Question: 1

(a) The Calvin cycle is the stage of photosynthesis during which carbon dioxide is fixed. The Calvin cycle uses the products of the light dependent stage.

(i) Name the products of the light dependent stage that are used in the Calvin cycle.

[2]

(ii) Discuss the fate of triose phosphate (TP) in the Calvin cycle.

[3]

(b) A process known as photorespiration also takes place in photosynthetic cells. In this process, oxygen competes with carbon dioxide for the active site of the enzyme RuBP carboxylase (Rubisco).

Fig. 3.1 (a) and Fig. 3.1 (b) outline the processes of photosynthesis and photorespiration.

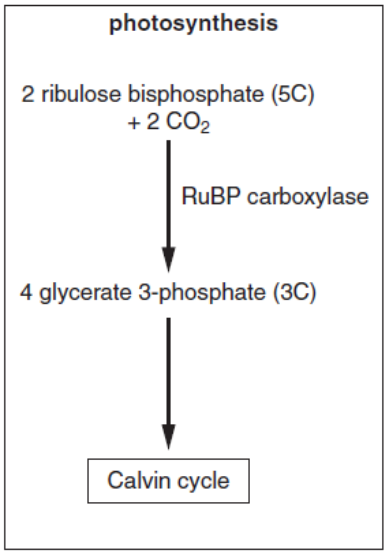


Fig. 3.1 (a)

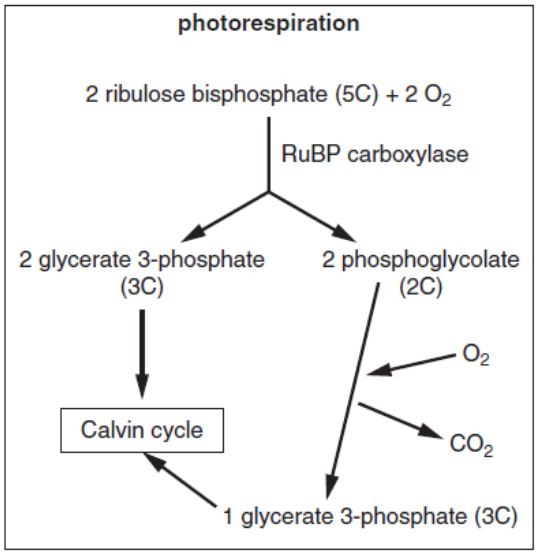


Fig. 3.1 (b)

(i) Suggest why the process outlined in Fig. 3.1 (b) is known as photorespiration.

_____

_____

_____

_____

_____

[2]

(ii) Using Fig. 3.1 (a) and Fig. 3.1 (b), describe and explain the likely effect on photosynthesis of an increase in the oxygen concentration.

_____

_____

_____

_____

_____

[3]

(iii) Some plants, known as C_4 plants, use an enzyme called PEP carboxylase, instead of Rubisco, to fix carbon dioxide.

Suggest why these plants do not show photorespiration.

_____

_____

_____

_____

_____

[1]
[Total: 11]

Question: 2

As part of a study to control Type 2 diabetes by modification of the diet, an investigation was carried out into the effects of different food compounds on the blood glucose and blood insulin concentrations of patients with this type of diabetes.

The food compounds, their components and their effect on blood glucose and blood insulin concentrations are summarised in Table 4.1.

Table 4.1

food compound	component(s)	effect on blood glucose concentration	effect on blood insulin concentration
sucrose	glucose and fructose	moderate increase	moderate increase
lactose	glucose and galactose	moderate increase	moderate increase
starch	glucose	substantial increase	substantial increase
cellulose	glucose	no effect	no effect
protein	amino acid	no effect	moderate increase
fat	fatty acid and glycerol	no effect	moderate increase

(a) Suggest an explanation for the differences observed in blood glucose concentration:

(i) between starch and sucrose,

_____

_____

_____

_____

_____

[2]

(ii) between starch and cellulose.

_____

_____

_____

_____

_____

[2]

(b) With reference to the food compounds in Table 4.1, explain how a person with Type 2 diabetes could control the condition by modifying their diet.

_____

_____

_____

_____

_____

[3]

(c) Glycogen and glucagon are compounds that are involved in the control of blood glucose concentration.

Complete the table below to distinguish between these two compounds.

	glycogen	glucagon
type of compound		
role of compound		
site of production		

[3]
[Total: 10]

Question: 3

Fig. 5.1 is a trace that shows the changes that occur in the membrane potential of a neurone during the generation of an action potential

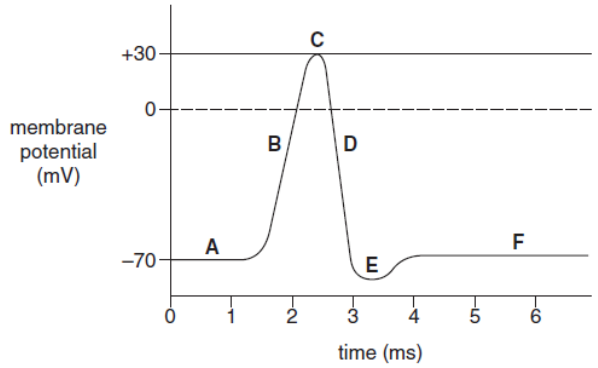


Fig. 5.1

.

