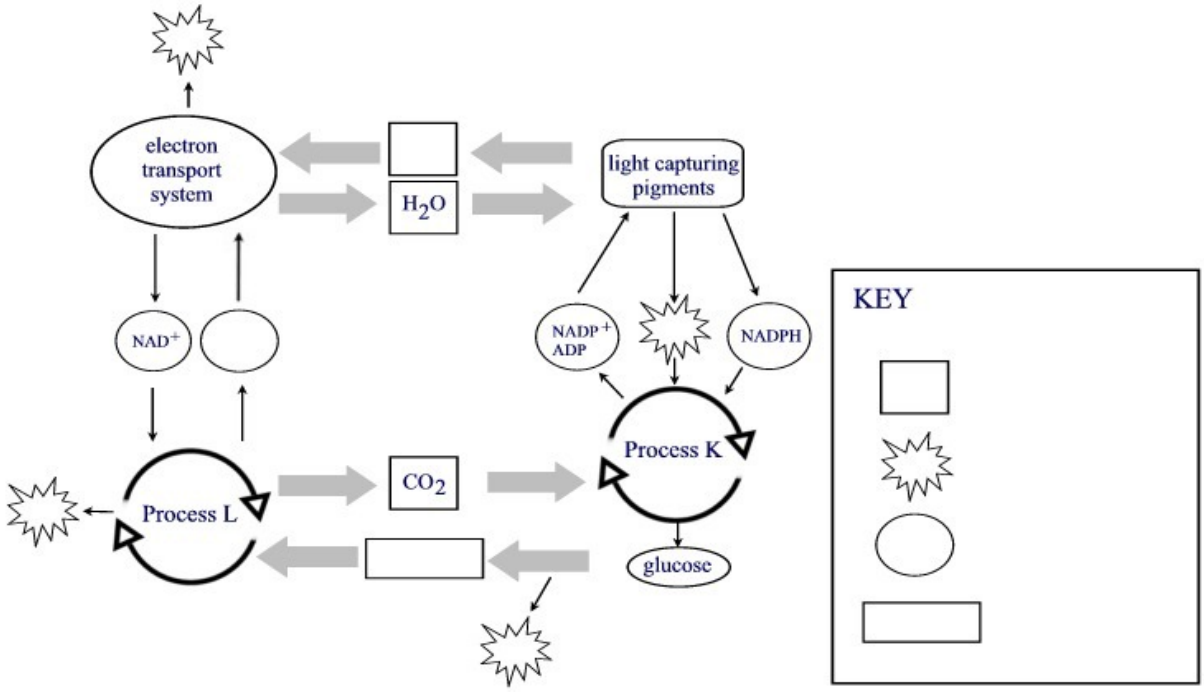
- Protein channels are water filled pores in the plasma membrane. The pores are hydrophilic allowing water-soluble substances to pass through easily. The pores are selective, allowing some ions to pass through when an appropriate chemical signal is received. Large, lipid-insoluble molecules can also gain entry to a cell through the process of bulk transport. Endocytosis involves the formation of a vesicle around the molecule (or molecules dissolved in fluid) to draw it into the cell. This process is known as phagocytosis.

Total 1 + 1 + 2 + 1 + 1 = 6 marks

Question 3

In living organisms, the processes of photosynthesis and cellular respiration are closely linked, with the outputs of one becoming the inputs of the other.

