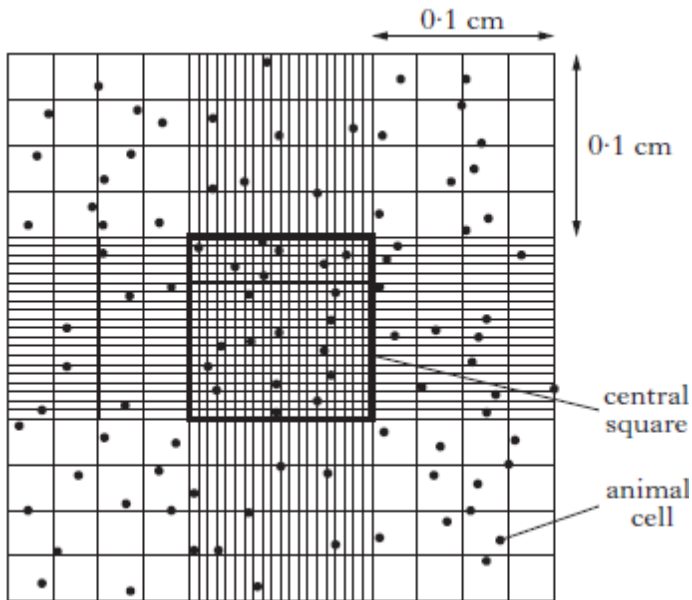


Homework 1

Q1 The diagram below shows a haemocytometer counting chamber containing animal cells. The depth of the chamber is 0.01 cm.



The concentration of animal cells, based on the cell count from the central square, is

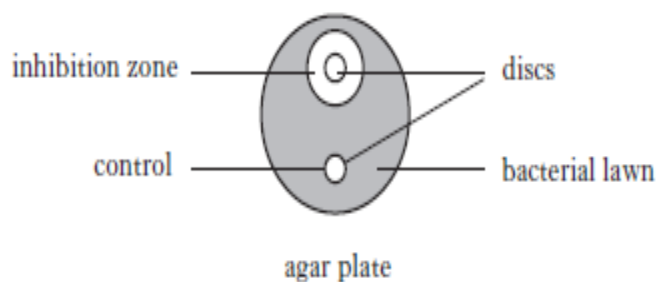
- A  $2.0 \times 10^4$  cells per  $\text{cm}^3$
- B  $2.0 \times 10^5$  cells per  $\text{cm}^3$
- C  $2.0 \times 10^6$  cells per  $\text{cm}^3$
- D  $2.0 \times 10^7$  cells per  $\text{cm}^3$ .

Q2 The information in the table explains terms that might be encountered by a scientist when reading scientific publications. Which line in the table is not correct?

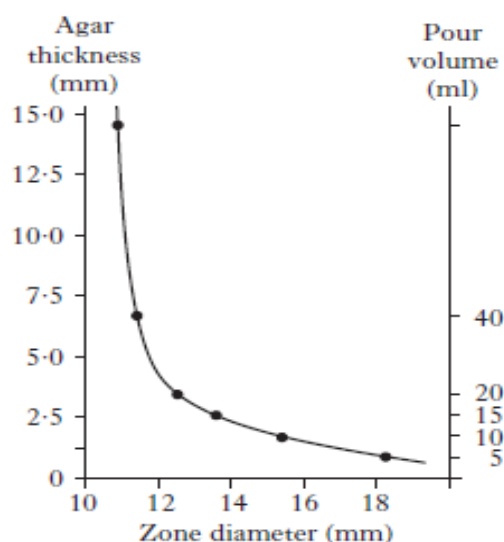
	<i>Term</i>	<i>Explanation</i>
A	Pilot study	allows modification of experimental design
B	Hypothesis	proposes an association between independent and dependent variables
C	Positive control	provides results in the absence of the treatment
D	Confidence interval	indicates variability of data around a mean

Q4 Substances can be screened for antibiotic effects using the diffusion plate method. In this method, filter paper discs soaked in the test substance are laid on a “lawn” of bacterial culture freshly spread on a nutrient agar plate. A clear zone in the lawn around the disc occurs where the diffusing antibiotic stops growth

The distance any substance travels in the agar depends on a range of factors that affect its rate of diffusion: these factors are confounding variables. In an experiment to evaluate one of these confounding variables, plates were made up by pouring different volumes of nutrient agar, creating different agar thicknesses. The results graph from the research paper is shown below.

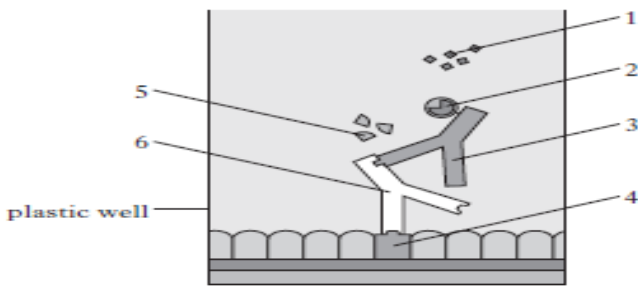


The distance any substance travels in the agar depends on a range of factors that affect its rate of diffusion: these factors are confounding variables. In an experiment to evaluate one of these confounding variables, plates were made up by pouring different volumes of nutrient agar, creating different agar thicknesses. The results graph from the research paper is shown below.



- (a) What is meant by the term confounding variable? 1
- (b) In this experiment identify the independent variable. 1
- (c) Describe the results of the experiment. 1
- (d) Plates poured and stored for use at a later date gradually lose water by evaporation. Explain why results of experiments involving the diffusion plate method may be invalid when using stored plates. 1

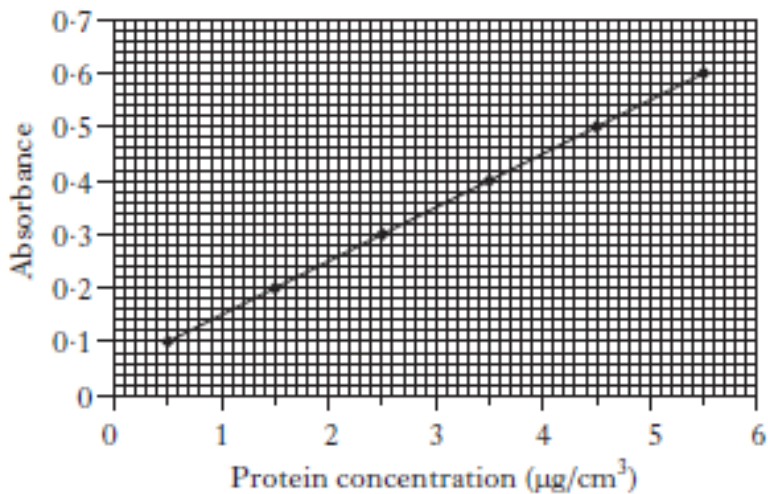
Q5 The diagram below represents a well in an immunoassay kit testing a blood sample from a person who may have been exposed to a virus. The substrate has been broken down to form a coloured product, so the result is positive



Which line in the table correctly identifies the roles of numbered components?

	<i>Antigen</i>	<i>Antibody</i>	<i>Enzyme</i>	<i>Substrate</i>
<b>A</b>	4	3	2	1
<b>B</b>	5	2	3	6
<b>C</b>	4	6	5	2
<b>D</b>	6	3	2	5

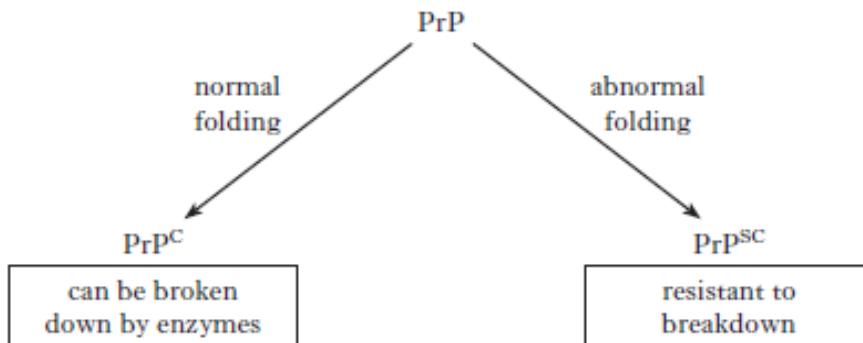
Q6 Colorimetry was used to produce the standard curve below.



In an experiment to extract soluble protein from potato tubers, 25 g tissue was ground with 50 cm<sup>3</sup> of buffer and centrifuged. The volume of extract produced was 65 cm<sup>3</sup>. When 1 cm<sup>3</sup> of extract was tested, the absorbance was found to be 0.5. Which of the following is the protein content of the potato tissue in µg/g fresh tissue?