(a) Using the letters A to F, indicate the point or points on the trace which correspond to the following:

(i) hyperpolarisation,

[1]

(ii) resting potential,

[1]

(iii) the membrane is most permeable to potassium ions,

[1]

(iv) depolarisation.

[1]

(b) Puffer fish, *Fugu spp.*, produce a powerful poison, tetradotoxin, and some species store it in high concentrations in their body tissues. Unless these fish are correctly prepared, eating them can be fatal.

Tetradotoxin is poisonous to humans because it blocks gated sodium channels in cell membranes, preventing action potentials. This does not happen in the fish themselves.

(i) With reference to Fig. 5.1, identify, using the appropriate letter, the part of the action potential trace that will be affected by tetradotoxin.

[1]

(ii) Suggest why tetradotoxin is not toxic to the puffer fish.

[1]

(c) Multiple sclerosis (MS) is an auto-immune condition in which the nervous system is damaged. This damage leads to loss of sensation. One form of damage is shown in Fig. 5.2.

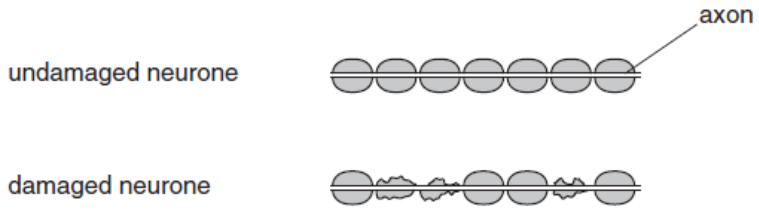


Fig. 5.2

(i) Suggest why MS is described as an auto-immune condition.

_____

_____

_____

_____

_____

[2]

(ii) Explain why this damage leads to a loss of sensation.

_____

_____

_____

_____

_____

[2]
[Total: 10]

Question: 4

The liver is an organ that is metabolically very active, carrying out over 500 different functions. Some of its important functions include converting chemicals including toxins, into other compounds.

Fig. 2.1 outlines some of the reaction pathways that take place in the liver cells.

The ***underlined words*** represent toxic compounds.

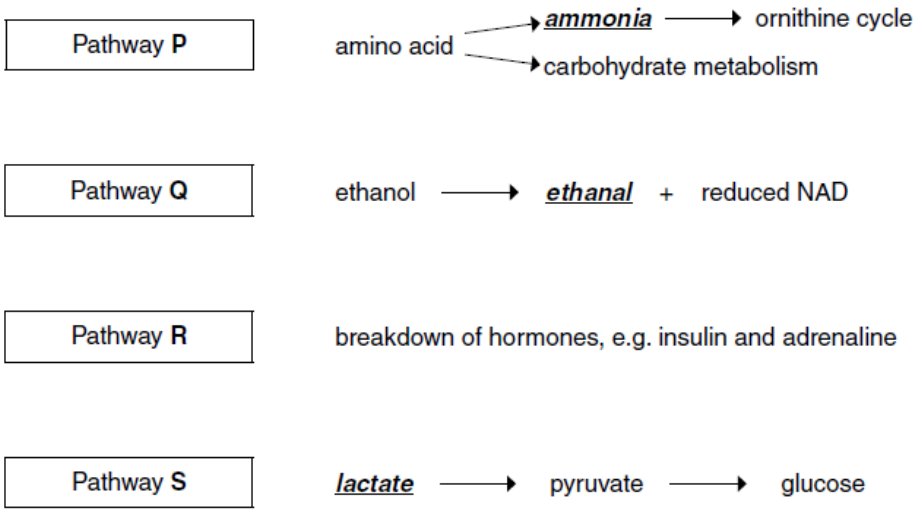


Fig. 2.1

(a) (i) State the product of the ornithine cycle in Pathway P and the organ to which this product is transported for removal from the body.

product .....

_____

_____

_____

_____

_____

organ the product is transported to .....

_____

_____

_____

_____

_____

[2]

(ii) The lactate that enters pathway S is produced by cells, such as muscle cells, undergoing anaerobic respiration.

Suggest why this lactate is converted into pyruvate by the hepatocytes (liver cells) rather than by the respiring cells in which it is produced.

[1]

(b) Insulin only remains in the bloodstream for a relatively short time. Pathway R breaks down insulin in the liver.

Explain what might happen to a person if the liver did not break down insulin.

[2]

(c) Alcohol (ethanol) is oxidised in the liver by Pathway Q. If a person has a high alcohol intake, it will result in the production of excess reduced NAD.

(i) Excess reduced NAD in the liver cells will influence some metabolic pathways by:

- inhibiting the conversion of lactate to pyruvate
- inhibiting fatty acid oxidation
- promoting fatty acid synthesis.

Using this information and the information in Fig. 2.1, suggest the consequences for liver metabolism if a person has a regular high alcohol intake.

[2]

(ii) State precisely where in the liver cell the excess reduced NAD can be re-oxidised.

