

## Answers: Chapter 2 Hormones help control the body

### Questions 2.1

#### RECALL KNOWLEDGE

**1** Where do exocrine glands secrete their products?

*Answer:* Exocrine glands secrete their substances to the body surface or to one of the body cavities.

**2** How do the products of endocrine glands move to their target cells?

*Answer:* They are secreted into the extracellular fluid and then they move into the capillaries to be transported by the blood.

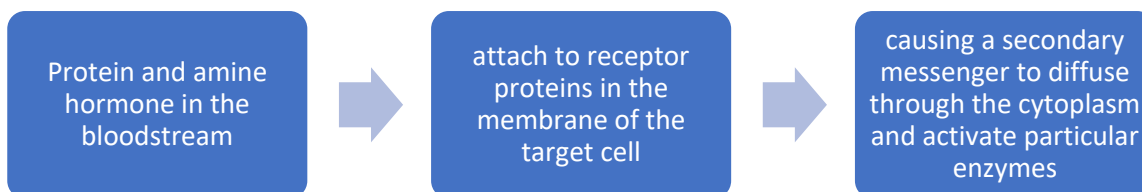
**3** List the three ways that hormones are able to change the functioning of cells.

*Answer:*

- They can activate certain genes in the nucleus so that a particular enzyme or structural protein is produced.
- They can change the shape or structure of an enzyme so that it is turned 'on' or 'off'.
- They can change the rate of production of an enzyme or structural protein by changing the rate of transcription or translation during protein production.

**4** Use a flow chart to show what happens to protein and amine hormones after they are secreted from the endocrine gland.

*Answer:*



**5** Describe the following properties of hormone receptors:

**a** specific

*Answer:* Receptor proteins are specific to a particular molecule (lock and key analogy), the receptor protein will only work with the correct binding molecule.

**b** saturation.

*Answer:* There is a limited number of receptor proteins in the membrane of each cell. When each receptor is bound to a molecule there can be no further increase in the rate of the cells activity. Once the receptor proteins are saturated the addition of more hormones will not produce a greater effect.

#### APPLY KNOWLEDGE

**6** Explain why the receptors for steroid hormones are located inside the cell.

*Answer:* Steroid hormones are lipid soluble, so they are able to diffuse across the membrane of the cell and enter the cytoplasm. As such, the receptors for steroid hormones are found inside the cell.

**7** Predict what would happen if hormone clearance were unable to occur.

*Answer:* Hormone clearance is required to turn the action of the hormone off. If there was no hormone clearance the target cells would be continuously stimulated to respond, and this would result in an imbalance or positive feedback.

## Questions 2.2

### RECALL KNOWLEDGE

**1** Describe the location of the hypothalamus.

*Answer:* The hypothalamus is located at the base of the brain, below the thalamus and above the pituitary gland.

**2** One of the types of hormones that the hypothalamus secretes is releasing factors.

**a** How do releasing factors reach their target cells?

*Answer:* The hypothalamus secretes releasing factors into blood vessels heading towards the anterior lobe of the pituitary gland.

**b** What are the target cells of releasing factors?

*Answer:* The anterior lobe of the pituitary gland.

**c** What is the function of releasing factors?

*Answer:* Releasing factors stimulate the release of a hormone from the anterior lobe of the pituitary gland.

**3** What is the alternative name for the neurohypophysis?

*Answer:* The posterior lobe of the pituitary gland.

**4** Compare and contrast the anterior and posterior lobes of the pituitary gland.

*Answer:* Compare: Together they form the pituitary gland, both have a relationship with the hypothalamus. Contrast: The posterior lobe of the pituitary gland does not make its own hormones, rather they are made in the hypothalamus and released by the posterior lobe of the pituitary gland under influence of nerve impulses from the hypothalamus. The anterior lobe of the pituitary gland makes its own hormones and secretes them due to releasing or inhibiting factors produced by the hypothalamus.

**5** List the gonadotrophins secreted by the anterior lobe of the pituitary gland and explain why they are classified as gonadotrophins.