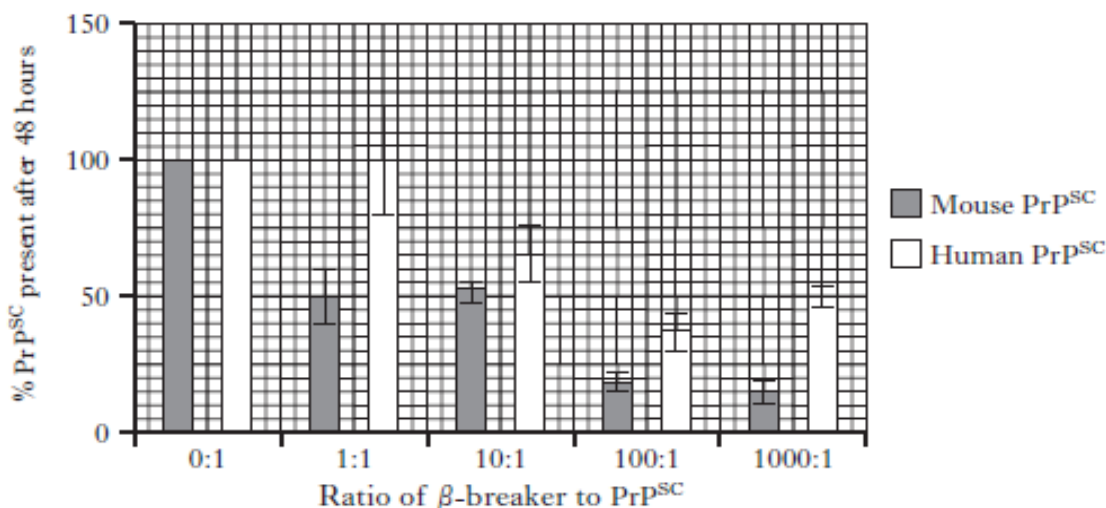
- A 3.9
- B 9.0
- C 11.7
- D 13.5

Q7 Bovine spongiform encephalopathy (BSE) and variant Creutzfeldt-Jakob disease (vCJD) are examples of fatal brain disease that can pass from one species to another. The nature of the infectious agent is as yet unidentified but, in both diseases, a protein known as PrP<sup>Sc</sup> accumulates in brain tissue. It has been shown that PrP<sup>Sc</sup> is an altered form of the normal membrane protein PrP<sup>C</sup>. Both molecules have the same primary structure (PrP) but they differ in how the PrP protein folds. Molecules of PrP<sup>Sc</sup> have a lower proportion of  $\alpha$ -helix and a higher proportion of  $\beta$ -sheets. Proteins are normally broken down after a certain length of time by intracellular enzymes. However, the increased  $\beta$ -sheet content makes PrP<sup>Sc</sup> more resistant to enzymatic breakdown, which leads to its accumulation



A substance capable of breaking  $\beta$ -sheets ( $\beta$ -breaker) was tested to find out if it could make PrP<sup>Sc</sup> more susceptible to the intracellular enzymes. PrP<sup>Sc</sup> samples from mice and humans were each incubated for 48 hours with different concentrations of  $\beta$ -breaker and the percentage of PrP<sup>Sc</sup> remaining after digestion was determined. The results are shown in the Figure on Page ten. In the same study, mouse PrP<sup>Sc</sup> was further analysed to determine if any change in the proportions of  $\alpha$ -helix and  $\beta$ -sheet had occurred. The results are shown in Table 1. In a second study, mice were treated with infectious material containing (i) PrP<sup>Sc</sup> and (ii) a 1:1 mixture of PrP<sup>Sc</sup> and  $\beta$ -breaker. Quantities of PrP<sup>Sc</sup> were equivalent in both treatments. Table 2 shows the mean time to onset of symptoms of brain disease in the two groups. Different concentrations of PrP<sup>Sc</sup> were prepared by diluting stock solutions

Figure: The effect of  $\beta$ -breaker on mouse and human PrP<sup>Sc</sup>



**Table 1: Proportions of secondary structure in mouse PrP<sup>SC</sup> before and after 48 hours incubation with  $\beta$ -breaker.**

Secondary structure	Proportions of secondary structure (%)	
	Before incubation	After incubation
$\alpha$ -helix	18	27
$\beta$ -sheet	36	9

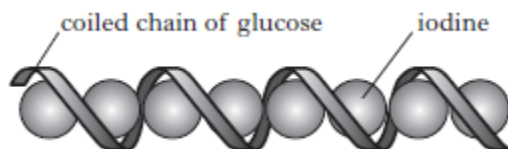
**Table 2: Time to onset of symptoms for mice treated with PrP<sup>SC</sup> with and without  $\beta$ -breaker.**

PrP <sup>SC</sup> concentration (relative to stock solution)	Time to onset of symptoms (days)	
	PrP <sup>SC</sup>	PrP <sup>SC</sup> + $\beta$ -breaker
$1 \times 10^{-2}$	129	143
$1 \times 10^{-3}$	145	159
$1 \times 10^{-4}$	173	185

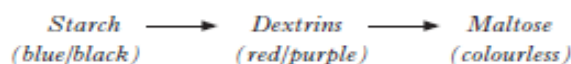
- (a) (i) PrPC and PrPSC have the same primary structure. Why should they be expected to fold in an identical way? 1
- (ii) Hydrogen bonds are important in the folding of proteins. Name two other types of interaction involved in protein folding. 1
- (b) Refer to the data in the Figure. The error bars represent confidence intervals.
- (i) What do the confidence intervals show about the data collected? 1
- (ii) How are confidence intervals used in the analysis of results? 1
- (iii) Draw two conclusions about the effect of  $\beta$ -breaker on human and mouse PrPC and PrPSC. 2
- (c) Refer to the information in Table 1.
- (i) Explain why the PrPSC protein should be more susceptible to breakdown by intracellular enzymes after incubation. 2
- (ii) How would a control showing the proportions of secondary structure in PrPC help in judging the success of the  $\beta$ -breaker on PrPSC? 1
- (d) Refer to the information in Table 2.
- (i) Describe how to produce a  $1 \times 10^{-4}$  concentration of PrPSC by serial dilution from the  $1 \times 10^{-2}$  solution. 1
- (ii) What is the effect of changing the concentration on the onset of brain disease? 1
- (iii) Calculate the greatest percentage improvement achieved in this experiment by using  $\beta$ -breaker. 1
- (iv) Suggest one alteration to the treatment that might improve the performance of the  $\beta$ -breaker. 1

Total 13

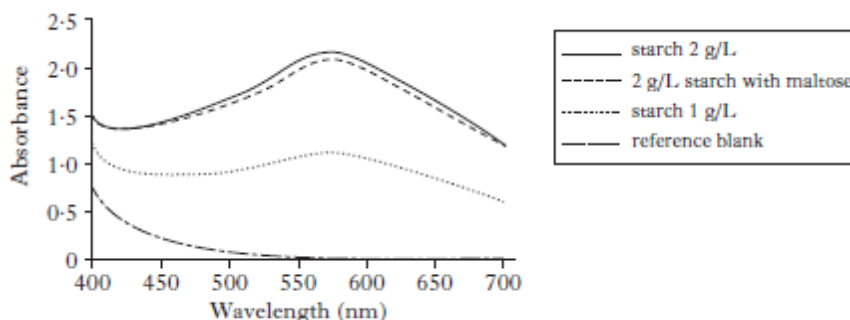
Q8 Starch consists of glucose molecules in long coiled chains, periodically joined at branching points. In the iodine test for starch, the iodine lies within the coils and the solution has a blue/black colour



The enzyme alpha amylase ( $\alpha$ -amylase) hydrolyses starch into maltose and dextrans (short chains of glucose molecules). Samples taken from an  $\alpha$ -amylase/starch mixture, when reacted with iodine solution, will show changes in colour as hydrolysis proceeds. Different reaction products contribute different colours, as shown below.