[1]
[Total: 8]

Question: 5

(a) Explain what is meant by the terms *autotroph* and *heterotroph*.

autotroph .....

_____

_____

_____

_____

_____

heterotroph .....

_____

_____

_____

_____

_____

[2]

(b) Fig. 3.1 is a transmission electron micrograph showing part of a chloroplast, including some of the internal membranes.

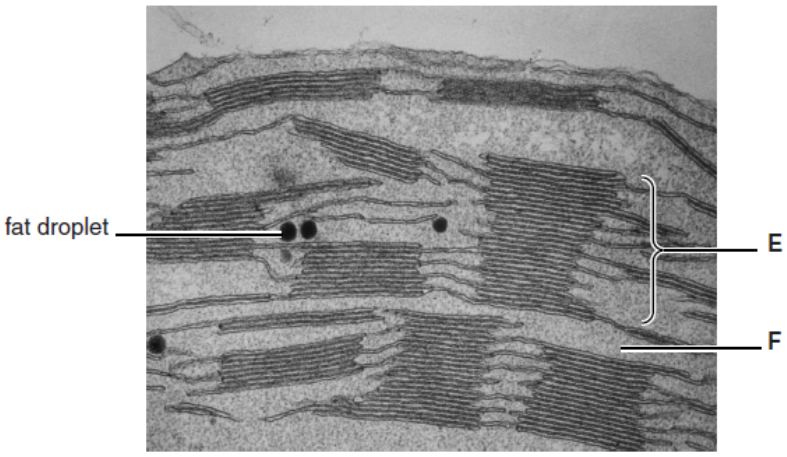


Fig. 3.1

(i) Identify E and F in Fig. 3.1.

E .....

F .....

[2]

(ii) The chloroplast contains fat droplets, as shown in Fig. 3.1. These act as a reserve of raw material for the chloroplast.

Suggest what this raw material might be used for in the chloroplast.

[1]

(c) Fig. 3.2 represents the light harvesting system found on the surface of the internal membranes of the chloroplast.

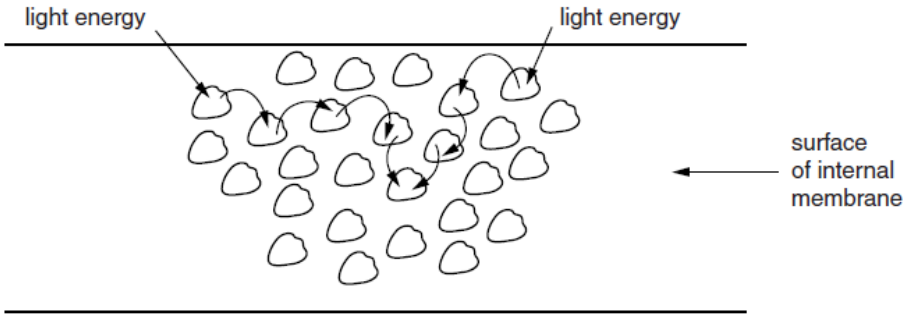


Fig. 3.2

Use the information in Fig. 3.2 to describe how light is harvested in the chloroplast membranes.

In your answer, you should use appropriate technical terms, spelled correctly.

[5]

(d) Many herbicides act by inhibiting photosynthesis in weeds. A series of research studies were carried out to evaluate the effectiveness of a triazine herbicide on the yield of a crop of corn, *Zea mays*. Some of the data obtained is shown in Table 3.1.

Study	Plots not treated with herbicide		Plots treated with herbicide		Yield difference with herbicide	
	Number of plots	Mean yield ($kg\,ha^{-1}$)	Number of plots	Mean yield ($kg\,ha^{-1}$)	($kg\,ha^{-1}$)	(%)
A	90	8321.4	51	8756.9	+435.5	+5.2
B	21	10344.8	3	11457.0	+1112.2	+10.8
C	30	10411.8	14	10954.5	+542.7	+5.2
D	20	13982.9	7	13607.7	–375.2	–2.7
E	2	6532.5	8	11041.6	+4509.1	+69.0
F	66	8750.2	63	8971.3	+221.1	+2.5
G	17	11671.4	7	10807.1		

Table 3.1

(i) Calculate the yield difference caused by the application of herbicide in study G.

Show your working.

Answer = ... $kgha^{-1}$
..... %

[2]

(ii) Suggest why the researchers concluded that the data obtained from Study E was not useful in evaluating the effectiveness of the herbicide.

[1]

(iii) Triazine herbicide acts on the weeds by binding to a specific protein associated with photosystem II, blocking the movement of electrons between electron carriers.

Explain the effect that the herbicide binding to this protein will have on photosynthesis.

[2]

(iv) Plants treated with triazine herbicide can, when illuminated under experimental conditions, be seen to fluoresce (emit light) and give off small quantities of heat.

Suggest how this experimental finding could be explained.

[1]
[Total: 16]

Question: 6

(a) Fig. 1.1 represents a sensory neurone connected to its associated receptor cells.

