2 Within the mammalian body, different systems of communication are used to coordinate and control activities.

(a) Complete the following passage by using the **most suitable** term in each case.

The pancreas and the adrenal glands are both examples of ..... glands. Adrenaline is a ..... that is secreted by the adrenal glands. These glands also secrete steroids such as corticosteroids from cells in the ..... region. The chemicals secreted by these glands are transported by the blood to their ..... cells and tissues. **[4]**

(b) Insulin is secreted from the beta cells of the pancreas in response to increased blood glucose concentration.

Fig. 2.1 is a diagram representing the sequence of events leading to the secretion of insulin from the beta cell.

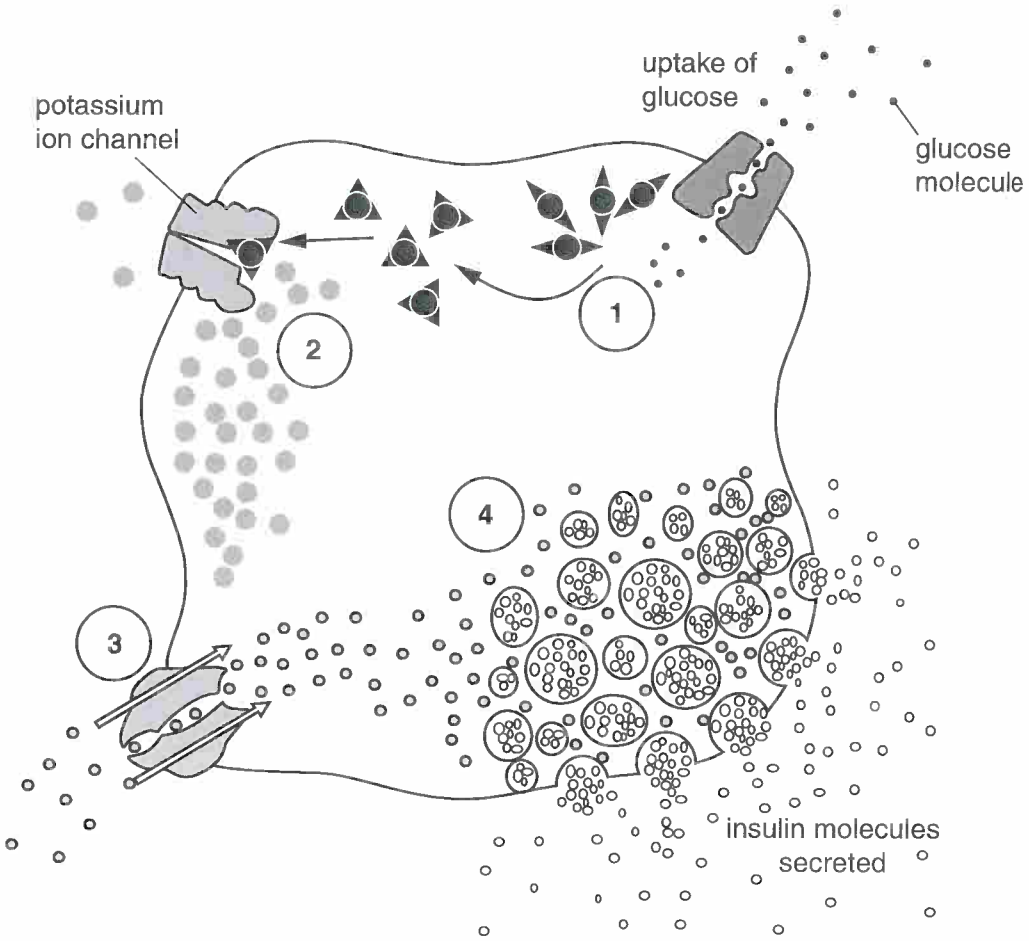

Fig. 2.1

(i) With reference to Fig. 2.1, describe the events occurring at the stages labelled 1 to 4.

1 .....

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2 .....

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3 .....

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4 .....