Within an investigation to test the effect of an inhibitor on the rate of amylase activity, researchers needed to develop a quick way to measure starch concentrations. They produced a colorimetric method based on the starch-iodine colour change. Part of the experiment to find the best wavelength is outlined below. Amylase buffered at pH7 was incubated with different reaction mixtures at optimum temperature. After 30 minutes, hydrochloric acid was used to stop any enzyme action and then the iodine solution was added to produce the colour. Absorbance was measured across a range of wavelengths for different reaction mixtures, as shown in the graph below



- (a) What term describes an experiment, like the one outlined, that is developing a technique within a larger investigation? 1
- (b) To serve its purpose as a control, what would be left out of the reference blank? 1
- (c) The researchers concluded that 580 nm would be the best wavelength for quantifying amylase activity by this method.
  - (i) Explain how they arrived at this conclusion. 1
  - (ii) The results show that the presence of the reaction product maltose is not a confounding variable. Explain what is meant by the term confounding variable. 1
  - (iii) How do the results show that the method will be valid in investigating the effect of amylase inhibitor on the rate of starch breakdown? 1

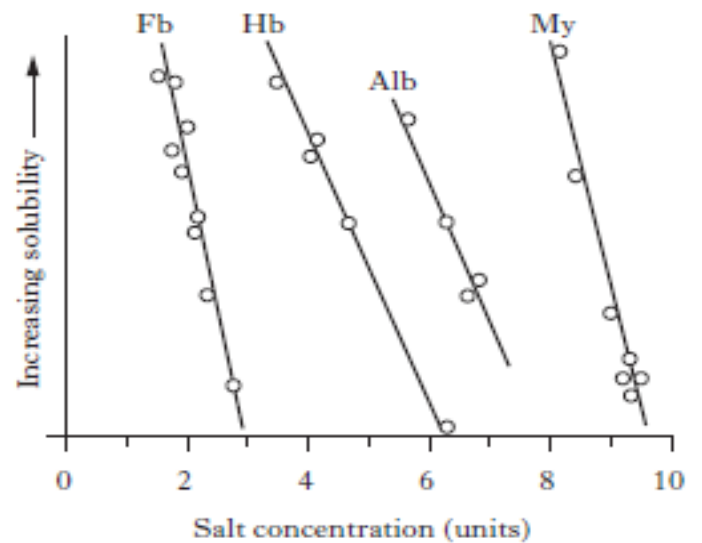
Total 5

## Homework 2

Q9 Some characteristics and properties of four proteins are shown below

<i>Protein</i>	<i>Symbol</i>	<i>Molecular mass</i>	<i>Type</i>
Fibrinogen	Fb	330 000	Fibrous
Haemoglobin	Hb	68 000	Globular
Albumin	Alb	65 000	Globular
Myoglobin	My	17 000	Globular

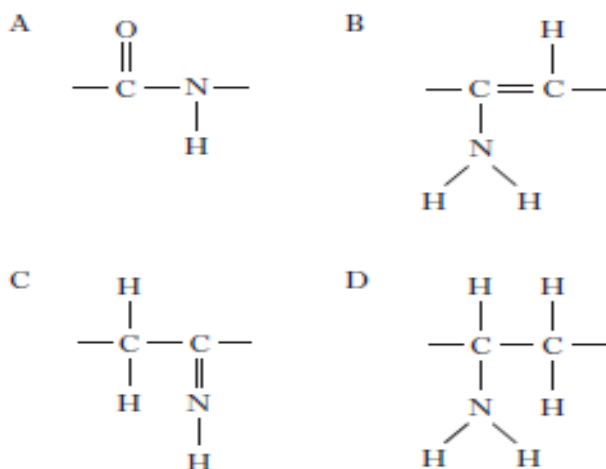
The solubility of proteins in salt solutions



Which conclusion about the solubility of proteins is valid from this information?

- A Protein solubility increases as salt concentration decreases.
- B Globular proteins are more soluble than fibrous proteins.
- C Fibrous proteins are more soluble than globular proteins at low salt concentrations.
- D Solubility of proteins is not related to molecular mass.

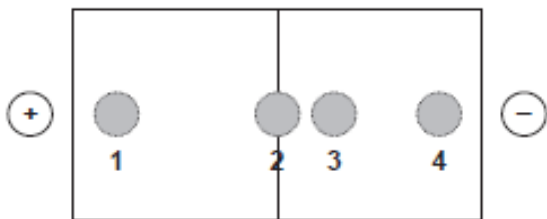
Q10 Which of the following diagrams illustrates a peptide bond



Q11 A hydrophobic amino acid has an R group that is

- A negatively charged
- B positively charged
- C not polar
- D polar.

Q12 A buffered solution of four amino acids was applied to the midline of a strip of electrophoresis gel. The result of running the gel is shown below.



Which of the amino acids was at its isoelectric point?

- A 1
- B 2
- C 3
- D 4

Q13 Table 1 shows the charge of amino acids at a certain pH.

Table 1

<i>Positively charged</i>	<i>Negatively charged</i>
arginine	tyrosine
lysine	cysteine
histidine	glutamate
	aspartate

Table 2

<i>Amino acid</i>	<i>Number</i>
arginine	13
lysine	19
histidine	2
tyrosine	7
cysteine	2
glutamate	20
aspartate	9

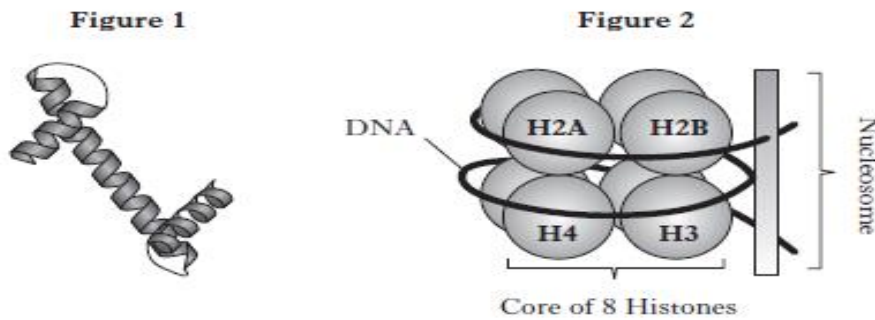
Table 2 shows the number of each amino acid in a protein.



Assuming that each amino acid carries a single positive or negative charge, what is the protein's net charge at this pH?

- A +34
- B +4
- C -4
- D -3

Q14 Figure 1 below shows the structure of a histone protein molecule, histone 4 (H4). Figure 2 represents a nucleosome showing the arrangement of the histones that make up its core



- (a) Name the type of bonding that maintains the shape of an alpha helix in a protein. 1
- (b) What level of protein structure is shown in Figure 1? 1
- (c) What is the importance of DNA being bound in nucleosomes? 1
- (d) Over 20% of the amino acids in histones are lysine and arginine. Explain why the high abundance of these positively charged amino acids is significant in the formation of a nucleosome. 1

Total 4

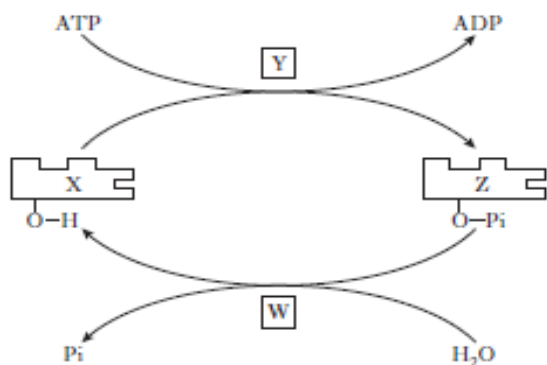
Q15 Which line in the table below correctly describes the charges on the two components of nucleosomes?

	<i>DNA</i>	<i>Histone proteins</i>
A	negative	negative
B	positive	negative
C	positive	positive
D	negative	positive

Q16 Which line in the table below correctly shows the arrangement of R groups in a globular protein found in the cytoplasm of a cell?

	<i>R groups on surface of protein molecule</i>	<i>R groups at centre of protein molecule</i>
A	Hydrophilic	Hydrophilic
B	Hydrophobic	Hydrophilic
C	Hydrophobic	Hydrophobic
D	Hydrophilic	Hydrophobic

Q17 The diagram below shows how phosphate is used to modify the conformation of an enzyme, phosphorylase, and so change its activity



Which line in the table correctly identifies the labels?

	<i>Kinase</i>	<i>Phosphatase</i>	<i>Phosphorylase</i>
A	Y	Z	W
B	W	Y	Z
C	X	Y	W
D	Y	W	Z

Q18 The table below shows data comparing some stages in the purification of an enzyme from a tissue sample. Total protein and enzyme activity are measured at the end of each stage.

	<i>Stage</i>	<i>Total protein (mg)</i>	<i>Enzyme activity (units)</i>
1	Liquidised tissue	10 000	2 000 000
2	Precipitation by salts	3000	1 500 000
3	Iso-electric separation	500	500 000
4	Affinity chromatography	30	42 000

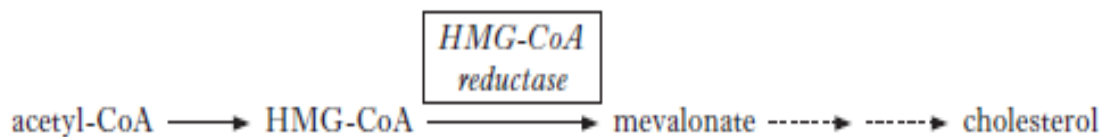
- (a) (i) By the end of the purification process, what percentage of the original protein has been removed? 1
- (ii) Enzyme purity can be calculated from these values as the activity per mg of protein. By how many times has the enzyme purity increased by the end of stage 4? 2
- (b) Explain the principle of iso-electric separation. 2
- (c) In affinity chromatography, a ligand specific to the enzyme was bonded to beads in a burette. Explain how this method can improve purity. 2

Total 7

Q19 In the post-translational modification of a protein, which of the following enzymes would remove a phosphate?