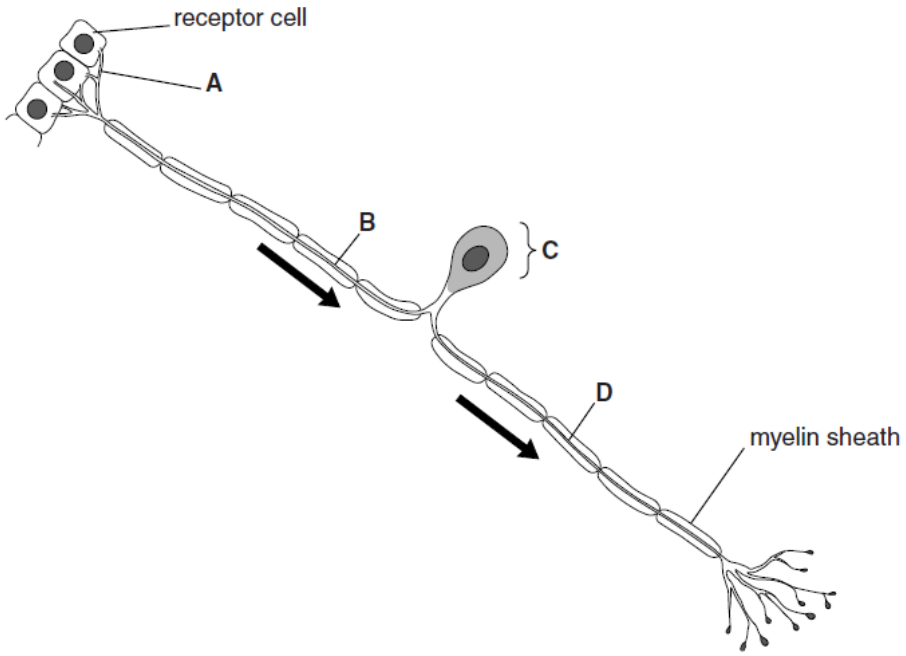


Fig. 1.1

(i) Identify the parts of the neurone labelled A to D.

A .....

_____

_____

_____

_____

_____

B .....

_____

_____

_____

_____

_____

C .....

_____

_____

_____

_____

_____

D .....

[4]

(ii) What is represented by the arrows on Fig. 1.1?

[1]

(b) Describe and explain how the resting potential is established and how it is maintained in a sensory neurone.

In your answer, you should use appropriate technical terms, spelled correctly.

[4]

(c) Fig. 1.2 shows the changes in the membrane potential of a sensory neurone when the receptor cells are stimulated.

Fig. 1.3 indicates the strength of the stimuli that results in the corresponding changes in membrane potential.

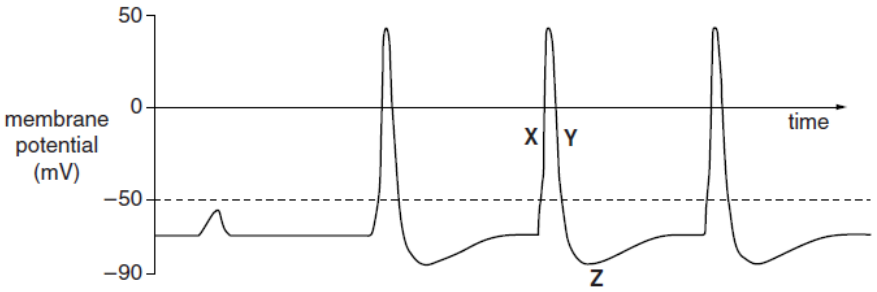


Fig. 1.2

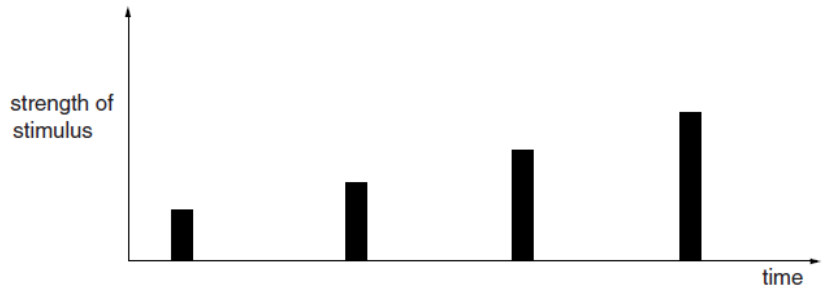


Fig. 1.3

(i) State the term used to describe what is happening at each of the points X, Y and Z on Fig. 1.2.

X .....

Y .....

Z .....

[3]

(ii) What term is used to refer to the value of −50 mV on Fig. 1.2?

[1]

(iii) Comment on the relationship between the strength of a stimulus, as shown in Fig. 1.3, and the resulting action potential, as shown in Fig 1.2.

[2]
[Total: 15]

Question: 7

The kidney is a vital organ in the body and is responsible for excretion. It also plays an important role in homeostasis.

(a) Complete the passage, using the most suitable term in each case.

The blood in the glomerulus has a high _____ pressure, which forces small molecules, such as glucose and _____ , out of the glomerulus and into the lumen of the Bowman's capsule. This process is known as _____ .