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..... [4]

(ii) After the initial release of insulin from the beta cell, insulin secretion continues even when there is no further glucose intake.

Suggest and explain why the cell continues to secrete insulin.

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..... [2]

[Total : 10]

3 **(a)** A doctor arranged for a 59-year-old patient to have a series of blood tests. One of these tests was to determine the patient's 'fasting blood glucose' concentration.

- The result of this test indicates whether or not the patient's blood glucose concentration is being regulated within the normal range.
- The validity of the result relies on the patient not having eaten for at least eight hours before the test.
- The patient confirmed to the doctor that he had not eaten since the previous evening.

(i) What condition was being tested for in this 59-year-old patient?

..... **[1]**

(ii) Why was it important that the patient had not eaten for at least eight hours before the test?

.....

.....

..... **[1]**

(iii) The result of the patient's fasting blood glucose test was $7.0\,\text{mmol}\,\text{dm}^{-3}$.

The upper limit for 'normal' blood glucose concentration is considered to be $5.9\,\text{mmol}\,\text{dm}^{-3}$.

Calculate the percentage by which this patient's blood glucose concentration is higher than the upper limit for normal concentration.

Show your working. **Give your answer to one decimal place.**

Answer = ... % **[2]**

(b) The patient was sent for a further blood test, known as the haemoglobin A1C (HbA1C) test.

- Glucose combines with haemoglobin in the bloodstream to form a 'glycosylated haemoglobin' molecule, HbA1C.
- The concentration of HbA1C is directly proportional to the mean concentration of glucose in the blood over an eight to twelve week period.

Suggest why a single HbA1C test cannot indicate accurately the mean blood glucose concentration for a period longer than twelve weeks.

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..... **[2]**

(c) The result of the patient's fasting blood glucose test showed a blood glucose concentration higher than the normal range even though the patient had not eaten food for at least eight hours before providing a blood sample.

The result of the patient's HbA1C test indicated that his mean blood glucose concentration had been within the normal range for the previous eight to twelve weeks.

Suggest an explanation for the patient's high value for the **fasting blood glucose test**.

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..... **[1]**

(d) Another patient shows severe symptoms of unregulated blood glucose concentration. Under certain circumstances this condition may need to be treated with glucagon injections.

(i) Under what circumstances might this patient need to be given a glucagon injection?

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..... [1]

(ii) Describe how glucagon is involved in the regulation of blood glucose concentration in a person who is able to regulate their blood glucose concentration correctly.

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

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..... [5]

[Total: 13]

2 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.

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..... [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.

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..... [1]

[Total: 10]

4 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]

4 Osmoregulation is a key feature of homeostasis and maintains the water potential of the blood within certain limits. This is achieved by the action of anti-diuretic hormone (ADH).

(a) Explain the likely effect on the blood cells if the water potential of the plasma was allowed to increase significantly.

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..... **[2]**

Fig. 4.1 is a simplified diagram of the structure of ADH.