*Answer:* Follicle stimulating hormone and luteinising hormone. They are classified as gonadotrophins because they affect the gonads (ovaries and testes).

**6** List the hormones released from the posterior lobe of the pituitary gland.

*Answer:* Oxytocin and antidiuretic hormone.

**7** Describe the target cells and function of each of the following hormones:

**a** adrenocorticotrophic hormone

*Answer:* Target cell: Adrenal cortex. Function: Controls the production and release of some of the hormones from the adrenal cortex.

**b prolactin**

*Answer:* Target cell: Breasts. Function: Works with other hormones to initiate and maintain milk secretion in females.

**c growth hormone**

*Answer:* Target cell: Body cells, particularly cells of the skeleton. Function: Increases the rate at which amino acids are taken up by the cells and built into proteins.

**d oxytocin**

*Answer:* Target cell: Uterus and mammary glands. Function: Contractions of the uterus during birth, release of milk from breasts.

**e luteinising hormone**

*Answer:* Target cell: In females the ovaries, in males the interstitial cells of the testes. Function: In females, it controls ovulation and the maintenance of the corpus luteum. In males, LH regulates the secretion of testosterone.

**f antidiuretic hormone**

*Answer:* Target cell: Kidney nephron. Function: Changes the permeability of the nephron wall to water.

**g thyroid-stimulating hormone**

*Answer:* Target cell: Thyroid. Function: Controls the production and release of thyroxine

**h follicle-stimulating hormone.**

*Answer:* Target cell: In females the ovaries, in males the testes. Function: In females it controls the growth of follicles, in males it controls the production of sperm.

**APPLY KNOWLEDGE**

**8** Explain why the pituitary gland is known as the master gland.

*Answer:* The pituitary gland, along with the hypothalamus, controls the functioning of many other glands.

**9** Predict what would happen if the infundibulum was severed.

*Answer:* If the infundibulum was severed then the hormones released by the pituitary gland would not be able to be secreted. This would be due to the releasing factors not reaching the anterior lobe, or the hormones not being able to be moved down the infundibulum for release via the posterior lobe.

**10** Explain why the posterior lobe of the pituitary gland is technically not an endocrine gland.

*Answer:* The posterior lobe of the pituitary gland does not manufacture the hormones, it simply stores and releases the hormones made in the hypothalamus.

## Questions 2.3

**RECALL KNOWLEDGE**

**1** Which endocrine gland secretes melatonin?

*Answer:* The pineal gland

**2** Describe the location of the thyroid gland.

*Answer:* The thyroid gland is located in the neck at the base of the larynx.

**3** Name the hormone secreted by the parathyroid gland and describe its function.

*Answer:* Parathormone (or parathyroid hormone) is secreted by the parathyroid glands and its function is to increase calcium levels in the blood and phosphate excretion in the urine.

**4** Name two endocrine glands that decrease in size with age.

*Answer:* The pineal gland and the thymus.

**5** Describe the location of the adrenal glands, and the arrangement of the adrenal medulla and adrenal cortex.

*Answer:* The adrenal glands are located immediately above each kidney. Each gland has an inner adrenal medulla and an outer adrenal cortex.

**6** Match the hormone in the following table with the gland that produces it.

*Answer:*

Hormone	Endocrine gland
adrenaline	adrenal medulla
thyroxine	thyroid gland
aldosterone	adrenal cortex
cortisol	adrenal cortex
testosterone	testes
insulin	pancreas
oestrogen	ovaries

### APPLY KNOWLEDGE

**7** Explain why people who suffer from hyperthyroidism (overactive thyroid) experience weight loss.

*Answer:* Hyperthyroidism is the over-secretion of thyroxine from the thyroid gland. Higher levels of thyroxine will result in a higher body metabolism, which uses glucose, glycogen stores and adipose tissue. As such, a person will not store excess glucose as fats, and will use up any stores they may have.