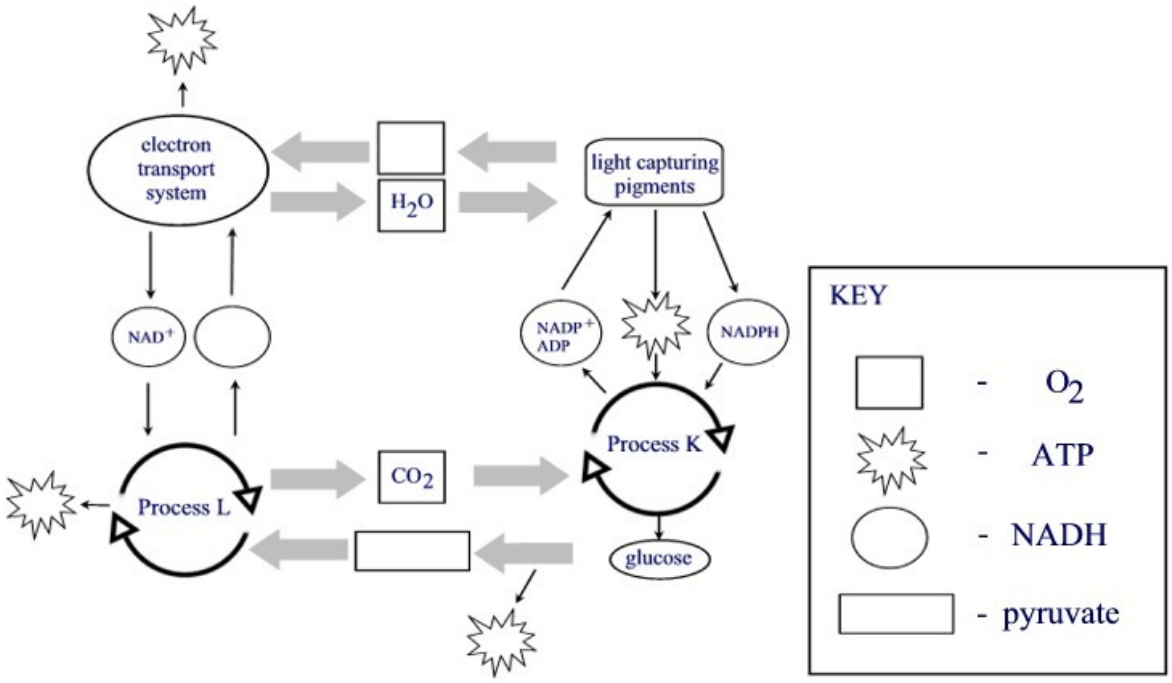
The diagram shows the relationship that exists between photosynthesis and cellular respiration.



3a. Provide correct labels for the key to this diagram. Write your answers next to the shapes in the key.

2 marks

Solution



Mark allocation

- 2 marks – 4 correct
- 1 mark – 3 or 2 correct
- 0 marks – 1 or 0 correct

3b. What is the name given to Process **K** and where exactly in a cell does it occur?

1 mark

Solution

Process **K** is the Calvin–Benson cycle which takes place in the stroma of the chloroplasts.

3c. What occurs in the light-dependent phase of photosynthesis?

1 mark

Solution

Radiant/light energy is absorbed and used to split water molecules into H^+, electrons and oxygen.

Explanatory notes

- Radiant/light energy is absorbed by different pigments found in the thylakoid membranes (chlorophylls, carotenoids, xanthophylls and phycobilins) and used to split water molecules into H^+, electrons and oxygen. The H^+ are picked up by an acceptor molecule (NADP), electrons pass through the electron transport chain releasing energy (ATP) at each step and oxygen is released as a by-product.

The following information applies to Question 3d.

The water plant *Elodea canadensis* is commonly used as an oxygenator in aquaria. Aquatic plants obtain all their requirements from the water surrounding them. Likewise, they return their gaseous wastes into the same environment. When carbon dioxide dissolves in water, carbonic acid is formed. Phenol red is an indicator that changes colour when the pH of water changes. When the water is acidic the indicator becomes yellow; when water is alkaline, the colour is pink.

It has been hypothesised that green plants take in carbon dioxide during photosynthesis and release carbon dioxide when photosynthesis is not taking place.

3d. Design an experiment to test this hypothesis. Use a diagram to explain your design.

The experimental design should

- clearly outline the experimental procedure that would be followed
- describe the results that would support the hypothesis.

3 marks

Solution

The design should compare the amount of carbon dioxide in pond water (carbonic acid) for a group of plants exposed to light (photosynthesis) and a group of plants in darkness (no photosynthesis) over a 48-hour period (or more). The amount of carbon dioxide present can be determined qualitatively using phenol red.