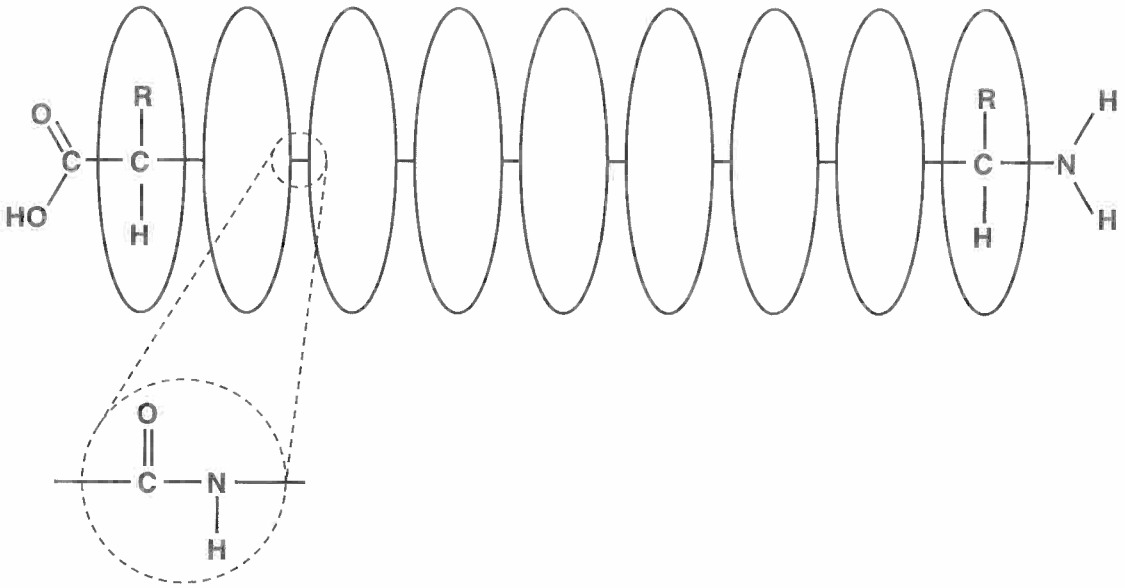

Fig. 4.1

(b) Name the type of monomer that makes up a molecule of ADH and the bond that joins the monomers together.

type of monomer.....

name of bond..... **[2]**

(c) Complete the following passage, using the **most suitable** term in each case:

ADH is a hormone that is produced by specialised nerve cells known as ..... cells. These cells detect changes in the water potential of the blood flowing through the ..... . If the water potential of the blood is too low then ADH is released.

ADH is not secreted immediately into the blood but passes along the ..... of the specialised nerve cells to the .... gland, from where it is released into the blood.

ADH acts on the cells of the ....

The ADH molecule attaches to receptors on the ..... of these cells and causes protein channels known as ..... to insert themselves into the membrane. Water passes through these channels by ..... and a smaller volume of more concentrated urine is produced. **[8]**

(d) ADH does not stay in the blood indefinitely.

Suggest where ADH is removed from the blood **and** describe what then happens to the ADH molecule.

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..... **[3]**

[Total: 15]

5 **(a)** Fig. 5.1 represents the sequence of events that takes place when adrenaline reaches a liver cell.

