

SUGGESTED TEXTBOOK ANSWERS

Chapter 9 Disruptions to homeostasis

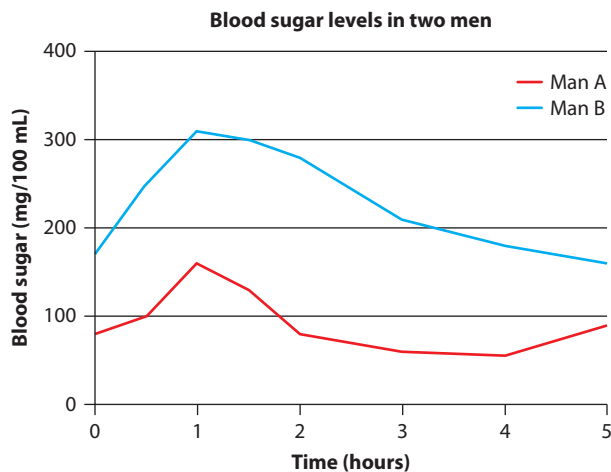
The following are suggested answers only. Other answers to the same questions may also be correct.

Science inquiry

Activity 9.1 Regulation of blood sugar

- 1 Plot the data for the two men as a graph.

Answer:



- 2 One of the men had a diseased pancreas. Which man was it? Give reasons to support your answer.

Answer: Man B has a diseased pancreas. His blood glucose level before the test was much higher than normal (see Figure 8.2 on page 103), and it took five hours for his blood glucose to return to the pre-test level. This is an indication of low levels of insulin, a hormone that is normally produced by the pancreas.

- 3 What is the name of the disease from which the man was suffering?

Answer: Diabetes mellitus

- 4 Which parts of the endocrine system are responsible for releasing each of the hormones listed in the table?

Answer:

- Adrenaline – adrenal medulla
- Glucagon – (alpha cells in the islets of Langerhans of the) pancreas
- Cortisol – adrenal cortex

- 5 A technician suggested giving the hormones to the dog by adding them to its drinking water. Would this method be effective? Explain.

Answer: No, it would not, because the hormones need to circulate through the blood. The hormones would be broken down in digestion before they could be absorbed into the blood.

6 Compare the effects of these hormones when acting:

a singly

Answer: The hormones acting alone caused a minor rise in blood sugar levels. The increase ranged from 3 to 30 mg/100 mL of blood.

b together.

Answer: The hormones working together result in a marked rise in blood sugar levels. The increase was particularly high when all three hormones were given together.

7 What do the data indicate about the response of body tissues to the hormone mixtures?

Answer: The tissues respond much more to combinations of the hormones than they do to any one hormone. The hormones seem to complement each other's effect.

8 In the light of your answers to questions 6 and 7, explain how stress could raise blood glucose levels. What would be the advantage of this response?

Answer: Stress causes an increase in levels of cortisol (long term) and adrenaline (short term). The experiment showed that both these hormones reinforce the effect of glucagon. Both cortisol and adrenaline promote glycogenolysis and gluconeogenesis, so that more glucose would be released into the blood. The extra glucose could then be used to provide energy for the body organs to deal with any stressful situation.

9 Describe at least three major criticisms of the design of the experiment on the dog.

Answer: The experiment could be criticised on the following grounds:

- The researchers did not say whether or not the dog had been fed.
- They did not appear to control the volumes of hormones given.
- Only one dog was used (sample size very small) and that dog may have been unusual in some way.
- There was no repetition of the procedure.
- The normal level of blood glucose was not measured before the experiment was begun.
- There was no control so the results could not be compared with a dog that had not been given the hormones.

Activity 9.2 Thyroid hormone

1 Suggest a hypothesis the scientist may have been testing.

Answer: That iodine is absorbed from the blood by the thyroid gland.

2 Why was the scientist using iodine, rather than some other substance, to investigate the thyroid gland?

Answer: Iodine is a part of the thyroxine molecule, the hormone that is secreted by the thyroid.

3 Why was radioactive iodine used?

Answer: Radioactive iodine was being used so that movement of the iodine in the body could be traced.

4 What do you think the scientist was trying to demonstrate with this experiment?

Answer: The scientist was demonstrating the ability of the thyroid to accumulate iodine, or that the iodine used by the thyroid gland to make thyroxine is absorbed from the blood. (Some students may mention the importance of dietary iodine to provide iodine for the blood.)

- 5 Using the graph, explain what happened to the iodine in the 40 minutes after it was injected into the arm.

Answer: The graph shows that as iodine in the blood declined there was an accompanying increase in iodine in the thyroid. Concentration of iodine in the arm (presumably the muscles) rose a little then fell.

- 6 An important part of the investigation was to measure the concentration of iodine in the person's arm. Why was this necessary?