**8** Explain how insulin and glucagon are able to keep blood glucose at the correct level.

*Answer:* Insulin is secreted when blood glucose levels are elevated, and acts to bring glucose levels down to within tolerance limits. Glucagon acts to raise blood glucose levels, so after a period of fasting glucagon will be released to bring blood glucose levels up into the tolerance limits.

**9** Explain why oestrogen and progesterone are called the female hormones when they exist in both males and females.

*Answer:* Progesterone in males acts to counteract the effect of oestrogen. Progesterone is seen as a precursor to the production of testosterone.

Oestrogen in males has a beneficial effect on bone metabolism, preventing the appearance of osteoporosis. At a cardiovascular level, oestrogen in males has been found to increase the good cholesterol. Oestrogen is produced by the adrenal glands and the testes in males.

**10** Explain how the body is able to maintain a consistent level of calcium in the blood.

**Answer:** Calcium levels are maintained in the blood stream under the influence of parathormone (released from the parathyroid glands) to act on the bones, intestine and kidneys to increase calcium levels. Calcitonin (released by the thyroid gland) acts to lower calcium levels in the blood stream by reducing the level of reabsorption at the kidneys.

## CHAPTER 2 ACTIVITIES

### ACTIVITY 2.1 Researching the discovery of insulin

#### Your task

**1** Use the Internet to research the story of insulin's discovery by:

- Frederick Banting
- Charles Best
- J.J.R. Macleod
- James Collip.

For each scientist, include the method they used to isolate insulin.

**Answer:** Suitable websites include the following:

- [https://www.diabetes.org.uk/about\\_us/news\\_landing\\_page/first-use-of-insulin-in-treatment-of-diabetes-88-years-ago-today](https://www.diabetes.org.uk/about_us/news_landing_page/first-use-of-insulin-in-treatment-of-diabetes-88-years-ago-today)
- <https://www.nobelprize.org/prizes/medicine/1923/summary/>

Student responses should include some of the following key points:

- Before insulin was discovered, diabetes was an incurable disease that led to death.
- In 1921 Frederick Banting and his assistant, Charles Best, removed the pancreas from a dog and demonstrated that the dog developed diabetes.
- Banting and Best removed the pancreas from another dog, ground it up, filtered it and injected the solution into the diabetic dog. By giving the diabetic dog regular injections, they were able to prevent the symptoms of diabetes.
- Professor John Macleod, who had provided Banting and Best with the finance and a laboratory for their experiments, insisted on more tests to confirm that pancreatic extract relieved the symptoms of diabetes. He suggested that they should call their extract insulin.
- Using pancreases from cattle, Banting and Best were able to keep several diabetic dogs alive.
- James Bertram Collip joined Banting and Best and was given the task of purifying the pancreatic extract so that it could be tested on humans.
- Early in 1922 a 14-year-old boy who was near death with diabetes was given injections of insulin. He rapidly recovered.

**2** In 2006 a research team at the CSIRO in Australia made another important discovery in the quest for a full understanding of how insulin works. Find out what the discovery was and its implications for the understanding of insulin.

**Answer:** Suitable websites include the following.

- <https://csiropedia.csiro.au/insulin-receptor-researchers-win-top-csiro-award/>

Students may make the following points.

- In 2006 CSIRO scientists worked out most of the three-dimensional structure of the insulin receptor – that is, the protein on the cell membrane that detects the presence of the insulin molecule.
- In 2011 researchers at the Walter and Eliza Hall Institute in Melbourne determined the structure of the part of the receptor where the insulin molecule binds.

- In 2012 CSIRO was developing a new therapy, which would mean that daily insulin injections were no longer required by people suffering from insulin-dependent diabetes. The new technique involved transplanting, into diabetics, insulin-producing tissue derived from stem cells.

### ACTIVITY 2.2 Understanding endocrine dysfunction

Write a short essay to show the cause-and-effect relationship between the information that you researched.

**Answer:** Students should produce an essay with one idea per paragraph. Depending on which endocrine dysfunction they select, the main points on cause and effect/symptoms and treatment can be checked from the table below.