In the proximal convoluted tubule, the glucose, most of the _____ and some of the salts are reabsorbed into blood _____ that surround the nephron at this point.

[5]

(b) One aspect of the kidney's homeostatic role is the ability of anti-diuretic hormone (ADH) to increase the number of aquaporins in the plasma membranes of the cells lining the collecting duct. This increases the amount of water reabsorbed.

ADH is released in response to a decrease in the water potential of the blood plasma.

(i) State precisely where the cells that detect a decrease in the water potential of the blood plasma are found.

_____

_____

_____

_____

_____

[1]

(ii) Name the cells that detect this decrease.

_____

_____

_____

_____

_____

[1]

(c) Fig. 6.1 outlines some of the events that take place if the blood volume decreases, for example, due to a significant loss of blood.

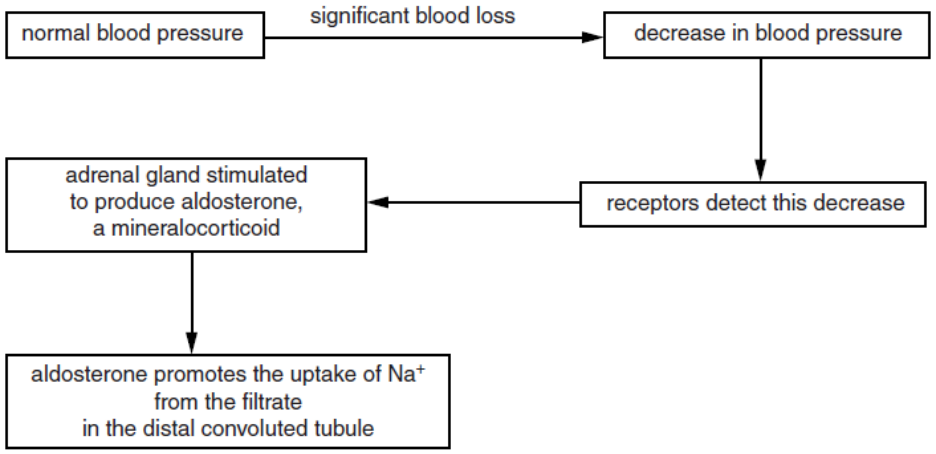


Fig. 6.1

(i) Name the part of the adrenal gland that releases aldosterone.

[1]

(ii) Suggest and explain what effect the action of aldosterone will have on the secretion of ADH.

[2]

(iii) As the action of aldosterone takes effect, this is detected by receptors in the body and secretion of aldosterone decreases.

State the name of the mechanism that results in this decrease in aldosterone secretion.

[1]
[Total: 11]

Question: 8

(a) Fig. 1.1 represents a cross section through a myelinated neurone.

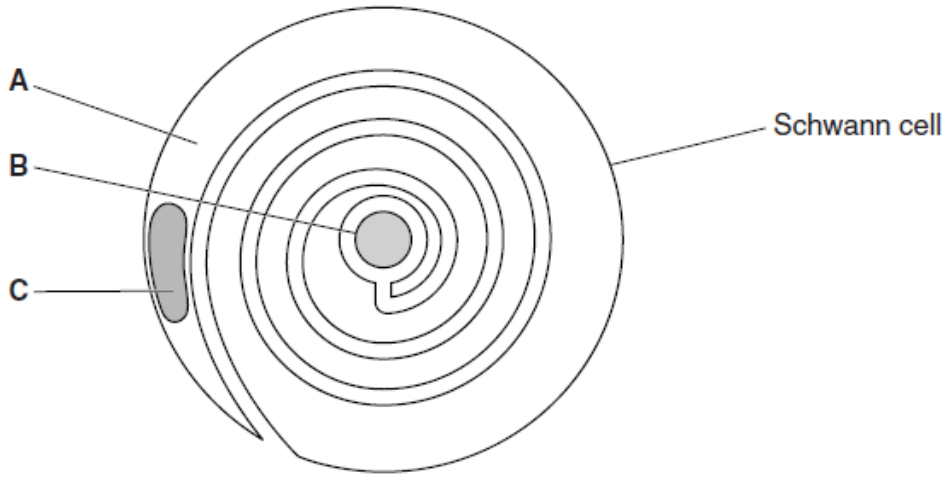


Fig. 1.1

(i) Identify A to C.

A .....

B .....

C .....

[3]

(ii) Name the gap between two adjacent Schwann cells along the length of the neurone.

[1]

(b) There are a number of differences between myelinated and non-myelinated neurones. One difference is the distribution of voltage-gated sodium ion channels in the membrane.

myelinated neurone

- voltage-gated sodium ion channels only occur at gaps between Schwann cells
- each gap is approximately 2 μm long
- gaps occur at approximately 1000 μm intervals

non-myelinated neurone

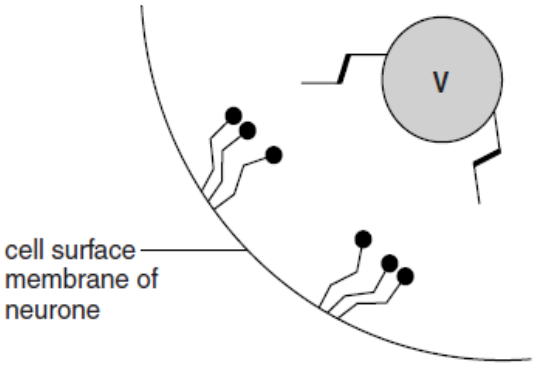
- voltage-gated sodium ion channels occur along the total length of the neurone

Use the information above to explain the difference in the speed of conduction of an action potential along the length of a myelinated neurone and a non-myelinated neurone.