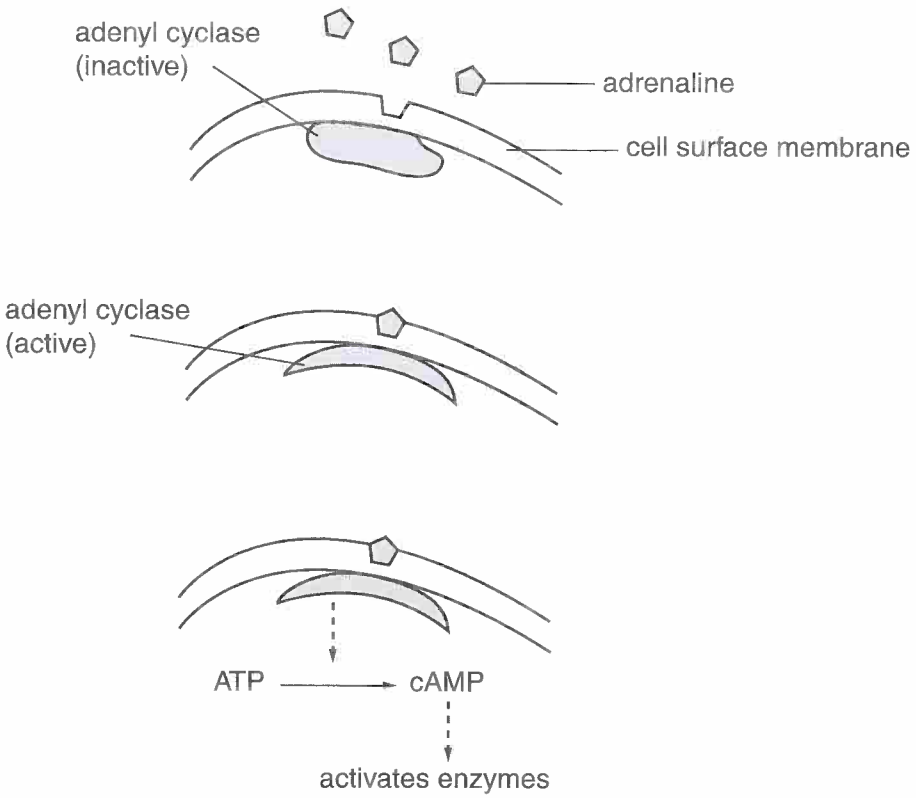

Fig. 5.1

(i) In terms of cell signalling, name the compound in Fig. 5.1 that is acting as:

the second messenger.....

the first messenger..... **[2]**

(ii) Suggest what happens to polysaccharides in the liver cell as a result of the events shown in Fig. 5.1.

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..... **[1]**

(iii) Adrenaline affects a range of target tissues in the body.

Suggest how the adrenaline molecule can cause different effects in different target tissues.

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..... [2]

(b) Outline the **hormonal** and **nervous** mechanisms involved in the control of heart rate.

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

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..... [5]

[Total: 10]

Answer **all** the questions.

1 **(a)** The control of blood glucose is a very important aspect of homeostasis.

(i) Explain what is meant by the term *homeostasis*.

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..... **[2]**

(ii) Describe how negative feedback is used to control blood glucose concentration.

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

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..... [6]

(b) A 55 year old man visited the doctor and was newly diagnosed with diabetes.

- The doctor initially recommended to the man that he should change his diet to cut out excess carbohydrate, including sugars such as glucose and make a further appointment to check on his progress.
- At this second appointment, however, it was discovered that the dietary changes had not been effective, which was unexpected.
- It turned out that the man had a form of diabetes that required daily hormone injections to control his blood sugar concentration.

Using **only the information given above**, state how **this** man's form of diabetes is **similar** to:

(i) Type 1 diabetes

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..... **[1]**

(ii) Type 2 diabetes.

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..... **[1]**

[Total: 10]

2 Urine is a liquid that is composed of a number of different substances.

(a) Urea is one compound that is excreted from the mammalian body in urine.

(i) Name the organ that **produces** urea.

..... [1]

(ii) It has been observed that the urea content of urine is relatively high when a person eats an excessive amount of protein in their diet.

Suggest why a high intake of protein in the diet will be likely to result in a high concentration of urea in urine.

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..... [3]

(b) Suggest what condition is indicated by the presence of glucose in a person's urine.

..... [1]

(c) **(i)** Pregnancy may be detected by testing a woman's urine.

State the substance that is being tested for in urine when a pregnancy test is carried out.

..... [1]

(ii) Ovulation is the release of an egg cell from the ovary. In order for pregnancy to occur, the egg cell must be fertilised within 24 hours of its release from the ovary.

Immediately before ovulation, the body produces a large amount of luteinising hormone (LH). This is known as the LH surge and triggers ovulation. It is during this time that fertilisation is most likely to occur.

- If a woman is trying to get pregnant, it can be useful to know when ovulation has occurred.
- It is possible to identify the LH surge by using a test stick to detect LH in urine.
- The test stick for LH works in a similar way to the test stick used for detecting pregnancy.

Fig. 2.1 shows the features of a test stick that can be used to test for LH in urine.