Essay example for Acromegaly:

Acromegaly is an endocrine dysfunction caused by the over secretion of growth hormone. Growth hormone is produced and secreted by the anterior lobe of the pituitary gland. If there is a tumour on the pituitary gland, it can secrete excess growth hormone, even if skeletal growth has ceased.

People suffering from Acromegaly may show the following symptoms: Large hands, feet and enlarged facial features due to overgrowth of bones in these areas. They may also experience coarse oily and thickened skin, excessive sweating and body odour, skin tags, fatigue and muscle weakness.

The goal of treatment is to restore the pituitary gland to normal function, and to produce normal levels of growth hormone. Treatment may include removal of the tumour, radiation therapy, and injection of growth hormone blocking drugs. Left untreated, acromegaly can lead to worsening diabetes mellitus and hypertension.

Disorder	Cause	Symptoms	Treatment
Acromegaly	Oversecretion of growth hormone after most skeletal growth has stopped; usually due to a tumour of the pituitary gland	Large hands, feet and jaw due to overgrowth of bones in these areas	Removal of the tumour or reducing activity of the tumour using drugs and/or radiation
Addison's disease	Undersecretion of cortisol and sometimes aldosterone. Usually caused by an auto-immune response that attacks the adrenal cortex. May be an infection or tumour	Low blood pressure, loss of appetite, weight loss, muscle weakness, chronic fatigue, nausea, vomiting, diarrhoea	Daily consumption of cortisol (and possibly aldosterone) tablets to replace the missing hormones
Androgen insensitivity syndrome	An inherited (sex-linked) condition in which males with normal X and Y chromosomes are resistant to male hormones (androgens)	The patient, although genetically male, develops some or all the physical characteristics of a female	Depends on severity of symptoms. May involve removal of testes, sex reassignment, hormone replacement therapy
Cushing's syndrome	Oversecretion of ACTH from the pituitary, which results in oversecretion of cortisol from the adrenal cortex. May also be caused by overconsumption of cortisol or other steroid	Weight gain in the upper body, moon face, thirst, high blood pressure, purple marks on the skin, muscular weakness, bone pain, rib and	Surgical removal of pituitary or adrenal tumours. Reduction in drug dose if caused by overconsumption of steroids

	hormones	spine fractures	
Exophthalmia (also called exophthalmos)	The most common cause is oversecretion of the thyroid. It is often one of the symptoms of Graves' disease	Marked protrusion of the eyeballs	Drugs to reduce thyroid secretions or radioactive iodine to kill some of the thyroid cells
Gigantism	Oversecretion of growth hormone during childhood, often due to a benign tumour of the pituitary	Excessive growth in height, as well as abnormally large muscles and other organs	Surgery to remove tumour or medications that reduce release of growth hormone
Goitre	Can be caused by both oversecretion and undersecretion of the thyroid gland. Oversecretion may be caused by Graves' disease (see below); undersecretion may be caused by dietary iodine deficiency, autoimmune disease or dysfunction of the pituitary	Enlargement of the neck due to swelling of the thyroid gland. If the thyroid becomes large enough it may press on the windpipe and impair breathing or press on the oesophagus and cause difficulty swallowing	If caused by iodine deficiency – consumption of iodine-rich foods. If caused by hyperthyroidism – drugs can be used to slow activity of the thyroid. If caused by hypothyroidism – hormone replacement therapy can be used
Graves' disease	Abnormal immune system response where the patient's immune system attacks the thyroid gland, leading to oversecretion of the thyroid	Tiredness, irregular or accelerated heartbeat, sleeplessness, anxiety, weight loss, trembling and muscle weakness, protruding eyes	There is no cure, but management of the condition may include drugs to reduce thyroid secretions, radioactive iodine to kill some of the thyroid cells, surgery to remove all or part of the thyroid
Myxoedema	Underactivity of the thyroid gland	Swelling of the face and hands, dry skin, slow reflexes, impaired mental ability, inability to tolerate cold weather	Treatment of the underlying cause of hypothyroidism accompanied by medication to replace thyroid hormones
Phaeochromocytoma	A tumour (usually benign) of the adrenal medulla that results in oversecretion of adrenaline and noradrenaline	High blood pressure, rapid and strong heartbeat, sweating, anxiety, weight loss, abdominal and/or chest pain	Medication to reduce high blood pressure, followed by surgical removal of the tumour. If the tumour is inoperable, drugs are used to control the effects of excessive hormones