Procedure should include at least four of the following:

- obtaining a suitable amount of pond water
- determining pH of pond water using phenol red (should be alkaline)
- bubbling carbon dioxide into the pond water
- observing and recording changes to the pH of the pond water (if any)
- filling a suitable quantity of beakers/test tubes with the carbonated pond water
- keeping two beakers/test tubes aside to use as controls
- immersing *Elodea canadensis* in the remaining beakers/test tubes filled with pond water
- placing half the beakers/test tubes in a well-lit area (or under a growth lamp) and the rest in the dark; place one control beaker/test tube in the well-lit group and the other control in the dark
- making observations of the changes in the colour of the pond water over at least 48 hours

The results that would support the hypothesis would be if the pond water for the group kept under the growth lamp (photosynthesis occurring) stays pink (alkaline, no carbon dioxide) and the pond water for the group kept in the dark (no photosynthesis) turns yellow (acidic, production of) carbon dioxide.

Explanatory notes

- Experimental designs will range, however, they must all test the hypothesis. Designs must demonstrate understanding of the requirement for light if photosynthesis is to proceed and that it involves the uptake of carbon dioxide. Application of the information about phenol red as an indicator must be incorporated in the experimental design and interpretation of results. In addition, knowledge that cellular respiration occurs at all times in a plant must be clear. Students must show use of controlled variables with an adequate number of replicates per group (more than 5 in each treatment).

Mark allocation

- 2 marks – if 4 appropriate steps in experimental procedure are provided
- 1 mark for 3 or 2 steps,
- 0 marks for 1 or 0 steps
- 1 mark – describing results that would support the hypothesis

Total 2 + 1 + 1 + 3 = 7 marks

Question 4

Human T-cell lymphotropic virus (HTLV) is a human retrovirus that causes T-cell leukaemia and T-cell lymphoma in adults. Of those infected with the virus, approximately 5% will develop cancer.

4a. Explain why viruses are considered to be non-cellular obligate parasites.

2 marks

Solution

A parasite is an organism that lives in or on the body of a host, obtaining nutrients with no benefit to the host. A virus is non-living and MUST parasitise a host in order to reproduce.

Mark allocation

- 1 mark – definition of a parasite
- 1 mark – virus MUST use host cell (metabolic machinery and products of) to reproduce.

4b i. What distinguishes a retrovirus from other viruses?

1 mark

Solution

A retrovirus is an RNA virus which produces DNA from viral RNA.

4b ii. What is a viroid?

1 mark

Solution

A viroid is a plant pathogen and occurs as a short piece of naked RNA that infects plants.

Explanatory notes

- Some viral diseases occur over a long period of time and it is thought that viroids are the cause. Viroids are the smallest known infectious particle.

4c. Using your knowledge of viral reproduction strategy and the information provided, design a drug that would be effective in treating a viral infection caused by this specific retrovirus. Indicate whether the host is likely to be affected by this virus. Use a diagram in your answer.

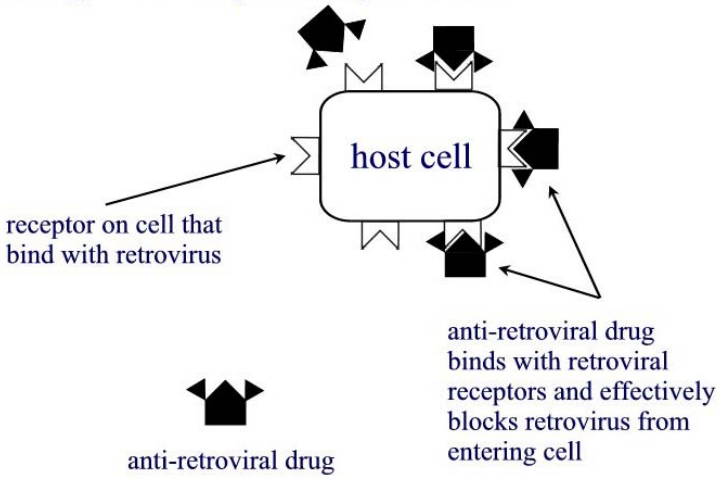
3 marks

Solution

There are two strategies that could be employed to treat a viral infection caused by this virus.