- A proteinase
- B ATPase
- C phosphatase
- D kinase

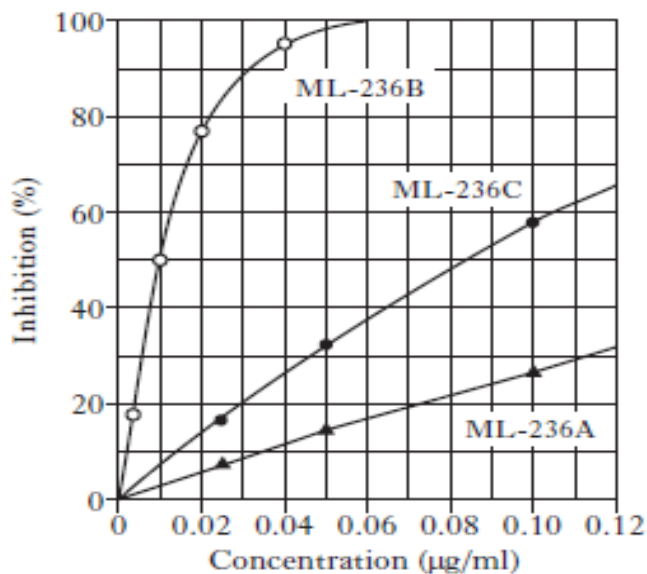
Q20 When cholesterol accumulates in the wall of an artery, the plaque that forms reduces the internal diameter of the vessel. Plaque formation (atherosclerosis) is a major cause of heart disease. Statins are taken to reduce blood cholesterol and are among the most commonly prescribed medications. Cholesterol is synthesised by cells in a sequence of steps starting with acetyl-CoA from the citric acid (Krebs) cycle. The step that limits the rate of production is near the start and is catalysed by the enzyme HMG-CoA reductase, as illustrated below



(a) In this pathway, a form of end-product inhibition occurs in which increasing cholesterol promotes the destruction of HMG-CoA reductase. Describe how end-product inhibition would be achieved if the enzyme was allosteric. 2

(b) Statins inhibit HMG-CoA reductase by competing for the active site of the enzyme. Explain why this would reduce cholesterol formation. 1

(c) The graph below shows results of an experiment carried out in 1976 on three forms of a substance, ML-236, extracted from a fungal culture. The experiment was assessing how well these substances inhibit cholesterol formation, the key requirement for a potential statin.



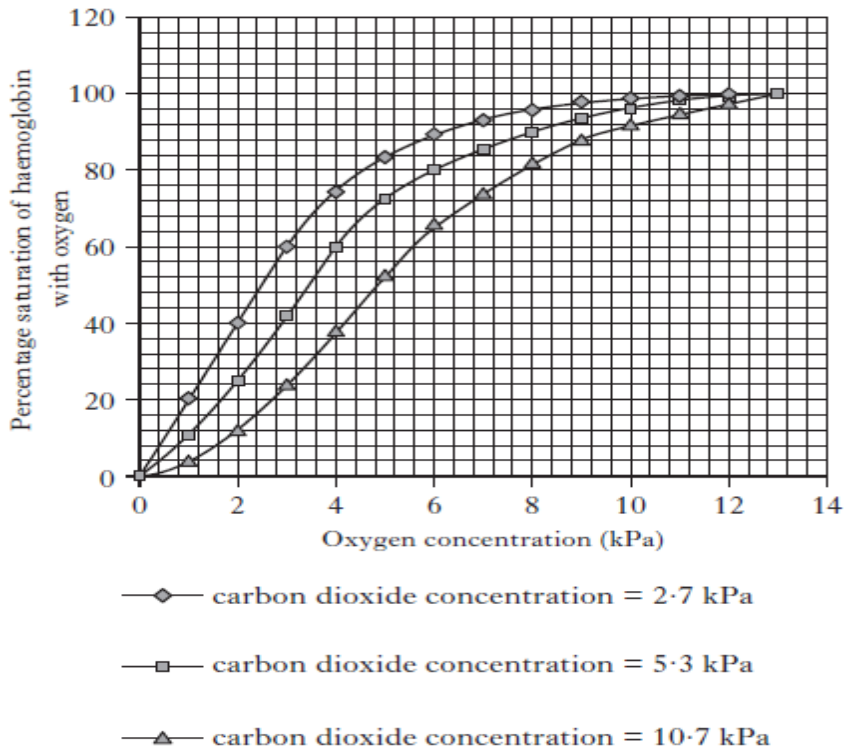
Use data for 50% inhibition to compare the effectiveness of the three molecules as potential statins. 2

Total 5

Q21 Each molecule of oxygen that binds to a subunit of haemoglobin has the effect of increasing the affinity of the remaining subunits to oxygen. This type of interaction is known as

- A cooperativity
- B facilitated transport
- C induced fit
- D positive modulation

Q22 The graph below shows the effect of carbon dioxide concentration on the affinity of haemoglobin for oxygen at different concentrations of oxygen



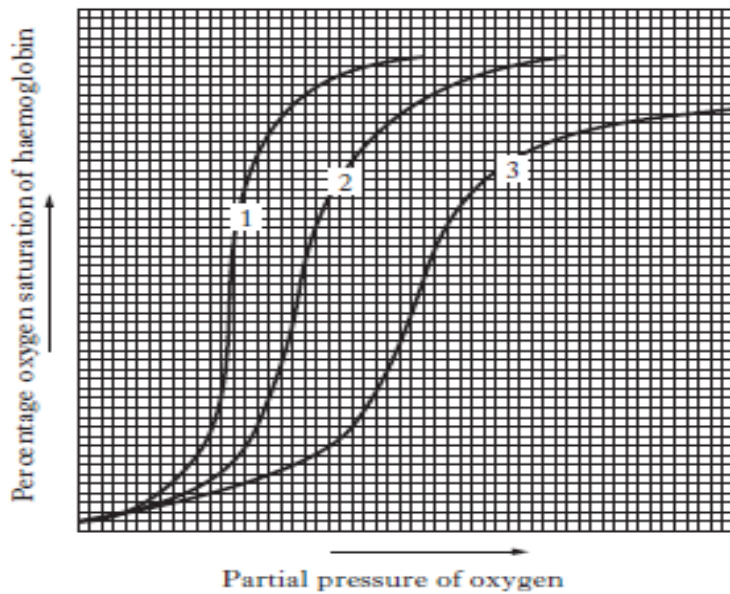
A list of possible conclusions is given below.

- 1 Increasing the concentration of carbon dioxide decreases the affinity of haemoglobin for oxygen.
- 2 Increasing the concentration of carbon dioxide increases the affinity of haemoglobin for oxygen.
- 3 Increasing the concentration of oxygen decreases the affinity of haemoglobin for oxygen.
- 4 Increasing the concentration of oxygen increases the affinity of haemoglobin for oxygen.

Which conclusions are valid for the data shown in the graph between oxygen concentrations of 2 kPa and 10 kPa?

- A 1 and 3
- B 1 and 4
- C 2 and 3
- D 2 and 4

Q23 Temperature influences the binding and release of oxygen in haemoglobin. The graph below shows the percentage oxygen saturation of haemoglobin at three different temperatures, 34 °C, 37 °C and 42 °C.



Which line in the table correctly identifies these temperatures?

	<i>Curve 1</i>	<i>Curve 2</i>	<i>Curve 3</i>
A	34 °C	37 °C	42 °C
B	37 °C	42 °C	34 °C
C	34 °C	42 °C	37 °C
D	42 °C	37 °C	34 °C

Q24 The total surface area of a red blood cell is about 136  $\mu\text{m}^2$ . A single sodium-potassium ATPase molecule takes up an area of  $1 \times 10^{-4} \mu\text{m}^2$ . In total these molecules account for 0.5% of the cell surface area. Approximately how many of these molecules are there on the surface of one red blood cell?

- A 13 600
- B 6800
- C 3400
- D 680

Q25 Which line in the table below correctly represents an allosteric enzyme binding with a positive modulator?

	<i>Modulator binding site</i>		<i>Affinity of enzyme for substrate</i>	
	<i>active site</i>	<i>secondary site</i>	<i>increased</i>	<i>decreased</i>
A	✓		✓	
B		✓		✓
C		✓	✓	
D	✓			✓

Q26 The stages of muscle contraction are listed below.

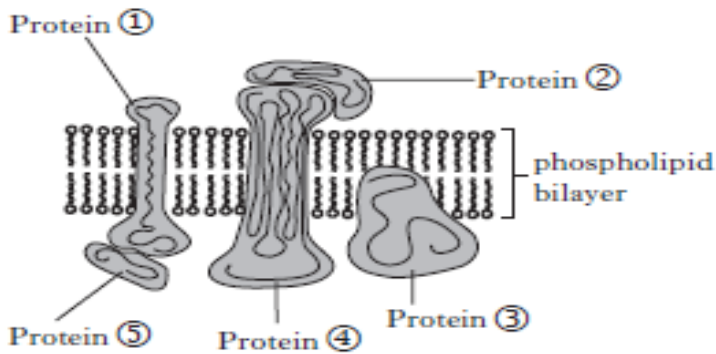
- 1 Phosphate ion released from myosin head.
- 2 ATP binds to myosin head and causes it to detach from actin filament.
- 3 Myosin head swings forward and attaches to actin filament.
- 4 Myosin head drags along actin filament.