## CHAPTER 2 REVIEW QUESTIONS

### Recall

**1 a** Describe the endocrine system.

*Answer:* The endocrine system is the collection of glands, tissues and organs involved in the secretion of chemical messengers or hormones into the blood stream. Its function is primarily to maintain homeostasis and control cellular activities.

**b** Describe the relationship between endocrine glands and hormones.

*Answer:* The endocrine glands are the site of production and secretion of hormones. The exception being the posterior lobe of the pituitary gland, which does not produce the hormones, merely secretes them.

**2 a** Define 'hormone'.

*Answer:* Hormones are substances that affect the functioning of cells. They are secreted by endocrine glands. Hormones may be proteins, steroids or amines. Most are transported throughout the body in the blood. A hormone may affect particular groups of cells, or one or more organs, or it may affect all the cells of the body.

**b** List the different types of hormones.

*Answer:* Steroids, proteins and amine hormones. Steroid hormones are lipid soluble and protein and amine hormones are water soluble.

**3** Describe enzyme amplification and state why it is important.

*Answer:* Enzyme amplification is the process whereby thousands of enzyme molecules are activated by one hormone molecule. The hormone triggers a cascading effect so that the number of reacting molecules involved is increased hundreds or thousands of times for each step in the metabolic pathway. It is possible for one hormone molecule to trigger the production of more than a billion enzyme molecules. This is important because a very small stimulus can produce a very large response.

**4** The pituitary gland is sometimes described as the 'master gland' because it secretes hormones that regulate the activity of other endocrine glands. Describe the pituitary hormones that are involved in the control of other endocrine glands.

*Answer:* Pituitary hormones that regulate other endocrine glands include:

- Gonadotropins: Follicle stimulating hormone (FSH) stimulates development of the follicles in the ovary, thus stimulating the production of oestrogen. Luteinising hormone (LH) works with FSH in the female to bring about ovulation and to form the corpus luteum after ovulation. The corpus luteum then produces oestrogen and progesterone. In males, LH stimulates interstitial cells in the testes to secrete male sex hormones.
- Thyroid stimulating hormone (TSH) stimulates production and release of hormones from the thyroid gland.
- Adrenocorticotrophic hormone (ACTH) controls production and release of some of the hormones from the cortex of the adrenal glands.

**5 a** What is a target organ?

*Answer:* A target organ for a particular hormone is the organ that responds to stimulation by that hormone.



**b** How do hormones get from their source to the target organ?

*Answer:* They are transported throughout the body in the blood.