[4]

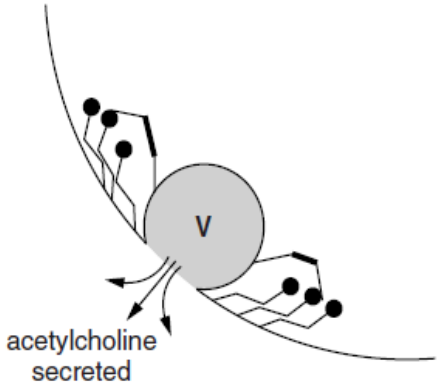
(c) A family of membrane proteins known as SNARE proteins are attached to vesicle membranes and cell surface membranes.

Fig. 1.2 summarises the mechanism by which vesicles secrete acetylcholine from a neurone.



Vesicle (**V**) has a type of SNARE protein attached to its membrane. This protein is known as vesicle associated membrane protein (VAMP).

The cell surface membrane of the neurone has a complex of SNARE proteins attached to it.



When the VAMP protein locks onto the SNARE complex, it enables the vesicle membrane to fuse with the cell surface membrane. This allows secretion of acetylcholine from the neurone.

Fig. 1.2

(i) Name the process by which the acetylcholine is secreted.

_____

_____

_____

_____

_____

[1]

(ii) Name the part of a neurone from which acetylcholine is secreted.

_____

_____

_____

_____

_____

[1]

(iii) Botulinum toxin is a protease that is produced by the bacterium, *Clostridium botulinum.*

If this toxin is present in the body, for example as a result of eating contaminated food, the toxin enters neurones.

With reference to Fig. 1.2, suggest, with reasons, the effects that botulinum toxin may have once it has entered a neurone.

_____

_____

_____

_____

_____

[2]
[Total: 12]

Question: 9

The maintenance of a stable body temperature is an important aspect of homeostasis in endotherms. This is known as thermoregulation.

(a) (i) State where the core body temperature is monitored.

[1]

(ii) Name the type of sensory cell in the skin that detects changes in environmental temperature.

[1]

(iii) Name the corrective homeostatic mechanism that works to restore any changes in body temperature to the normal range.

[1]

(b) Endotherms respond in different ways to changes in environmental temperature. Some of these responses are listed below:

J	secretion of adrenaline
K	sweating
L	shivering
M	contraction of erector pili muscles (attached to base of hairs)
N	curling up
O	finding shade
P	vasoconstriction of arterioles near to skin surface

Use the letters, J to P, to identify:

(i) the responses that conserve heat.

_____

_____

_____

_____

_____

[1]

(ii) the responses that cool the body.

_____

_____

_____

_____

_____

[1]

(iii) a physiological response that generates heat.

_____

_____

_____

_____

_____

[1]

(iv) a behavioural (not physiological) response to a decrease in environmental temperature.

[1]

(c) Different endotherms have evolved different physiological and behavioural adaptations to assist with temperature control.

Explain how each of the following adaptations help the animal to control its body temperature.

(i) Elephants have large, thin ears that they move backwards and forwards when hot.

[2]

(ii) Penguins living in cold climates have 'shunt' blood vessels. These shunt vessels link arterioles carrying blood towards their feet with small veins that carry blood away from their feet.

[1]
[Total: 10]

Question: 10

Organisms respond to changes in their internal environment. These responses are controlled by nervous and hormonal mechanisms.

(a) The concentration of blood glucose is regulated by hormones.

Complete the passage below, using the most suitable term in each case.

The pancreas releases hormones directly into the blood and these regulate the concentration of blood glucose. The pancreas, therefore, acts as an _____ gland.

When the blood glucose concentration increases, insulin is released from the beta cells in the regions of the pancreas known as the _____ .

A different hormone, glucagon, is released from the alpha cells of the pancreas and this hormone causes _____ to be broken down into glucose, in a process known as _____ .

[4]

(b) The heart rate is controlled by both nervous and hormonal mechanisms.

(i) Name one hormone which will increase the heart rate.

_____

_____

_____

_____

_____

[1]

(ii) State one way in which the nervous system decreases the heart rate.

_____

_____

_____

_____

_____

[1]
[Total: 6]

Question: 11

The molecules listed below are all associated with photosynthesis.

amino acid	reduced NADP
ATP	ribulose bisphosphate (RuBP)
carbon dioxide	rubisco
glycerate-3-phosphate (GP)	triose phosphate (TP)
oxygen	water

From these molecules, identify:

(a) the enzyme.

[1]

(b) a product of the light-dependent reaction that is used in the light-independent reaction.

[1]

(c) a 3-carbon compound.