The sequence in which these stages occur is

- A 2, 1, 3, 4
- B 2, 3, 1, 4
- C 3, 2, 1, 4
- D 3, 2, 4, 1.

# Homework 3

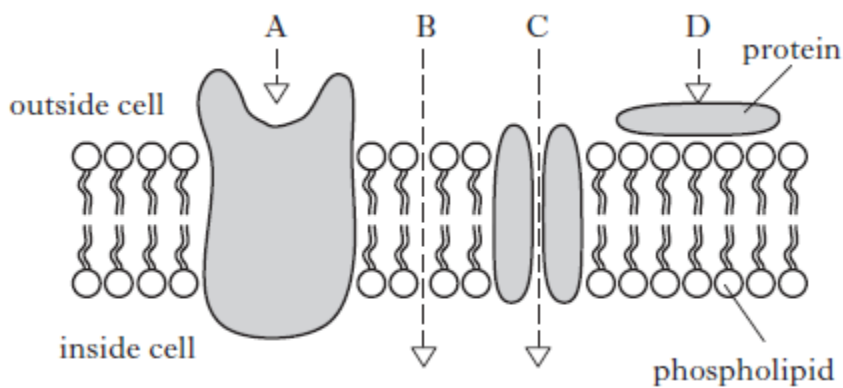
Q27 The diagram below shows the distribution of protein molecules in a cell membrane



Which line in the table correctly identifies a peripheral and an integral membrane protein

	<i>Peripheral membrane protein</i>	<i>Integral membrane protein</i>
A	1	5
B	2	1
C	3	4
D	5	2

Q28 Cortisol is a steroid hormone. Which letter in the diagram below shows the first stage in cell signalling for this hormone?



Q29 (a) Describe how insulin stimulates the uptake of glucose into cells.

2

(b) Research has shown that fatty (adipose) tissue secretes a number of signalling molecules that regulate a variety of metabolic processes. One of these molecules, adiponectin, is thought to increase the sensitivity of cells to the hormone insulin. Table 1 shows the results of a study that compared the concentration of adiponectin in patients having type 2 diabetes with non-diabetic subjects.

**Table 1**

<i>Subjects</i>	<i>Average plasma adiponectin concentration (<math>\mu\text{g cm}^{-3} \pm \text{SE}</math>)</i>
type 2 diabetes	$6.6 \pm 0.4$
non-diabetics	$7.9 \pm 0.5$

Use the information to explain the relationship between type 2 diabetes and the average plasma concentration of adiponectin.

2

(c) Table 2 below shows the results of a second study that measured changes in adiponectin following treatment of individuals at risk of developing type 2 diabetes.

1

**Table 2**

<i>Treatment</i>	<i>Average increase in adiponectin concentration (<math>\mu\text{g cm}^{-3} \pm \text{SE}</math>)</i>
drug treatment	$0.83 \pm 0.05$
lifestyle changes	$0.23 \pm 0.05$
none	$0.10 \pm 0.05$

How do the data in Table 2 confirm that both treatments were effective in increasing adiponectin concentration?

(d) Both studies used human subjects. For this type of research:

(i) give one important ethical consideration;

1

(ii) explain why a large sample size is required to produce valid conclusions

1

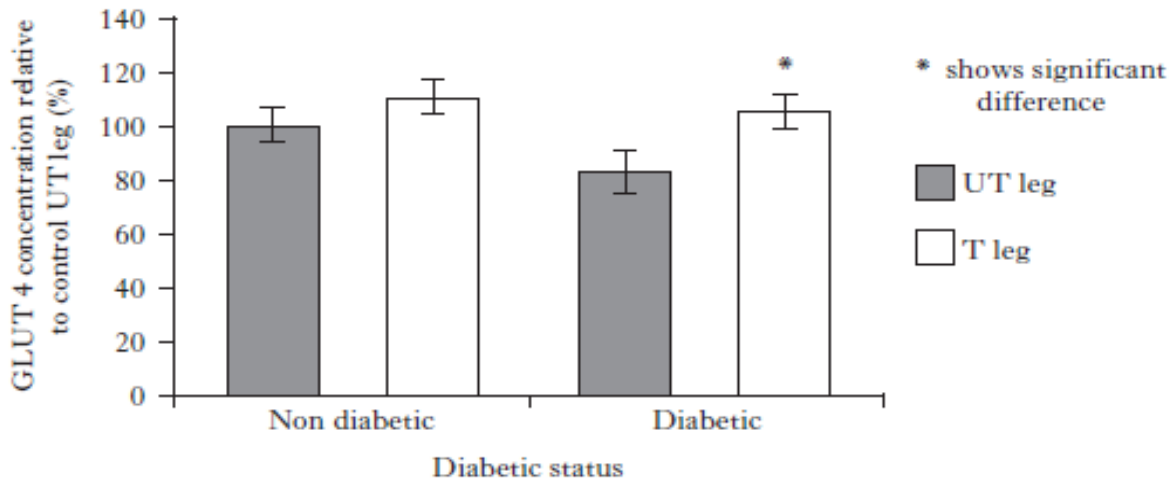
Total 7

Q30 Which line in the table correctly describes the effects of a failure to produce ADH?

	<i>Aquaporin recruitment</i>	<i>Urine production</i>
A	increase	decrease
B	increase	increase
C	decrease	decrease
D	decrease	increase



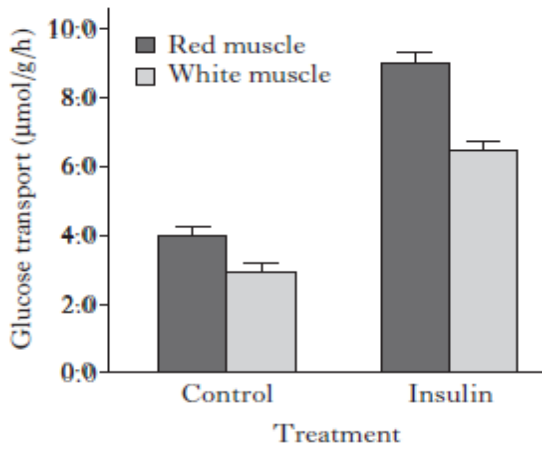
Q31 When insulin attaches to its receptor in the plasma membrane of fat cells and muscle cells, GLUT 4 glucose transporter proteins in the cytoplasm are recruited into the membrane to take in glucose. Type 2 diabetes is associated with insulin resistance in which cells are less able to respond to insulin in this way. A recent study concluded that moderate strength training increases the GLUT 4 content of muscle tissue in those with type 2 diabetes. Individuals taking part all did strength training on one leg (T leg) for six weeks while the other leg was left untrained (UT leg). The subjects either had type 2 diabetes or did not. At the end of the training, muscle biopsies (samples) were taken from the trained and untrained legs and compared for GLUT 4 protein content. The results are shown in the Graph below.



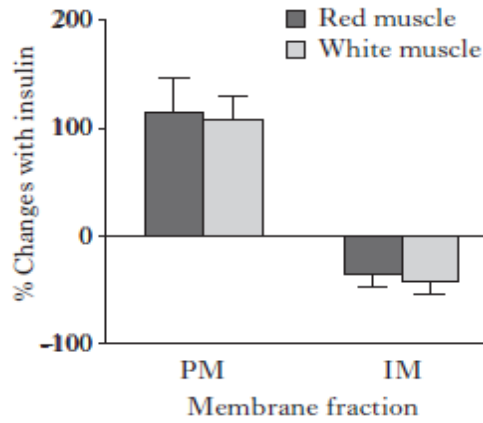
- (a) In this investigation, what would be a suitable null hypothesis? 1
- (b) What comparisons did the researchers make in order to conclude that moderate strength training increases the GLUT 4 content of muscle tissue only in those with type 2 diabetes? 2
- Total 3

Q32 Two types of muscle, red and white, can be distinguished by their colour in samples of fresh tissue and can be easily separated. Red muscle cells obtain energy mainly using aerobic respiration: they have many large mitochondria and a good supply of oxygen. White muscle cells obtain energy mainly by anaerobic respiration: they have fewer mitochondria and a poorer oxygen supply. In both muscle types, glucose is the substrate for respiration. It is widely thought that the mechanism of glucose transport into these cells is the step that limits their ability to use glucose, and it is considered that red muscle cells have a greater capacity for glucose transport than white muscle cells. Glucose diffuses into cells through glucose transporters (GLUTs), which are protein molecules embedded in cell membranes. There are several types of GLUT. GLUT1 is responsible for glucose uptake in all cells; the membranes of muscle and fat cells also contain GLUT4. The study below investigated the contribution of these two GLUTs to glucose uptake in red and white muscle cells, before and after exposure to insulin. Figure 1 shows the effect of insulin on glucose transport in the two types of muscle. An extract of membranes from the muscle cells was centrifuged to separate it into two portions, plasma membrane (PM) and the internal membranes (IM) from the cytoplasm. The protein components of the membranes were separated by gel electrophoresis and blotted. The blots were exposed to radioactively-labelled antibodies specific for each of the two GLUT proteins, to allow identification and quantification. Figure 2 shows the percentage change in total GLUT level in the two membrane fractions following the insulin treatment. In Figure 3, the blots indicate the changing abundances of the two GLUTs. Figure 4 shows the relative amount of GLUT4 in the two muscle types in response to insulin. Error bars show standard error.