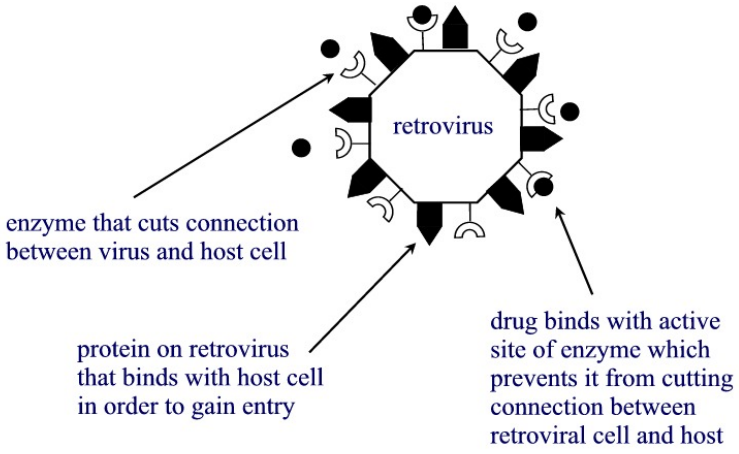
Strategy 1: Design a drug that prevents the retrovirus from gaining entry to the cell. This would involve a molecule that binds with or blocks the sites on the host cell membrane that are receptive to the virus. Host is unlikely to be affected by this virus because host cells are not infected by virus and the immune system will encounter and respond to virus exposed on outer surface of host membrane.

Strategy 1 - An example of a diagram could be



Strategy 2: Design a drug that prevents a new virus bud from detaching from the host cell. This is normally possible because an enzyme cuts the attachment. The drug would interfere/interact with the active site of the enzyme and the virus will not leave the surface of the cell. Even though the host is infected by the virus, it is a retrovirus (which transcribes RNA to DNA; not DNA to RNA) and normal functions of body cells will not be affected. The immune system will encounter and respond to the virus exposed on outer surface of host membrane.

Strategy 2 - An example of a diagram could be



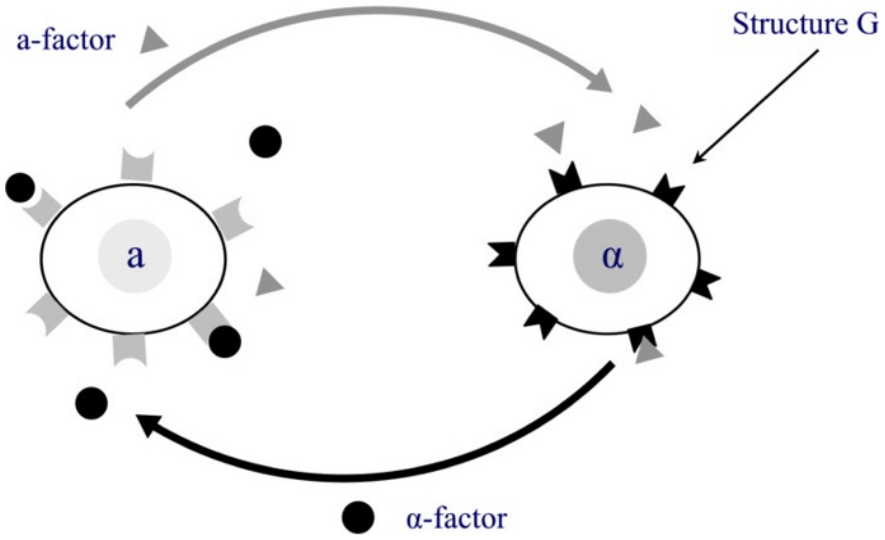
Mark allocation

- 1 mark – use of diagram if it contributes to a sensible explanation
- 1 mark – drug must be shown to selectively block enzyme
- 1 mark – normal functions of body cells not affected because transcription of RNA to DNA does not normally occur in human cells

Total 2 + 1 + 1 + 3 = 7 marks

Question 5

In the yeast *Saccharomyces cerevisiae*, there are two types, Mating Type **a** and Mating Type **α**. Cells of each type release a chemical signal, **a**-factor and **α**-factor respectively, which cause the cells to draw toward each other until they fuse and mate.



5a. What is Structure **G**?