[1]

(d) a compound that can be made from TP but is not part of the Calvin cycle.

[1]

(e) a 5-carbon compound.

[1]

(f) a product of the light-dependent reaction that is not used in the light-independent reaction.

[1]
[Total: 6]

Question: 12

Biological terms are often used incorrectly. This may be because they have similar spelling or refer to similar structures.

glucagon	*glycogenolysis*
gluconeogenesis	*glycolysis*
glycogen	*insulin*
glycogenesis	*negative feedback*

Select from the list above, the term(s) that refer to:

(a) a stage in respiration

[1]

(b) hormone(s)

[1]

(c) process(es) that produce glucose

[1]

(d) process(es) that have glucose as a starting point

[1]
[Total: 4]

Question: 13

(a) Adenosine tri-phosphate (ATP) is an important product of respiration. The ATP molecule is made up of five sub-units, as shown in Fig. 5.1.

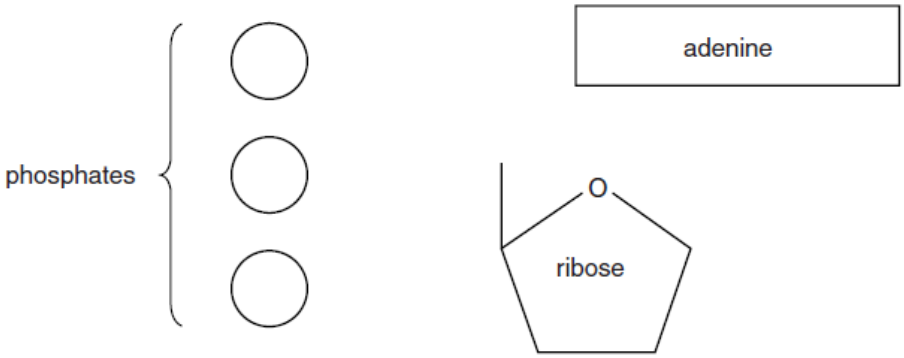


Fig. 5.1

(i) In the space below, indicate how these sub-units are joined in a molecule of ATP.

[2]

(ii) Suggest the type of reaction that removes a phosphate group from an ATP molecule.

_____

_____

_____

_____

_____

[1]

(b) The formation of ATP is now widely accepted as being achieved by the process of chemiosmosis.

Various pieces of evidence have been documented to support this theory. Three of these are described below.

1	In isolated mitochondria that have had their outer membranes removed, electron transfer takes place but the mitochondria are unable to produce ATP.
2	The pH of the inter-membrane space is lower than the pH inside the rest of the mitochondrion.
3	The outer mitochondrial membrane is permeable to protons. If isolated mitochondria are supplied with ADP and inorganic phosphate and placed in a solution of pH 8, no ATP is produced. If, however, these mitochondria are placed in an acidic solution, ATP is produced.

Identify the pieces of evidence above, 1, 2 or 3, that supports each of the following statements about the theory of chemiosmosis.

Write 'none' if a statement is not supported by any of the pieces of evidence above.

(i) Electron transfer occurs on the inner membrane of the mitochondrion.

_____

_____

_____

_____

_____

[1]

(ii) Protons are actively pumped across the inner mitochondrial membrane into the inter-membrane space.

_____

_____

_____

_____

_____

[1]

(iii) Protons accumulate in the inter-membrane space.

_____

_____

_____

_____

_____

[1]

[Total: 6]

Question: 14

As blood passes through the kidney it is filtered and the urine formed in the nephron leaves the kidney through the ureter.

Table 3.1 below shows the concentration of some of the components of blood, glomerular filtrate and urine.

Component	Blood ($g\,100\,cm^{-3}$)	Glomerular filtrate ($g\,100\,cm^{-3}$)	Urine ($g\,100\,cm^{-3}$)
Glucose	0.10	0.10	0.00
Urea	0.03	0.03	1.80
Amino acids	0.05	0.05	0.00
Large proteins	8.00	0.00	0.00
Inorganic ions (total)	0.90	0.90	variable, up to 3.60

Table 3.1

Table 3.2 below shows the presence or absence of erythrocytes in blood, glomerular filtrate and urine.

Component	Blood	Glomerular filtrate	Urine
Erythrocytes	present	absent	absent

Table 3.2

(a) Explain the changes in fluid composition shown in Table 3.1 and Table 3.2.

In your answer, you should use appropriate technical terms, spelled correctly.

[5]

(b) Kidney function can be assessed by measuring the Glomerular Filtration Rate (GFR). GFR is a measure of the rate at which blood is filtered by the kidneys.

The GFR is estimated using the concentration of creatinine in the blood plasma. This compound is produced naturally by the body and is normally filtered from the blood by the kidneys and excreted.

(i) Suggest what a high concentration of creatinine in the blood plasma indicates about kidney function. Give a reason for your answer.

_____

_____

_____

_____

_____

[1]

(ii) A formula is used to obtain a value for GFR that takes into account the various factors that contribute to concentration of creatinine in the blood.

GFR is expressed as $cm^3\ min^{-1}$.