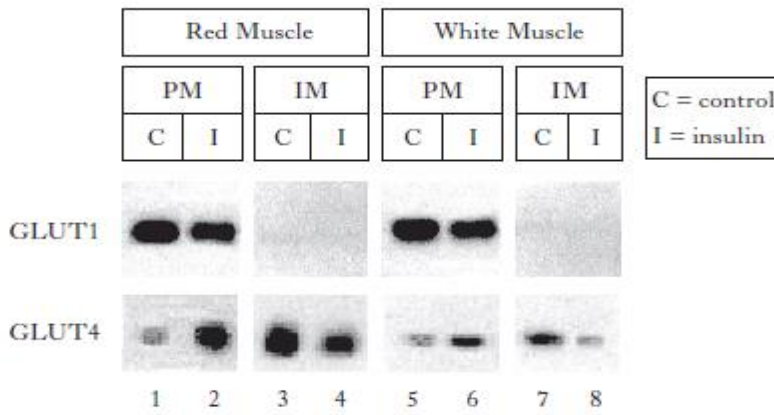
**Figure 1: Glucose transport with and without insulin**



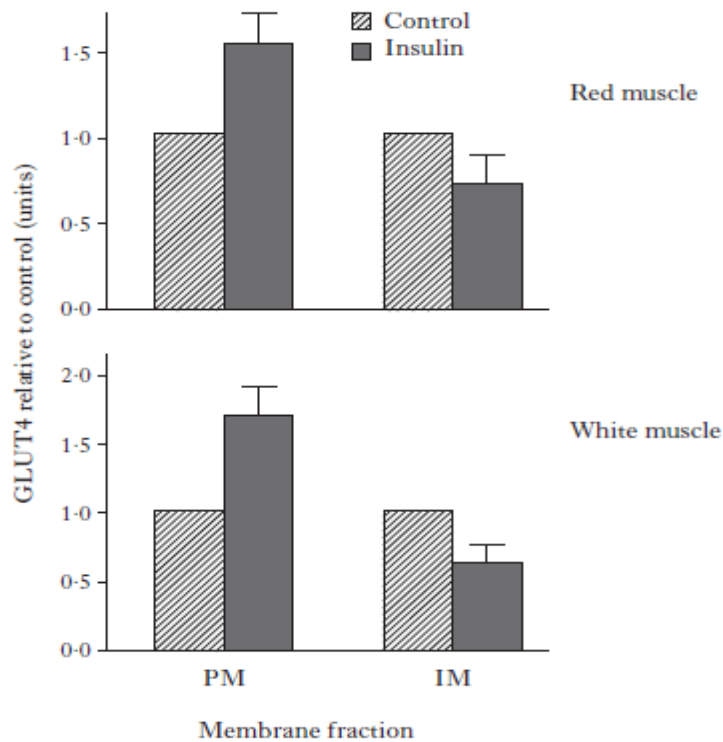
**Figure 2: Effect of insulin on total GLUT levels**



**Figure 3: Blots showing the effect of insulin on the distribution of GLUTs 1 and 4**



**Figure 4: Relative amounts of GLUT4 quantified from several blots**



Q32 (cont)

- (a) Use data from Figure 1 to support the statement that “red muscle cells have a greater capacity for glucose transport than white muscle cells”. 2
- (b) Figure 2 shows that GLUT increases in the PM fraction and decreases in the IM fraction after insulin treatment. It was concluded that both muscle types have the same underlying GLUT response to insulin. Explain how the error bars confirm this conclusion is valid. 1
- (c) Refer to Figure 3.
- (i) Describe the distribution of GLUT1 in muscle cells before insulin treatment. 1
- (ii) Give one conclusion about the effect of insulin treatment on GLUT1. 1
- (iii) What evidence is there that the effect of insulin on the distribution of GLUT4 is the same in both types of muscle? 1
- (d) It was hypothesised that insulin triggers the transport of additional GLUT4 to the plasma membrane from storage on membranes in the cytoplasm, and that this “recruitment” mechanism is greater in red muscle cells. How do the results from Figures 3 and 4 support this hypothesis? 2
- (e) Explain how glucose uptake by cells is reduced in Type 2 diabetes. 2
- Total 10

Q33 The contribution of aquaporins (AQPs) to osmosis was studied by measuring the rate of movement of radioactive water across a plasma membrane. Rates were measured in either isotonic or hypertonic external solution when the pores were either open or closed. Results are shown in the table.

<i>External solution</i>	<i>Rate of water movement (units s<sup>-1</sup>)</i>	
	<i>Open AQPs</i>	<i>Closed AQPs</i>
<b>Isotonic</b>	2.5	1.0
<b>Hypertonic</b>	20.0	1.8

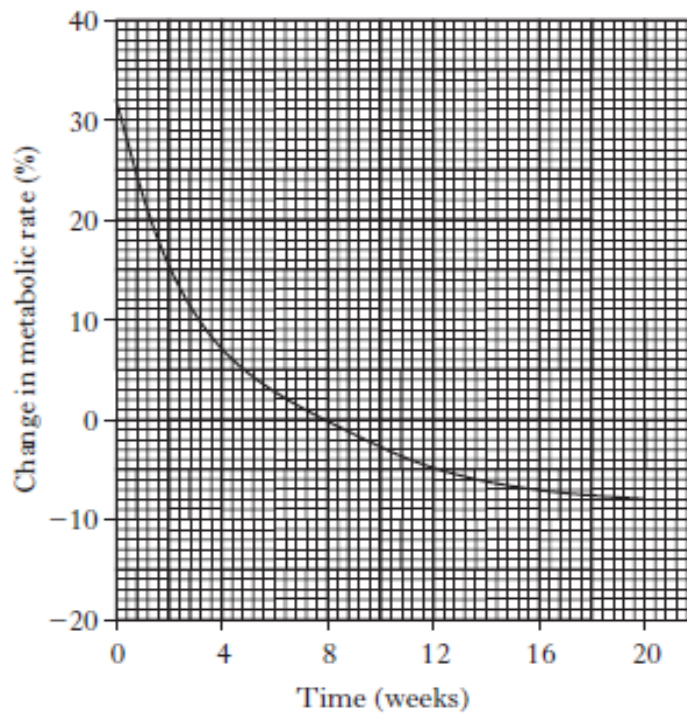
Which of the following is the dependent variable in the experiment?

- A External solution
- B Radioactivity of water
- C Rate of water movement
- D Aquaporins

Q34 Which of the following describes how genes that increase metabolic rate are activated by a hydrophobic signalling molecule?

- A Thyroxine binds to a receptor protein on DNA and stops it inhibiting transcription.
- B Testosterone binds to a receptor protein on DNA and stops it inhibiting transcription.
- C Thyroxine binds to a receptor protein in the cytosol and the complex regulates transcription.
- D Testosterone binds to a receptor protein in the cytosol and the complex regulates transcription.

Q35 Thyroxine is a hormone that acts as a regulator of metabolic rate in most tissues. Thyroxine causes an increase in metabolic rate by binding to specific receptors located within the nucleus of a target cell. Hyperthyroidism is a condition caused by overproduction of thyroxine. The figure shows the average change in metabolic rate of individuals with hyperthyroidism who were treated over a twenty week period with a drug (carbimazole). The drug decreases the synthesis of thyroxine from the thyroid gland.



- (a) What property of thyroxine allows it to cross the membrane of cells? 1
- (b) Describe how thyroxine binding to its receptor affects transcription of genes that influence metabolic rate. 2
- (c) (i) How many weeks of drug treatment were required to reach normal metabolic rate? 1
- (ii) How do the data support the conclusion that the thyroid gland has large stores of thyroxine? 1
- (iii) Why have changes in metabolic rate been presented as percentages? 1

Total 6

Q36 To which group of signalling molecules does the sex hormone testosterone belong?

- A Extracellular hydrophilic
- B Extracellular hydrophobic
- C Peptide hormones
- D Neurotransmitters

Q37 Which of the following statements about the sodium-potassium pump is correct?

- A The transport protein has an affinity for sodium ions in the cytoplasm.
- B It results in a higher concentration of sodium ions inside the cell.
- C The transport protein has an affinity for sodium ions in the extracellular fluid.
- D It results in a higher concentration of potassium ions outside the cell.