**c** Describe target organs/cells and the role of the following hormones.

*Answer:*

Hormone	Target organ/cell	Role
i Oxytocin	The target organs for oxytocin are the muscles of the uterus and the mammary glands	Oxytocin is released in large quantities during labour. It stimulates contraction of the muscles of the uterus. Oxytocin also stimulates contraction of cells in the mammary glands, resulting in release of milk during breastfeeding
ii Antidiuretic hormone	The target organs for ADH are the (distal convoluted tubules and collecting ducts of) kidney tubules	Antidiuretic hormone (ADH) causes the kidneys to remove water from urine that is forming
iii Adrenaline	The target cells occur throughout the body, including in the heart, iris of the eye, and the alimentary canal	Adrenaline, also called epinephrine, has an effect similar to that of the sympathetic division of the autonomic nervous system. Adrenaline helps to prepare the body for reaction to a threatening situation; that is, it is concerned with fight-or-flight responses
iv Parathyroid hormone	The bones and the kidneys	Parathyroid hormone (PTH or parathormone) controls calcium and phosphate levels in the blood
v Insulin	Target organs/cells for insulin are the liver, skeletal muscles, fat storage cells and body cells in general	Insulin has the effect of reducing the amount of glucose in the blood, and this is achieved by promoting the uptake of glucose from the blood by the cells of the body. In the liver, insulin causes the conversion of glucose to glycogen and fat; in the skeletal muscles it causes formation of glycogen from glucose; in fat storage tissue it causes glucose to be converted into fat
vi Glucagon	The targets for glucagon are the liver and fat storage tissue	Glucagon acts in the opposite way to insulin. It works to increase blood sugar level, mainly by promoting the breakdown of glycogen to glucose in the liver. Glucagon also stimulates breakdown of fat in the liver and fat storage tissues
vii Thyroxine	All cells in the body are targeted by thyroxine	Thyroxine controls body metabolism by regulating reactions in which complex molecules are broken down to release energy and in which complex molecules are synthesised from simple ones. The overall effect of thyroxine is to bring about release of energy and, since some of the energy released is in the form of heat, to maintain body temperature

**6 a** Which gland produces thymosins, and what is the function of these hormones?

*Answer:* Thymosins are secreted by the thymus. They bring about the maturation of T lymphocytes.

**b** Which gland secretes melatonin? What is the role of melatonin?

*Answer:* Melatonin is secreted by the pineal gland. It is involved in the regulation of sleep patterns.

### Explain

**7** Explain the difference between endocrine and exocrine glands and give five examples of each.

*Answer:* Endocrine glands are sometimes called ductless glands, because they secrete substances (hormones) into the extracellular fluid that surrounds the cells making up the gland, rather than through a duct. The secretion then usually passes into the capillaries to be transported by the blood. Examples of endocrine glands include the pituitary gland, the thyroid gland, the ovaries, the testes, the adrenal glands,

the thymus, the pineal gland, the parathyroid glands and the pancreatic islets.

Exocrine glands secrete substances into a duct, which then carries the secretion to the body surface or to one of the body cavities. Examples of exocrine glands include the sweat glands, the mucous glands, the salivary glands, the part of the pancreas that secretes pancreatic juice, the gastric glands, the sebaceous glands, the tear glands, the milk glands, the bulbourethral glands, the seminal vesicles and the prostate gland.

**8** Hormones are specific. Explain what this means and how it is achieved.

*Answer:* Hormones are only able to influence cells that have the correct receptor for the hormone. That is, hormone receptors are specific. The receptors consist of chemical structures that only allow specific hormones with specific chemical structures to interact with them.

**9** The hypothalamus and the pituitary gland are closely related. Describe their relationship in terms of:  
**a** their location in the body

*Answer:* Both organs are located very close together: the hypothalamus is a part of the brain and the pituitary lies just underneath it. They are joined by a stalk called the infundibulum.

**b** the ways in which they function.

*Answer:* The hypothalamus controls the release of many hormones from the pituitary gland.

- The hypothalamus produces releasing or inhibiting hormones, such as ACTH and TSH, that regulate secretion of hormones from the anterior lobe of the pituitary.
- The hypothalamus produces the hormones oxytocin and ADH, which travel by way of nerve fibres to the posterior lobe of the pituitary. Secretion of these hormones from the posterior lobe is stimulated by nerve impulses from the hypothalamus.

**10** Hormones act by changing the functioning of a cell. Explain how they are able to do this.

*Answer:* Hormones change the functioning of cells by attaching to receptor molecules on the cell membrane or by entering a cell and attaching to a receptor molecule inside the cell. Hormones change the type, activities or quantities of proteins the cell produces. Often hormones exert their influence by changing the activity of enzymes or by changing the concentration of enzymes.

This may be done by:

- activating certain genes in the nucleus so that a particular enzyme or structural protein is produced
- changing the shape or structure of an enzyme so that it is turned 'on' or 'off'
- changing the rate of production of an enzyme or structural protein by changing the rate of transcription or translation during protein production.