A typical person is assumed to have a body surface area of 1.73 m^2.

In order to obtain an estimate of GFR (eGFR) for individuals who are smaller or larger than a typical person, the following calculation is performed:

$$\text{eGFR} = \text{GFR} \times \frac{1.73}{\text{individual's body surface area}}$$

A man has a GFR of 82 $cm^3\ min^{-1}$ and a body surface area of 2.56m^2.

Calculate the eGFR for this man.

Show your working and give your answer to the nearest whole number.

eGFR = _____ $cm^3\ min^{-1}$

[2]

(iii) Chronic Kidney Disease (CKD) is divided into five stages according to the eGFR value.
These stages are listed in Table 3.3 below.

CKD stage	eGFR ($cm^3\,min^{-1}$)	Effect on kidney
1	greater than 90	little or no damage
2	60 – 90	some or no damage
3	30 – 59	moderate reduction in function
4	15 – 29	severe reduction in function
5	less than 15	kidney failure

Table 3.3

Use the information in Table 3.3 to:

- identify the CKD stage indicated by the eGFR that you calculated in (b)(ii)
- determine the effect on the kidney of this man.

stage _____ effect on kidney _____

[1]

(c) The following are some of the pieces of information relating to kidney transplantation that have appeared in some news items during the last 15 years.

November 2002

The trade in human organs is growing. One woman sold her kidney for £400 (two year's worth of her wages) to an agent. The agent then sold it for an estimated £20 000 to a man who was in desperate need of a transplant.

November 2010

A private medical group has admitted to the charge of carrying out illegal kidney transplants at one of its hospitals. The people from whom the kidneys were taken were poor and some were below the legal age of consent. They were paid for the kidneys, which were sold to wealthy people who needed transplants.

April 2011

The number of people donating one of their kidneys for transplant is increasing year by year. The donor receives no payment, undergoes months of medical and psychiatric tests, and cannot specify who receives their kidney. While the numbers of donors are still small compared to the numbers needing a kidney transplant, each kidney donated is making the difference between life and death for someone.

Discuss, with reference to the information given on page 12, whether it is ethical for live donors to be used as a source of kidneys for transplantation.

_____

_____

_____

_____

_____

[3]
[Total: 12]

Question: 15

(a) Glycolysis is the initial stage of cellular respiration.

(i) State precisely where in the cell glycolysis occurs.

[1]

(ii) Outline the process of glycolysis.

In your answer, you should use appropriate technical terms, spelled correctly.

[4]

(b) Yeast cells can carry out anaerobic respiration.

Fig. 5.1 outlines the process of anaerobic respiration in yeast.

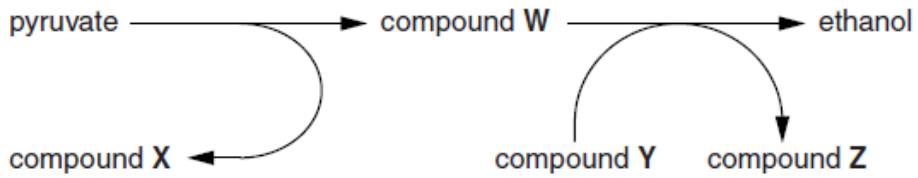


Fig. 5.1

Identify the compounds W to Z.

W .....

X .....

Y .....

Z .....

[4]

(c) In South-East Asia the main source of commercial sugar is the palm, *Borassus flabellifer*. Sap of this species has a high sugar content. Yeasts and bacteria, however, can contaminate the sap as it is collected and ferment the sugar, producing ethanol. This contamination makes it less suitable as a source of sugar.

A study was carried out to investigate the effect of three treatments traditionally used to reduce fermentation during the collection of the sap. The sap is treated in one of the following ways:

- with a weak alkaline solution (treatment A)
- with bark from the tree *Vateria copallifera* (treatment V)
- with bark from the tree *Careya arborea* (treatment C)

The sap was collected from the palm trees over a 60-hour period. Samples of the collected sap were taken at 15 hour intervals. In each sample, the concentration of alcohol and the number of bacteria were recorded.

The results are shown in Table 5.1.

Treatment	Sample time (hours)	Alcohol concentration (%)	Number of bacteria ($10^6\,cm^{-3}$)
Control (no treatment)	15	0.2	19
	30	3.5	800
	45	5.2	2200
	60	2.6	3400
A	15	0.0	3
	30	0.1	4
	45	0.2	5
	60	0.3	7
V	15	0.2	110
	30	1.1	2900
	45	1.2	2400
	60	1.8	2000
C	15	0.4	230
	30	1.1	160
	45	1.3	3
	60	3.6	40

Table 5.1

(i) With reference to Table 5.1, describe the effect of the different treatments on the alcohol concentration of the treated samples compared with the control samples.

[2]

(ii) Suggest a reason for the difference in alcohol concentration at 60 hours between the two bark treatments V and C.

[1]

(iii) To be used as a source of commercial sugar, the sap needs to be as uncontaminated as possible.

Suggest, with a reason, which of the treatments shown in Table 5.1 would be the best for use with sap so that it is suitable as a source of commercial sugar.

[2]
[Total: 14]