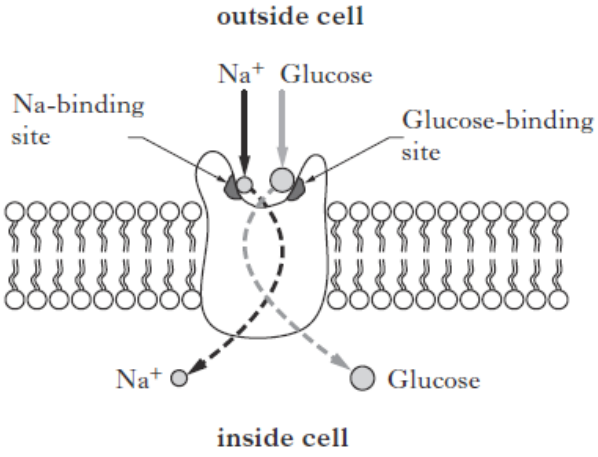
Dalkeith High School
Advanced Higher Biology
Homework 3

5. The diagram below shows cotransport (symport) of sodium ions (Na^+) and glucose into a cell lining the gut.



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

	Sodium		*Glucose*	
	Outside cell	*Inside cell*	*Outside cell*	*Inside cell*
A	high	low	low	high
B	high	low	high	low
C	low	high	low	high
D	low	high	high	low

6. A typical cell is estimated to possess 4×10^{11} potassium ions. Only 10^7 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

11. The mechanism of action of the sodium-potassium pump includes the following events:

P membrane protein loses a phosphate group

Q potassium binds to membrane protein

R potassium ions are released

S membrane protein shape is restored.

The correct sequence of these events is

A P, Q, R, S

B P, Q, S, R

C Q, P, R, S

D Q, P, S, R

8. 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

9. 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.

10. The total surface area of a red blood cell is about $136\,\mu m^2$. A single sodium-potassium ATPase molecule takes up an area of $1 \times 10^{-4}\,\mu m^2$. 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

Dalkeith High School
Advanced Higher Biology
Homework 3

1. 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

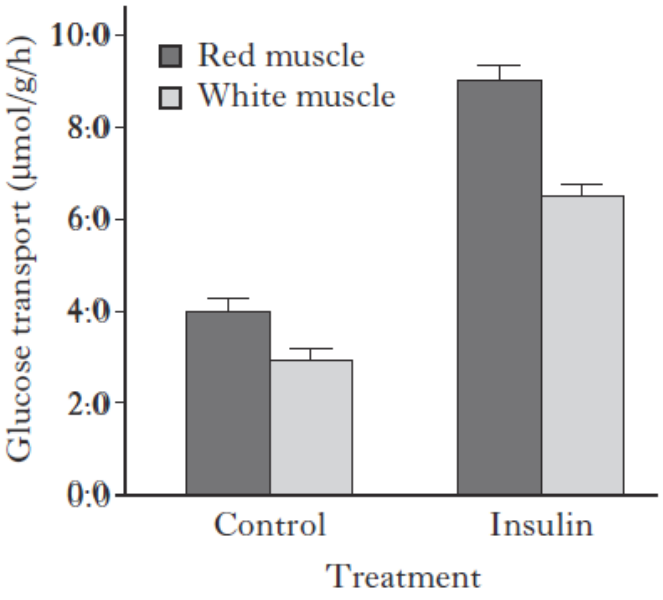
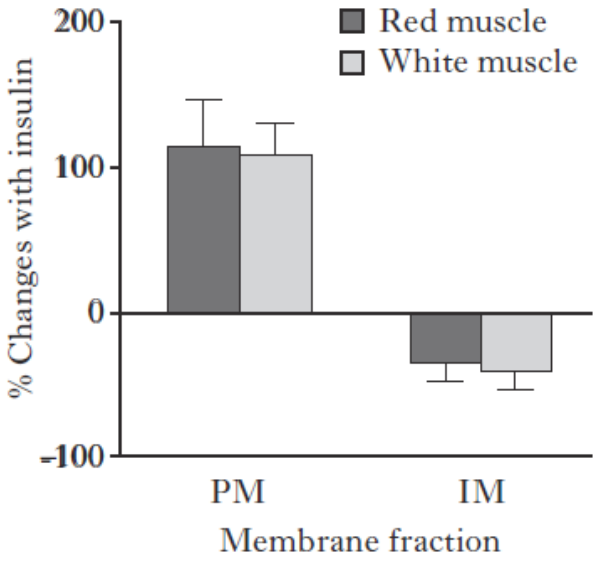


Figure 2: Effect of insulin on total GLUT levels



Question 1 (continued)