1 mark

Solution

Receptor protein

Explanatory notes

- A receptor is a protein found embedded in the plasma membrane. A signalling molecule or a ligand (e.g. a neurotransmitter, a hormone, a drug or a toxin) will bind to the receptor, resulting in conformational change which triggers a cellular response.

5b i. **Mating Type a** has communicated with **Mating Type α** using a chemical called **a-factor**. What name is given to the type of communication between these cells that leads to the cellular response of mating?

1 mark

Solution

Cell signalling OR signal transduction pathway

5b ii. What is the sequence of stages associated with this process?

1 mark

Solution

Reception, transduction and response

Explanatory notes

There are three stages associated with cell signalling. Reception occurs when the target cell detects a signal coming from outside the cell (when the signalling molecule binds with the receptor protein). Transduction occurs as a result of the change in conformation of the receptor protein and usually involves relay molecules in a signal-transduction pathway. This stage converts a chemical signal to a form that will bring about a specific cellular response. The third stage of chemical signalling produces a specific cellular response.

The following information applies to Questions 5c and 5d.

The diagrams show two examples of cell communication in animals.

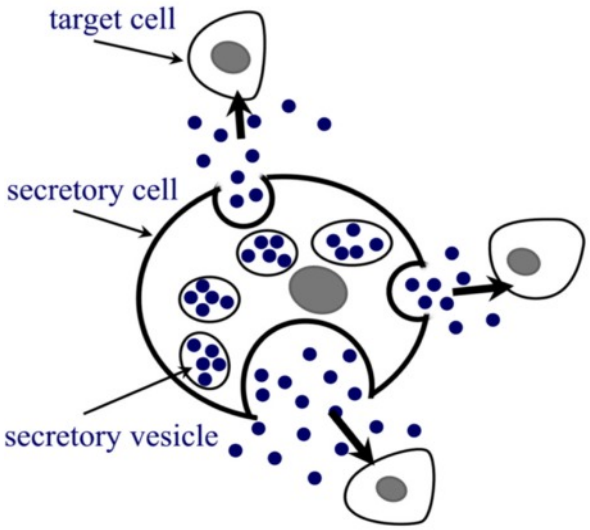


Diagram C

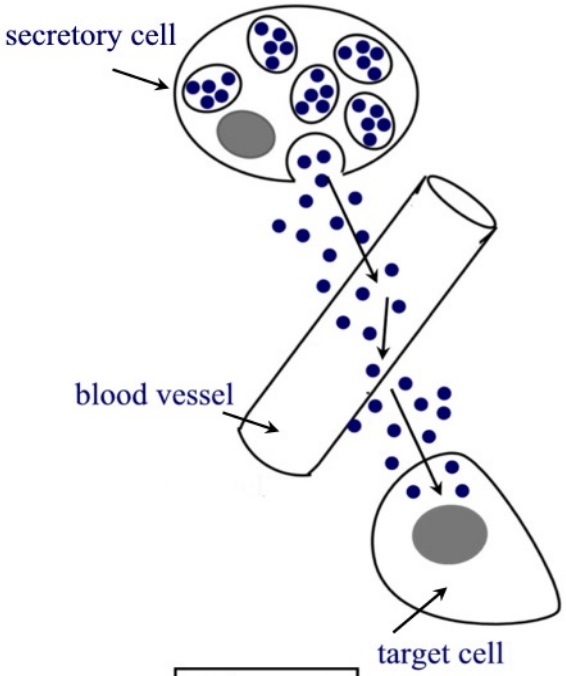


Diagram D

5c. Diagram C

Type of chemical signalling _____

Explain why chemicals involved in this kind of signalling can only be used on nearby cells.

2 marks

Diagram D

Type of chemical signalling _____

Provide a definition of the chemical involved in this signalling.

2 marks

Solution

Diagram C

Paracrine signalling

Paracrine hormones can only be used on nearby cells because they break down (become chemically bound or destroyed) soon after they are released.

OR

Nearby cells are the only cells with appropriate receptors to bind to these chemicals.

Diagram D

Endocrine signalling

Chemicals involved in endocrine signalling are released into the bloodstream and act on distant target cells.

Mark allocation

- 2 marks – paracrine AND paracrine hormones break down rapidly
- 2 marks – endocrine AND correct definition of a hormone

The following information applies to Question 5d.