**11** Hormones that are lipid-soluble work in a different way from those that are water-soluble. Explain the difference and why it occurs.

*Answer:* Protein and amine hormones are water-soluble hormones. They are unable to cross the phospholipid bilayer, so instead they attach to receptor molecules on the surface of the target cell. When the hormone combines with the receptor on the cell membrane it stimulates a secondary messenger substance to diffuse through the cell and activate particular enzymes.

Steroid hormones are lipid-soluble and can cross the phospholipid bilayer. As such, they diffuse into the target cell and combine with a receptor protein, which may be on the mitochondria, on other organelles or in the nucleus. The complex formed by the hormone and receptor activates genes controlling the formation of particular proteins.

**12** Hormones secreted by the posterior lobe of the pituitary are not actually made in the posterior lobe. Explain the process of producing and releasing these hormones.

*Answer:* The hormones oxytocin and antidiuretic hormone are both produced in special nerve cells in the hypothalamus of the brain. These cells have long extensions that pass through the infundibulum to the posterior lobe. Hormones manufactured in the cells move along the extensions and are stored in the posterior lobe ready for release into the bloodstream. Nerve impulses initiated in the hypothalamus and conducted along the cell extensions stimulate release of the hormones.

### Apply

**13** Explain why endocrine glands are sometimes called ductless glands.

*Answer:* Endocrine glands secrete hormones directly into extracellular fluid. The hormones then diffuse through capillary walls into the blood to be transported throughout the body. There are no ducts into which the hormones are released, and they are not released into a body cavity or onto the surface of the body.

**14** Hormones affect the activity of their target cells. Explain why the addition of more and more hormone does not continue to increase the intensity or rate of the response.

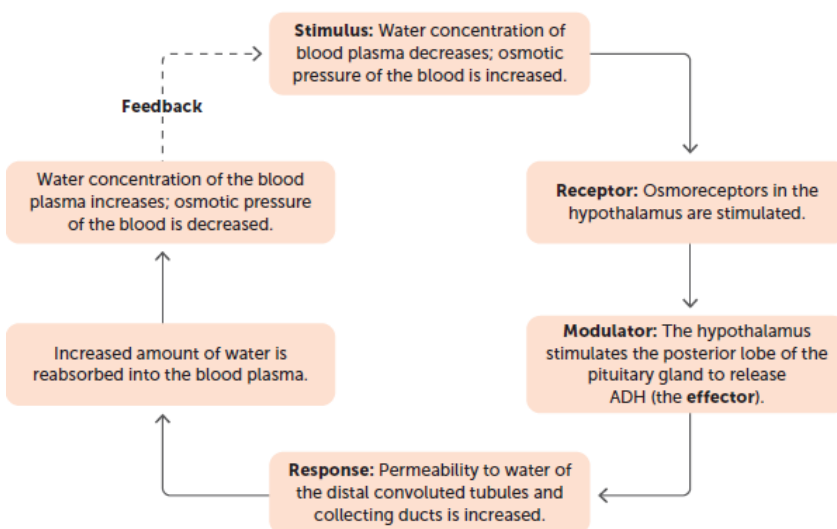
*Answer:* Once all the receptor molecules of a cell are combined with hormone molecules, the addition of more hormone cannot produce any greater effect. This is called saturation.

**15** Athletes have sometimes taken (illegally) the hormone erythropoietin in an effort to improve their performance. In what ways would this hormone improve sporting performance?

*Answer:* Erythropoietin stimulates the production of red blood cells in the bone marrow. This hormone would improve performance because more red blood cells circulating throughout the body results in greater uptake and carriage of oxygen to cells. Aerobic respiration, which uses oxygen to provide the energy for muscle contraction, is therefore enhanced.

**16** Construct a flow diagram similar to Figure 2.11 for the hormone ADH and its role in water balance. Include the role of feedback in your diagram.

*Answer:*



**17** Thyroid-stimulating hormone (TSH) is secreted by the anterior lobe of the pituitary gland. If a cancer patient had their thyroid gland removed, would you expect the level of TSH in the person's blood to rise or fall? Explain your answer.