Answer: To compare the original concentration injected with the concentration in the thyroid – that is, as a control. This was necessary to show that any reduction in the level of iodine in the blood was not due to iodine being absorbed by the tissues of the arm.

- 7 Would it have made any difference to the investigation if the iodine had been injected into the person's leg?

Answer: It may have taken slightly longer to reach the thyroid, but otherwise it should not have made a difference.

Review questions

- 1 Explain the differences between type 1 and type 2 diabetes.

Answer: A person with type 1 diabetes does not produce insulin. In most cases the patient's cells respond to insulin in the normal way so that the disease can be managed by giving the patient insulin.

Type 2 diabetes (also known as non-insulin dependent or adult onset diabetes) usually develops in people over the age of about 45 years, although increasing numbers of younger people are now being diagnosed. Unlike type 1 diabetes, type 2 patients are able to produce insulin, but their cells do not respond to it.

	Type 1 diabetes	Type 2 diabetes
Onset	Usually in childhood	Usually over age 45, but increasing numbers of younger people affected
Cause	Immune system fault causing destruction of beta cells in pancreas so that insulin is not produced	Associated with lack of physical activity and being overweight
Treatment	Cells usually respond to insulin normally so insulin can be given to manage the condition	Cells do not respond to insulin so management involves careful diet with regular physical activity

- 2 Which of the two types of diabetes can frequently be treated by modifying the patient's behaviour? Explain the nature of the behaviour modification that is necessary for effective treatment.

Answer: Type 2 diabetes is a lifestyle disease and can therefore be managed by behaviour modification. (It is more common in people who are not physically active and are overweight or obese.) It is treated by a careful diet, regular physical activity, maintaining a healthy weight, monitoring blood glucose and perhaps medication as the disease develops.

3 How can a person minimise the chance of developing type 2 diabetes later in life?

Answer: Type 2 diabetes is preventable. The chances of suffering from the disease can be reduced by adopting a healthy lifestyle.

Lifestyle factors that can decrease the risk of developing type 2 diabetes include:

- maintaining a high level of physical activity
- not being overweight or obese/maintaining a healthy body weight
- consuming a diet that is low in fat, sugar and salt, and high in fibre
- maintaining low blood cholesterol
- not smoking.

4 Explain the difference between hyperthyroidism and hypothyroidism.

Answer: Hyperthyroidism results from too much thyroxine. It occurs when the thyroid gland produces too much hormone. (The most common type of hyperthyroidism is known as Graves' disease. It is an enlargement of the thyroid caused by an immune system reaction.) Symptoms of hyperthyroidism include weight loss, increased appetite, increased heart rate, fatigue and anxiety.

Hypothyroidism results from too little thyroxine. Causes include deficiency of iodine in the diet, surgery involving removal of all or part of the thyroid, attack on the thyroid by the immune system (Hashimoto's disease), and problems with the pituitary or hypothalamus. Symptoms include slow heart rate, weight gain, fatigue, intolerance to cold and swelling of the neck.

5 Explain how a dietary deficiency can cause hypothyroidism.

Answer: A thyroxine molecule contains four iodine atoms (hence, T₄) and a tri-iodothyronine molecule contains three atoms of iodine (T₃). Thus, if there is a deficiency of iodine in the diet, the thyroid gland cannot make enough of the thyroid hormones. If the cause of hypothyroidism is a lack of iodine, it is easily treated by the inclusion of extra iodine in the diet.

6 Describe how biosynthetic insulin is produced.

Answer: Biosynthetic insulin is produced by inserting the gene for human insulin production into bacteria or yeast cells. The bacteria or yeasts are then cultured in large vats. Because they have the gene for insulin production the cultured cells produce human insulin.

7 Drugs used to treat thyroid deficiency are produced synthetically. What advantages are there in using synthetic drugs rather than those obtained naturally?

Answer: Hormones obtained naturally from the thyroid glands of animals like pigs may contain traces of other hormones. Also they may not contain the correct proportions of T₃ and T₄. The content of synthetic hormones can be closely regulated.

8 a What is a deficiency disease?

Answer: A deficiency disease is a condition that results from an inadequate level of a particular vitamin or mineral in the diet.

b Describe one dietary deficiency that may have an effect on homeostasis.

Answer: Dietary deficiencies that may have an effect on homeostasis include:

- a lack of iodine: the body cannot produce enough thyroid hormone to maintain normal metabolic rate and therefore body temperature
- a deficiency of iron in the diet resulting in anaemia – insufficient haemoglobin to carry enough oxygen to the tissues
- a deficiency of vitamin B₁₂ in the diet, which causes pernicious anaemia
- a deficiency of vitamin K, which is essential for normal blood clotting, so a deficiency can cause excessive bleeding if a person is injured.