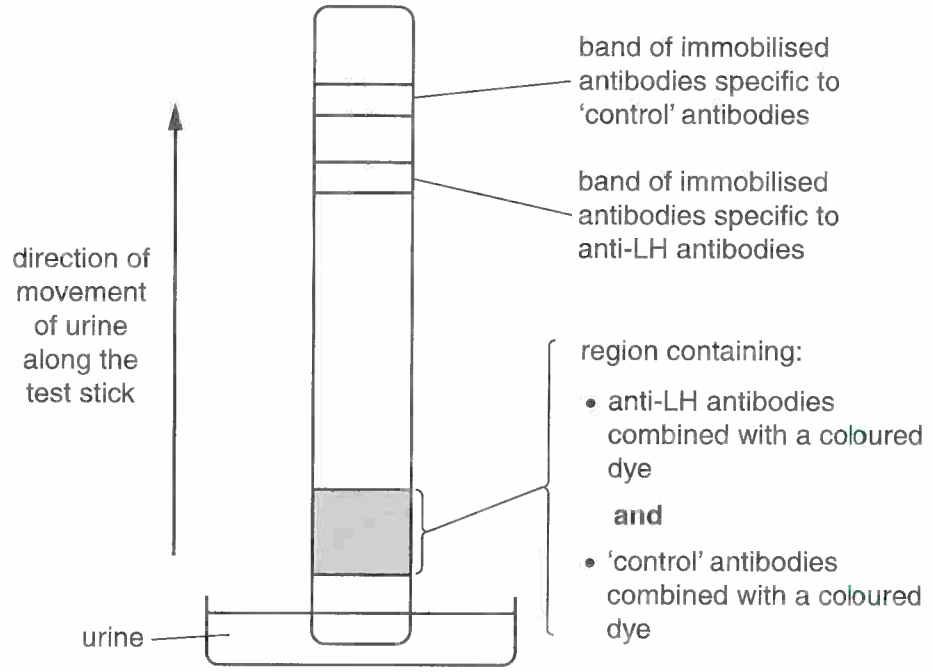

Fig. 2.1

Using your knowledge of how a test stick works, suggest how the test stick in Fig. 2.1 can be used to indicate a positive result for LH in urine.

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..... **[3]**

[Total: 9]

5 The regulation of blood glucose concentration is important for homeostasis and involves hormonal control.

(a) **(i)** Name the endocrine tissue in the pancreas that is responsible for secretion of hormones.

..... [1]

(ii) Identify the **specific** cell type in pancreatic tissue that secretes the hormone insulin.

..... [1]

(b) The incomplete flowchart below outlines the way in which the secretion of insulin from a pancreatic cell is controlled.

Complete the flowchart by inserting the most appropriate word(s) in the spaces provided.

Insulin secretion is stimulated when the blood glucose concentration .....

↓

Glucose enters the pancreatic cell through channel proteins. The glucose enters the..... pathway and ATP is produced.

↓

The increase in ATP causes ATP-controlled potassium ion channels to close and the cell membrane becomes .....

↓

This results in the opening of voltage-gated ..... ion channels and the concentration of this ion inside the cell increases.

↓

The increased concentration of these ions causes the secretion of insulin from the cell by the process of .....

[5]

(c) (i) Insulin is a polypeptide molecule.

State where in a pancreatic **cell** insulin molecules are synthesised.

..... [1]

(ii) Outline the events that occur after the synthesis of an insulin molecule until it is ready to be secreted from the pancreatic cell.

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..... [3]

[Total: 11]

END OF QUESTION PAPER

3 Fatigue is a symptom of some medical conditions. One feature of fatigue is extreme tiredness, due to a lack of energy.

Medical conditions that have fatigue as a characteristic symptom include Type 2 diabetes, certain heart conditions, chronic fatigue syndrome (CFS) and emphysema.

(a) Explain how emphysema could result in fatigue.

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..... **[2]**

(b) In Type 2 diabetes, the target cells do not respond correctly to the insulin produced when there is an increase in blood glucose concentration.

Suggest why fatigue may occur in a person with Type 2 diabetes who is **not** taking medication.

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..... **[2]**

(c) Certain heart conditions result in a weak and irregular heart beat.

Suggest how a weak and irregular heart beat could result in fatigue.

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..... **[2]**

(d) Chronic fatigue syndrome (CFS) is a condition in which symptoms vary from individual to individual.

It is thought that a number of different malfunctioning processes can contribute to this condition in an individual.

CFS can affect every system in the body and is identified by symptoms that include fatigue, muscle weakness and aching muscles.