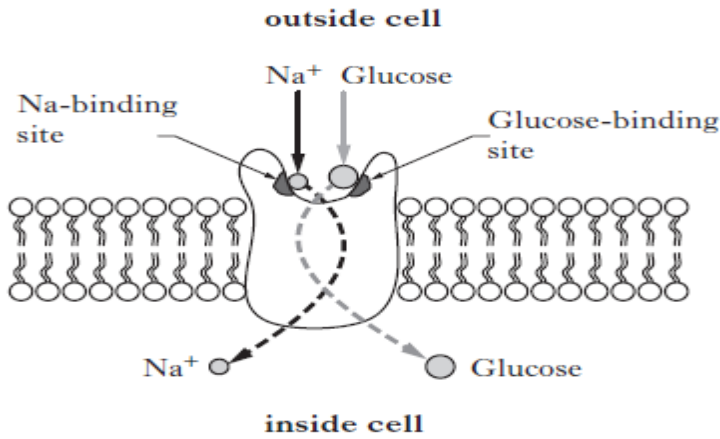
Q38 The sodium-potassium pump spans the plasma membrane. Various processes involved in the active transport of sodium and potassium ions take place either inside the cell (intracellular) or outside the cell (extracellular). Which line in the table correctly applies to the binding of potassium ions

	<i>Binding location of potassium ions</i>	<i>Conformation of transport protein</i>
<b>A</b>	intracellular	not phosphorylated
<b>B</b>	extracellular	phosphorylated
<b>C</b>	intracellular	phosphorylated
<b>D</b>	extracellular	not phosphorylated

Q39 The Na,K-ATPase moves ions in the ratio 3 sodium : 2 potassium. 5000 of these ions are pumped across the membrane every ten seconds. The number of potassium ions moved across in one second is

- A 200
- B 500
- C 2000
- D 3000.

Q40 The diagram below shows cotransport (symport) of sodium ions (Na<sup>+</sup>) and glucose into a cell lining the gut.



Which line in the table below represents the relative concentrations of glucose and Na<sup>+</sup> on the two sides of the plasma membrane when cotransport occurs?

	<i>Sodium</i>		<i>Glucose</i>	
	<i>Outside cell</i>	<i>Inside cell</i>	<i>Outside cell</i>	<i>Inside cell</i>
A	high	low	low	high
B	high	low	high	low
C	low	high	low	high
D	low	high	high	low

Q41 A typical cell is estimated to possess  $4 \times 10^{11}$  potassium ions. Only 107 of these are used in establishing membrane potential. What fraction of the total potassium ions is involved in this function?

- A 1/250
- B 1/2500
- C 1/30000
- D 1/40000

Q42 Which of the following is not a function of Na/KATPase?

- A Maintaining the osmotic balance in animal cells
- B Phosphorylating channel proteins
- C Generating the ion gradient for glucose symports
- D Maintaining resting potential of membranes

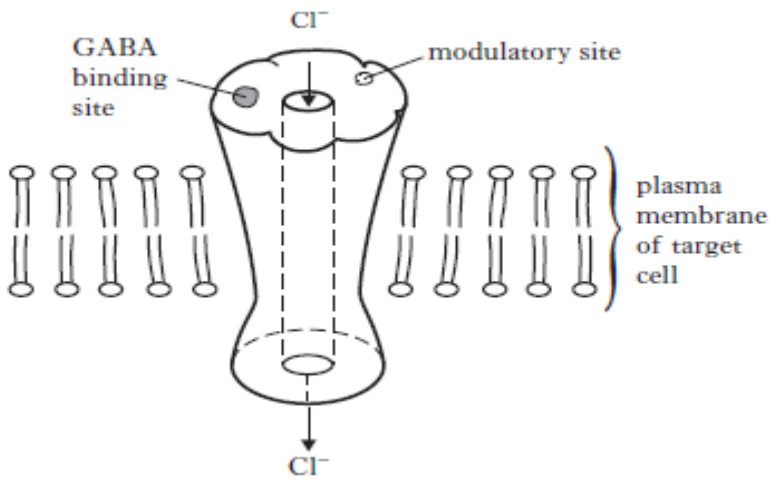
# Homework 4

Q43 Discuss the movement of ions across membranes under the following headings:

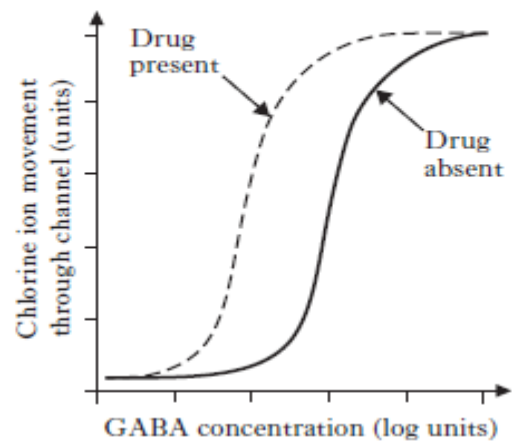
- (i) mechanism and functions of Na/KATPase; 6
- (ii) nerve transmission 4

Q44 Gamma-aminobutyric acid (GABA) is a neurotransmitter that functions as a signalling molecule in the central nervous system. GABA binds to a receptor protein located in the plasma membrane of target cells as shown in Figure 1. Binding of a GABA molecule opens a channel that allows chloride ions ( $\text{Cl}^-$ ) to enter the cell.

**Figure 1**



**Figure 2**

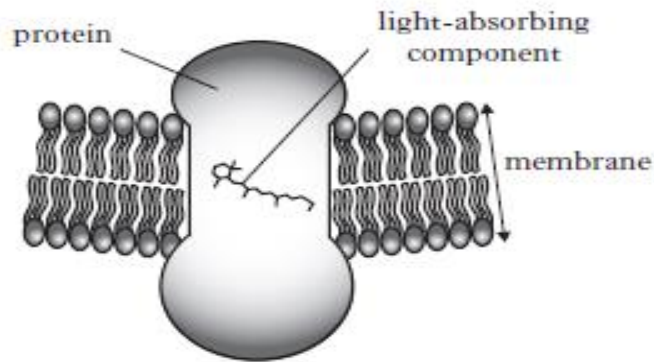


Benzodiazepines are sedative drugs that bind to the receptor protein and increase its affinity for GABA. These drugs act as allosteric modulators by binding at a site that is distinct from the GABA-binding site. Figure 2, above, shows the movement of chloride ions through the channel as GABA is increased with and without the drug being present.

- (a) Use the information provided to explain why the GABA receptor is described as a ligand-gated channel. 2
- (b) What term describes the action of a membrane receptor in which signal binding brings about an effect in the cytoplasm? 1
- (c) (i) How does the information in Figure 2 show that the affinity of the receptor for GABA has been increased by the benzodiazepine? 1
- (ii) Why does the affinity of the receptor for GABA increase when the drug binds to the modulatory site? 1
- (iii) What effect will chloride ion influx have on the membrane potential of the nerve cell? 1

Total 6

Q45 Rod cells and cone cells are photoreceptors in vertebrate eyes. Membranes in these cells contain rhodopsin, a protein molecule that has a light-absorbing component. Rhodopsin generates a nerve impulse when light is absorbed.



- (a) Name the light-absorbing component of rhodopsin. 1
- (b) Explain how the absorption of a photon by rhodopsin leads to the generation of a nerve impulse. 2
- (c) Give one feature of the photoreceptor system in rods that allows these cells to function in low light intensity. 1
- (d) Cone cells are sensitive to different wavelengths of light. Name the component of rhodopsin that varies in cone cells. 1

Total 5

Q46 Which type of ion is pumped across membranes by bacteriorhodopsin?

- A Sodium
- B Potassium
- C Chloride
- D Hydrogen

Q47 Which line in the table below correctly describes features of rod cells in humans?

	<i>Function in low light intensity</i>	<i>Contain different forms of opsin</i>
A	no	yes
B	yes	yes
C	no	no
D	yes	no

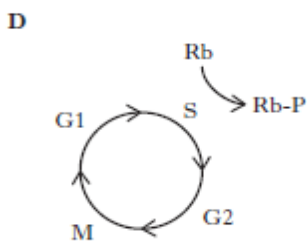
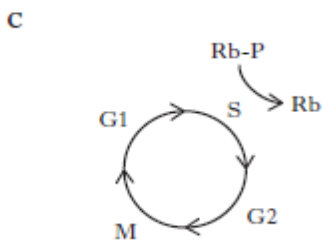
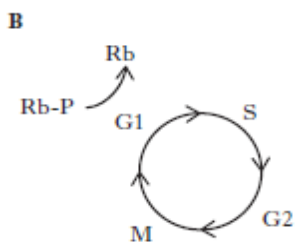
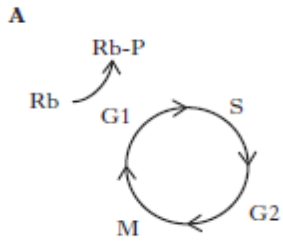
Q48 Discuss photoreception in animal eyes under the following headings:

- (i) photoreceptor system proteins; 6
- (ii) triggering of a nerve impulse. 4



# Homework 5

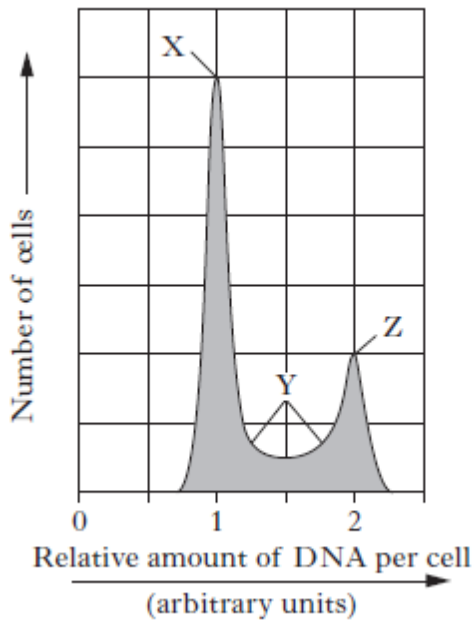
Q49 Retinoblastoma protein (Rb) has a role in regulating progress through the cell cycle. It can be phosphorylated (Rb-P) or unphosphorylated (Rb). Which of the following diagrams represents how the protein is altered to let the cycle progress?