Substance **W**, released from the secretory cell in **Diagram D** is hydrophobic.

5d i. How will Substance **W** be transported in the blood?

1 mark

Solution

Substance **W** will be transported by a carrier molecule in the blood.

Explanatory notes

Hormones that are hydrophobic do not dissolve in blood plasma and require a carrier molecule to be transported in the blood.

5d ii. Suggest a possible response triggered by Substance **W** when it reaches the target cell.

1 mark

Solution

Secretion of another hormone OR activation of an enzyme OR activation of DNA OR protein production.

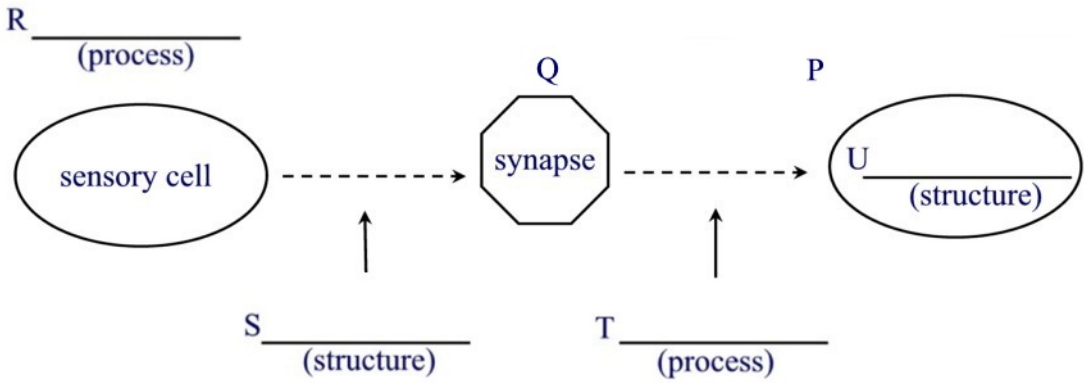
Explanatory notes

- When a signalling molecule (such as a hormone) reaches the receptor on its target cell, depending on the molecule it could trigger one of many possible responses including secretion of another hormone, activation of an enzyme, activation of DNA or protein production.

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

Question 6

In the nervous system, the transmission of a signal involves three mechanisms. These are represented in the diagram below.



6a. Complete the diagram by labelling the boxes.

2 marks

Solution

R – generation of impulse

S – sensory nerve

T – conduction

U – effector organ

Mark allocation

- 4 correct = 2 marks
- 3 or 2 correct = 1 mark
- 1 or 0 correct = 0 marks

6b. What is the process which occurs at **Q** and **P** during a nerve impulse?

1 mark

Solution

Synaptic transmission

Explanatory notes

Synaptic transmission is a form of chemical communication that occurs between two neurons or between a neuron and an effector cell. In contrast, a synapse is the point at which one neuron links to another.

A response stating that chemical communication occurs at **Q** and **U** is not specific enough.

6c. Give the name of the substance that is fundamental to the process named in Question **6b**. and identify a specific example.

1 mark

Solution

A neurotransmitter is fundamental to this process and an example could be acetylcholine OR noradrenaline OR epinephrine OR serotonin OR dopamine OR any other appropriate.

Explanatory notes

- A neurotransmitter is a chemical substance released from a nerve ending (neuron axon) in response to a nerve impulse. A neurotransmitter interacts specifically with receptors on a target cell, carrying the action potential across a synaptic cleft or gap. The neurotransmitter will stimulate or inhibit the target cell.

Total 2 + 1 + 1 = 4 marks

Question 7

Gastric ulcers are associated with the use of drugs, such as ibuprofen and aspirin, and also the presence of the spirochaete bacterium *Helicobacter pylori*. In a sample of individuals with gastric ulcers, 95% of the group tested positive for the presence of the bacterium.

7a. What would be the shape of *Helicobacter pylori*?

1 mark

Solution

Spiral – the term spirochaete means spiral.

Explanatory notes

- Bacteria can be described by a range of physical and chemical properties including shape, size, mode of locomotion, oxygen and nutritional requirements and reaction to Gram stain. Bacteria are found in three shapes – spherical (coccus), rod-like (bacillus) and spiral (spirochaete).