9 Describe two examples to illustrate how disease can affect homeostasis.

Answer: Emphysema is a lung disease often caused by smoking. The walls of the alveoli (air sacs) break down creating abnormally large air spaces. This reduces the surface area available for gas exchange, so that the patient has difficulty taking in enough oxygen.

Many infections or other diseases result in fever, which itself is not a disease, but is a symptom of disease. The temperature at which homeostasis maintains core temperature is usually increased by 1 or 2°C. This higher temperature may affect many of the chemical reactions occurring in the body, and thus disrupt homeostasis.

Hypertension occurs when the normal homeostatic responses are unable to maintain healthy blood pressure. It contributes to cardiovascular disease and kidney failure.

Apply your knowledge

1 The most commonly used test to see whether thyroid function is adequate is a blood test for thyroid-stimulating hormone (TSH).

a How would a blood test for TSH show whether the thyroid is functioning normally?

Answer: TSH regulates the release of thyroxine from the thyroid. It is released by the anterior pituitary gland in response to low levels of thyroxine. If thyroxine levels are very low, higher than normal levels of TSH would be expected in the blood. Likewise, if thyroxine levels are higher than normal, TSH levels will be very low. If TSH levels are normal, it probably means that thyroxine secretion is normal.

b A test for TSH in the blood can also be used to determine whether a person's diet has sufficient iodine. How would such a test be able to show whether iodine levels are adequate?

Answer: Iodine is needed for production of thyroxine. If iodine levels are low, less thyroxine will be able to be produced by the thyroid gland. This, in turn, would cause TSH levels to increase in order to try to stimulate the thyroid to produce more thyroxine.

2 Imagine that you are a doctor. One of your patients is overweight and complains of feeling constantly hungry and thirsty. You suspect the patient may have type 2 diabetes.

a What tests would you do to find out whether the person is suffering from type 2 diabetes?

Answer: You could test the patient's urine to see if glucose is present and, if necessary, test blood sugar concentration.

b If type 2 diabetes is positively diagnosed, what treatment would you recommend for the patient?

Answer: A change in lifestyle should be recommended. It would incorporate:

- a balanced diet with many serves of fruit and vegetables and fewer serves of fat and sugar
- an exercise regime to be carried out at least three times per week for one hour
- a weight loss program, because obesity causes the insulin receptors to become less sensitive to insulin.

3 Design a poster, or a leaflet, to make the public aware of the dangers of iodine deficiency and how to avoid it.

Answer: The poster should include the following information:

- symptoms of lack of iodine such as swelling of the neck (goitre), lack of energy, intolerance to cold, slow heart rate
- effects of a mother's iodine deficiency during foetal development – retarded mental and physical growth of the foetus
- treatment for iodine deficiency – inclusion of extra iodine in the diet.

4 Goitre, enlargement of the thyroid gland, can be associated with both over-production and under-production of thyroid hormone. Explain how this is possible.

Answer: Over-production of thyroid hormone is caused by overactive thyroid cells. This increased cellular activity causes enlargement of the thyroid. Underproduction also results in goitre, because the thyroid enlarges to try to accumulate as much iodine as possible from the blood so that it can synthesise more thyroxine. It is constantly stimulated by TSH to do so.

5 List the ways in which homeostasis might be affected if a person lost a litre of blood in an accident.

Answer: The loss of a litre of blood may result in:

- a body fluid imbalance, with a decrease in the volume of fluids, which would in turn, put strain on the heart
- a decline in blood pressure, due to decreased stroke volume and cardiac output
- the heart compensating from the effects of a decline in blood pressure by increasing the rate of contraction
- less oxygen available for cellular respiration, and less carbon dioxide circulating in the blood, which may lead to a decreased rate of breathing
- vasoconstriction in the skin and in other less important organs, which would direct blood mainly to vital organs
- a decrease in blood pressure, which would reduce filtration in the kidneys, and an increase in water reabsorption, so that less urine would be produced.

6 Graves' disease is caused by an abnormality of the immune system. The immune system produces an antibody that behaves in the same way as TSH. Explain how this would lead to hyperthyroidism.

Answer: If the antibody behaves in the same way as TSH, it would stimulate the thyroid to produce more thyroid hormones leading to hyperthyroidism and the symptoms of Graves' disease.

7 Pregnant women need up to three times more insulin than normal. If the body is unable to produce that much insulin, a condition called gestational diabetes develops. Find out how gestational diabetes could affect the developing foetus.

Answer: Babies born to mothers with gestational diabetes have an increased risk of obesity and an increased chance of developing type 2 diabetes later in life.

If untreated, gestational diabetes can cause growth abnormalities and chemical imbalances after the baby is born.