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

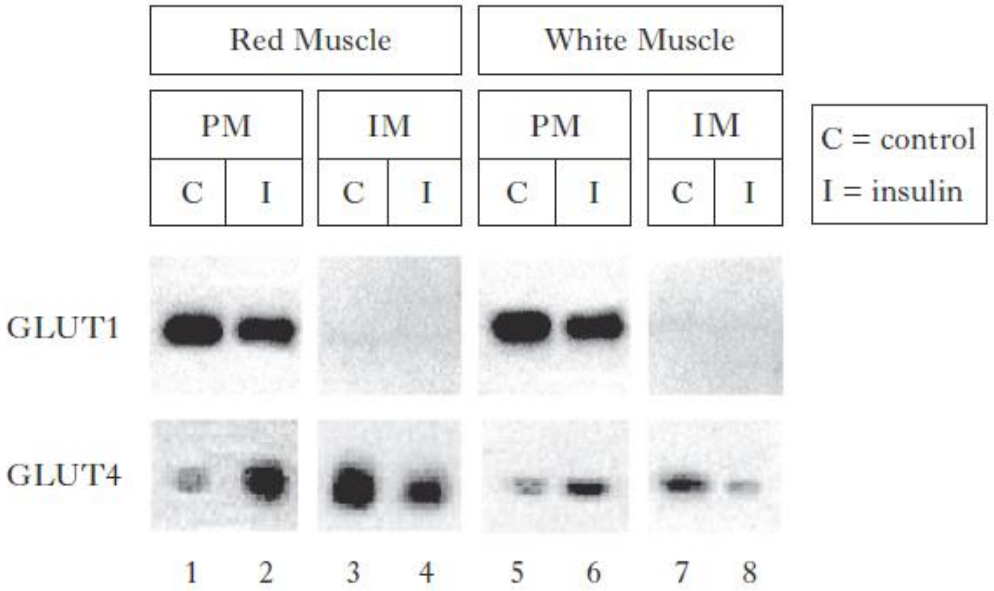
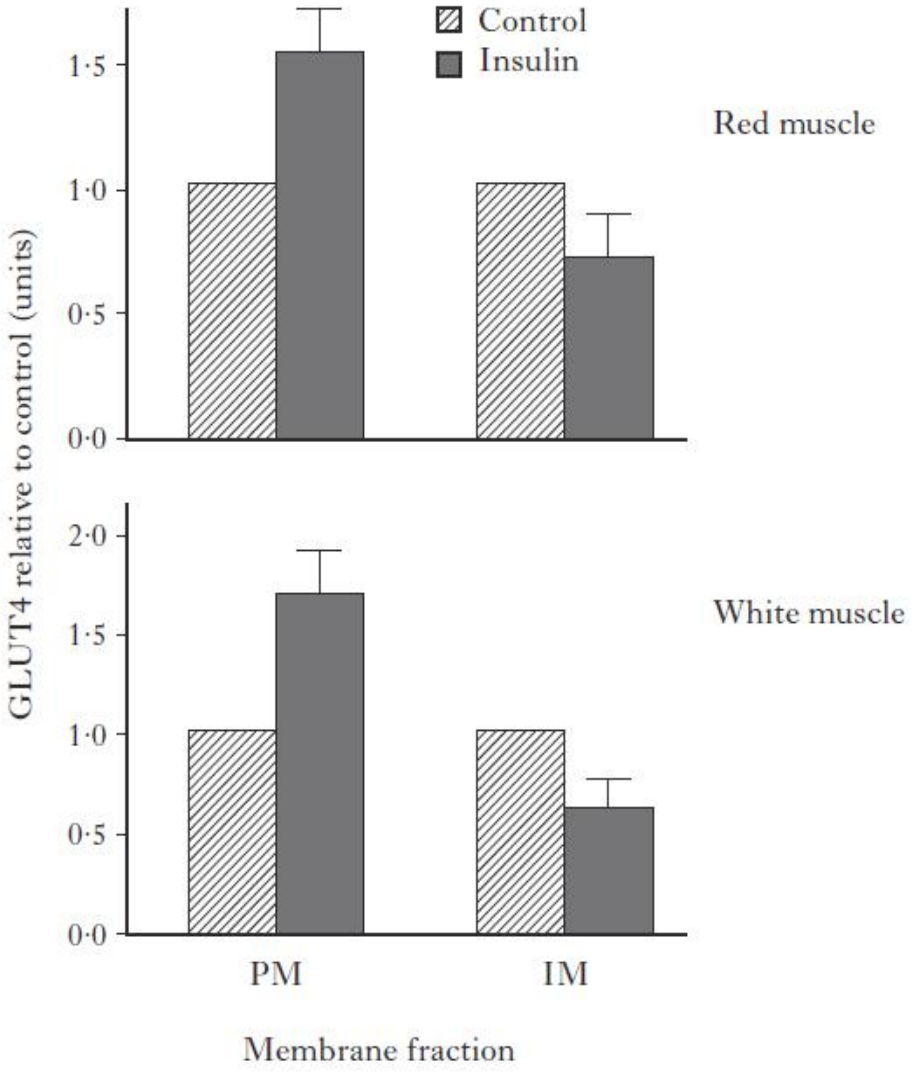


Figure 4: Relative amounts of GLUT4 quantified from several blots



Marks

Question 1 (continued)

(*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**

(10)

B. Give an account of proteins in the following contexts:

(*a*) membranes; **5**

B. Discuss the movement of ions across membranes under the following headings:

(i) mechanism and functions of Na/KATPase; **6**

(ii) nerve transmission. **4**

(10)