Q50 Which of the following would not be a substrate for caspases?

- A DNA
- B actin
- C histone
- D tubulin

Q51 The figure below shows the relative DNA content of cells from a culture.



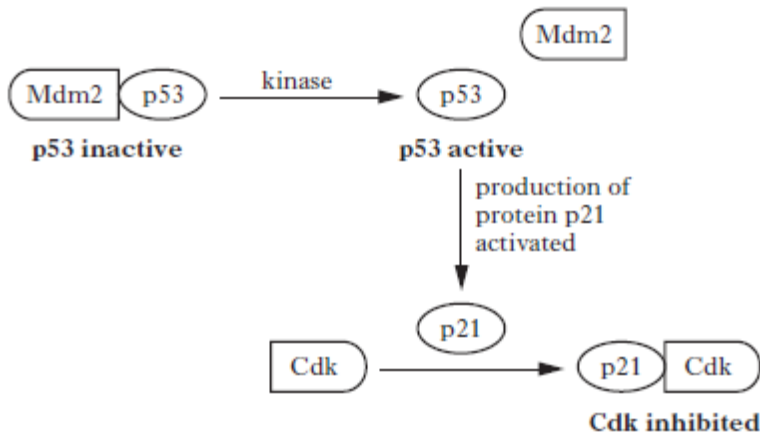
In which two phases of the cell cycle are cells in region Z?

- A G1 and S
- B S and G2
- C G2 and M
- D M and G1

Q52 From which stage in the cell cycle could cells switch to G0?

- A M
- B G1
- C S
- D G2

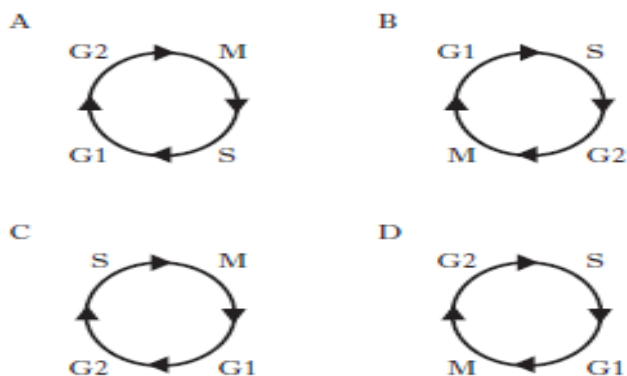
Q53 The protein p53 plays an important role in controlling cell division. The diagram below represents how the activation of p53 can result in arrest of the cell cycle.



- (a) Explain why binding of p21 protein to cyclin dependent kinase (Cdk) prevents the cell cycle from progressing. 2
- (b) Give one trigger that would stimulate the activation of p53. 1
- (c) Apart from arrest of the cell cycle, give one other fate of a cell that has had p53 activated. 1
- (d) Explain why it is important that the cell cycle is controlled in a multicellular organism 2

Total 6

Q54 Which of the following diagrams correctly represents the sequence of phases in the cell cycle?

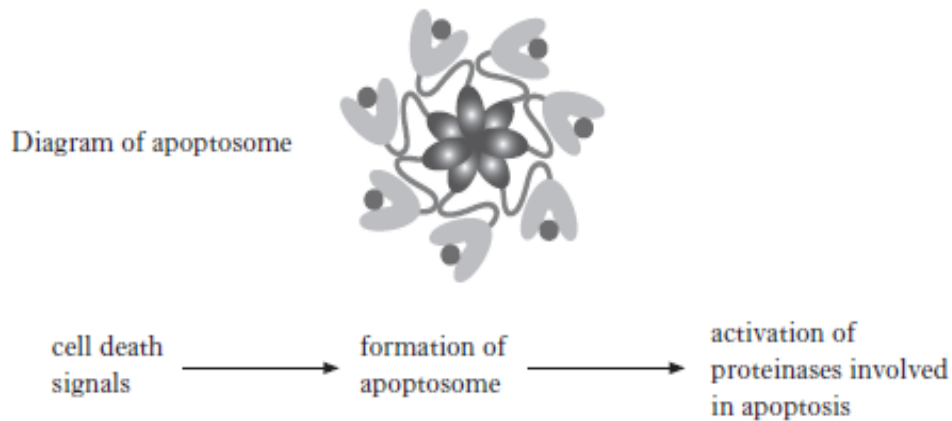


Q55 Animal cells growing in culture are found to spend 20% of their time in the G2 phase of the cell cycle. G2 lasts for 4 hours. If cells spend 12% of their time in the M phase, how long does this last?

- A 2 hours 4 minutes
- B 2 hours 12 minutes
- C 2 hours 24 minutes
- D 2 hours 40 minutes

- Q56 During the cell cycle, sufficient phosphorylation by G1 cyclin-dependent kinases allows
- A the cell to pass into M phase
  - B p53 to be activated
  - C the cell to be held in G1 phase
  - D DNA replication to occur.

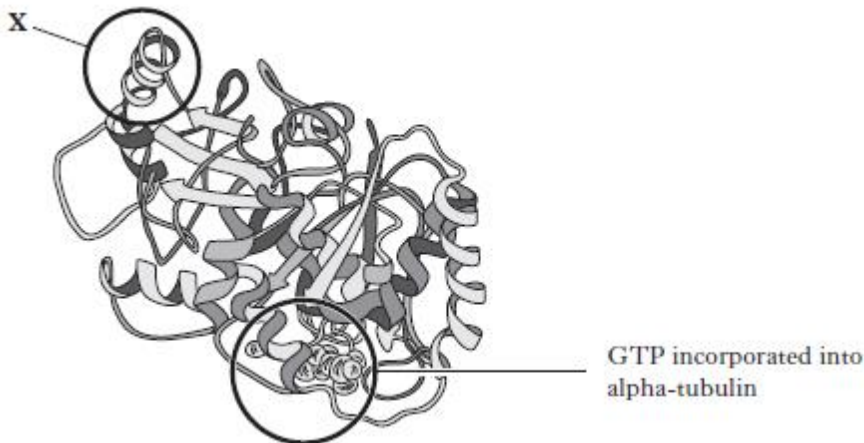
Q57 Apoptosomes are large protein structures formed inside cells during the process of apoptosis. Apoptosomes are formed in response to cell death signals.



- (a) Name the type of proteinase activated by apoptosomes. 1
- (b) Give one reason why cell death must be carefully controlled in a multicellular organism. 1
- (c) Cell death signals can originate within the cell (intrinsic) or outwith the cell (extrinsic).
- (i) Give one example of an event that would trigger an intrinsic cell death signal. 1
- (ii) Describe how an extrinsic cell death signal initiates apoptosis. 2
- (d) Bcl-2 is a protein that regulates apoptosis by binding to apoptosomes, preventing them from activating proteinase. Some mutations cause an increase in the level of Bcl-2 protein. Suggest why these mutations are associated with tumour growth 2

Total 7

Q58 Tubulin is described as a dimer because it is made of two polypeptide subunits, alphatubulin and beta-tubulin. Both subunits contain GTP, a molecule that is similar to ATP but has the base guanine instead of adenine. A representation of alpha-tubulin is shown below



- (a) (i) Name the type of bonding that maintains the secondary structure component labelled X. 1
- (ii) What term is used to describe a component, such as GTP, embedded in a polypeptide? 1
- (b) Microtubules are straight, hollow rods that extend by the addition of more dimers in columns at the 'growing' end.
- (i) During mitosis, to which structures do the two ends of a spindle fibre normally attach? 1
- (ii) What is the role of spindle microtubules in cell division? 1
- (iii) Various drugs, introduced into the bloodstream during chemotherapy, treat cancer by blocking the formation of microtubules. Suggest one disadvantage of treating tumours with drugs that target microtubule formation. 1

Total 5