(i) It has been suggested that, in the cells of people with CFS, pyruvate may not be transferred into the mitochondria efficiently.

Outline the consequences of an inefficient transfer of pyruvate into mitochondria and link this to the symptoms of CFS stated above.

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..... **[3]**

(ii) Some people with CFS overproduce T lymphocytes and associated cytokines. Despite this, the specific immune response is poor in these people, resulting in an increased susceptibility to infection.

Suggest a reason for the poor specific immune response in people with CFS.

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..... **[1]**

[Total: 10]

4 **(a)** The pancreas is an unusual gland as it is both an endocrine and an exocrine gland.

Fig. 4.1, **on the insert**, shows a group of cells in the pancreas.

(i) State the name given to the group of cells labelled **X**.

..... **[1]**

(ii) Describe the different ways in which the pancreas acts as both an endocrine and an exocrine gland.

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

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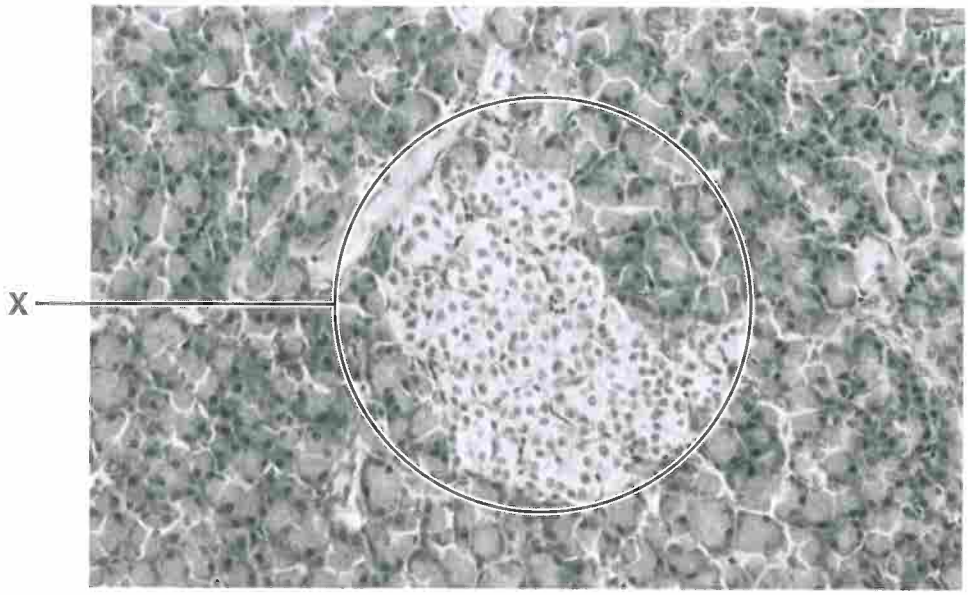

Fig. 4.1

(b) One particular type of cell in the pancreas is responsible for secreting insulin. The various events involved in the secretion of insulin are listed below.

A	Glucose is phosphorylated and metabolised to produce ATP
B	Potassium channels open, allowing potassium ions to diffuse out of the cell
C	The change in voltage across the membrane causes calcium channels to open
D	Glucose enters the cell
E	The movement of ions results in a potential difference across the cell surface membrane of –70 mV
F	Calcium ions diffuse into the cell
G	The presence of extra ATP causes the potassium channels to close
H	The membrane potential changes to –30 mV
J	The calcium ions cause the vesicles to fuse with the membrane and release insulin

Complete the following list by placing the events in the correct order.

B ..... E .... J ..... [4]

(c) (i) State **two** advantages of treating **Type 1** diabetes by using insulin that has been produced by genetically modified bacteria rather than insulin that has been extracted from pigs.

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..... [2]

(ii) A potential treatment for Type 1 diabetes is the use of stem cells.

State an advantage of this form of treatment compared to treatment using insulin.

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..... [1]

[Total: 13]

4 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,

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..... **[2]**

(ii) between starch and cellulose.

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..... [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.

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..... [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]