7b. What characteristic is common to all bacteria?

1 mark

Solution

They are all prokaryotes and therefore do not have membrane-bound nuclei or membrane-bound organelles.

Explanatory notes

- Whilst bacteria are described by a range of properties, the one characteristic they share is that they are all prokaryotic and therefore do not have membrane-bound nuclei or membrane-bound organelles. Typically they have a cell wall and one circular double-stranded thread of DNA.

7c. How does the bacterium survive in the environment of the stomach?

1 mark

Solution

The bacterium would produce a protective alkaline coating which would protect it from the acidic environment of the stomach.

Explanatory notes

- The stomach is highly acidic (pH 2) and the bacterium is capable of secreting an alkaline substance which coats the bacterium and 'neutralises' the effect of the acidic environment of the stomach.

The following information applies to Question 7d.

Antibiotic medication is usually prescribed in the event of a bacterial infection. Sometimes a full course can last for two weeks.

7d. Why is it essential to finish the full course of antibiotics even if the symptoms of the condition have ceased after four days of the treatment?

1 mark

Solution

Even though symptoms of infection have ceased, bacteria could still be present in low numbers and infection could return AND this can contribute to the problem of antibiotic resistance in bacteria.

Explanatory notes

- Reference to antibiotic resistance is important for the full mark.

Total 1 + 1 + 1 +1 = 4 marks

Question 8

In 2008, doctors in Spain replaced the damaged trachea (windpipe) of a woman, Claudia Castillo, with a windpipe created from her own stem cells. A donor windpipe was used as a scaffold for the stem cells to grow around. The procedure, a world first, is considered revolutionary because in the past organ transplants have never involved recipient tissue, only donor tissue. In the past, tracheal transplants using donor tissue have been associated with several side-effects including uncontrolled cell death (necrosis) and lethal bleeding.

8a i. What is a stem cell?

1 mark

Solution

An undifferentiated cell that is capable of differentiating into various other types of cell.

8a ii. Explain the advantage of Claudia Castillo's tracheal transplant over previous tracheal transplant procedures.

2 marks

Solution

Previous tracheal transplants procedures use donor tissue which is recognised as non-self and the risk of rejection by the immune system is high. In Claudia Castillo's transplant her own tissue is used which her immune system recognises as self, therefore there is no risk of rejection.

Explanatory notes

Claudia Castillo's transplant uses an organ/windpipe that is lined with cartilage grown from her own stem cells. These cells will be recognised as self and not rejected by the immune system. Previous transplant procedures have used donor organs, not exhibiting self antigens and therefore they will be rejected by the recipient immune system.

Mark allocation

- 1 mark – previous transplants use donor tissue, recognition of non-self, transplant rejected
- 1 mark – Castillo transplant uses self cells, recognition of self, transplant accepted

It has been standard practice to administer a drug such as cyclosporine to patients after they have received an organ transplant. Cyclosporine works (at a cellular level) to enhance the success of organ transplants.

8b i. What is the name of the process which normally prevents cancer in humans?

1 mark

Solution

Apoptosis

8b ii. Explain why the use of drugs like cyclosporine might be associated with a higher incidence of cancer in organ transplant patients.

2 marks

Solution

Cancer cells are normally detected and destroyed by T cells as part of the normal immune response. Drugs such as cyclosporine act by interfering with the signalling process of a cell to suppress the normal immune response.

Mark allocation

- 1 mark – cancer cells normally detected and destroyed as part of the immune response
- 1 mark – drugs interfere with signalling process of cell to suppress normal immune response

8c. What potential does the technique used for Claudia Castillo's tracheal transplant hold for the future of transplant technology?

1 mark

Solution

The technique can be developed and applied to other organ transplants eradicating the risk of organ rejection.

OR

The technique can be developed and applied to other organ transplants eliminating the need to use immunosuppressant drugs.

OR

The technique can be developed and applied to other organ transplants reducing the occurrence of cancer and other diseases that occur as a result of immunosuppressant use.

Total 1 + 2 + 1 + 2 + 1 = 7 marks

END OF SOLUTIONS BOOK