*Answer:* The levels of TSH would rise, because the levels of thyroxine would fall without an intact thyroid. The decrease in thyroxine, through a negative feedback mechanism, will stimulate the pituitary gland to secrete more TSH, such that the thyroid will produce more thyroxine. If the thyroid is removed, this cannot be achieved, so the pituitary does not receive any negative feedback; thus, it continues to secrete TSH. The patient would need to have supplements of thyroxine to cause a decline in TSH levels.

### Extend

**18** Many famous people have suffered from endocrine disorders.

**a** John F Kennedy, President of the United States from 1960 until his assassination in 1963, suffered from Addison's disease. Consult references to see if you can find out some of Kennedy's medical history. How was he able to carry out his duties as President of the United States while having such a serious illness?

*Answer:* Addison's disease is an endocrine or hormonal disorder that occurs in all age groups and affects men and women equally. The disease is characterised by weight loss, muscle weakness, fatigue, low blood pressure, and sometimes darkening of the skin in both exposed and non-exposed parts of the body. Addison's disease occurs when the adrenal glands do not produce enough of the hormone cortisol and, in some cases, the hormone aldosterone. President Kennedy had Addison's disease, which is incurable. However, the disease can be treated by daily cortisol tablets (and perhaps aldosterone as well), so Kennedy was able to function normally.

**b** Napoleon Bonaparte is believed to have suffered from a disease of the hypothalamus that caused the pituitary gland to function abnormally. Because the anterior lobe regulates the functioning of the gonads and the adrenal and thyroid glands, these organs were also affected. See if you can find out the symptoms of Napoleon's disorder.

*Answer:* It is likely that Napoleon suffered from an underactive thyroid gland, and some reports suggest that this may have been due to a deficiency of the pituitary, a condition known as Froehlich's syndrome. Evidence for the condition is given as a big increase in weight, slow deliberate movements, tiredness and drowsiness, failing judgement and occasional bursts of phrenetic energy. These are symptoms of a combined decrease in secretions of the pituitary, thyroid and adrenal glands. There is considerable doubt and dispute about the accuracy of the above diagnosis, because Napoleon suffered from a multitude of illnesses – what one author described as a hypochondriac's wish list. His ailments included skin problems, stomach ulcer, piles, epilepsy, migraine, underactive thyroid, pneumonia, insomnia, bladder stones and a relapsing fever, which was probably malaria.

**c** Akhenaton, an Egyptian pharaoh who lived 3500 years ago, is portrayed in statues made later in his life with feminine features – prominent breasts, hips wider than the shoulders, and a large amount of fat on the buttocks and thighs. It has been suggested that Akhenaton may have had a disorder of one of the endocrine glands. Which gland, or glands, could it have been, and what hormones could have been involved?

*Answer:* It is most likely to have been the testes not producing testosterone or the anterior pituitary gland failing to produce/release luteinising hormone that would normally stimulate the testes to produce testosterone. Another possibility is that it may have been the hypothalamus not secreting gonadotropin releasing factors.

**19** In an average person the thymus weighs about 35 g just before puberty, but by age 50 it has shrunk to around 12 g and by 75 to about 6 g. It has been suggested that this decline in size may be responsible for elderly people becoming more susceptible to disease. Research the thymus to find out:

**a** how the role of the thymus was discovered

*Answer:* The thymus was one of the last organs to have its function determined in 1961. Professor Jacques Miller was working as a PhD student at the Institute of Cancer Research in London and was researching leukaemia in mice linked to a cancer-causing virus.

In his research he found that removing the thymus could prevent leukaemia in mice which had previously been injected with the cancer-causing virus. This led him to believe the virus was replicating in thymus cells, so he removed the thymus from new-born mice to test whether this would prevent the development of cancer following later viral infection. He found that these newborn mice died following removal of the thymus, whether they had the viral injection or not. In examining the blood of these mice, he found a greater tendency for infection and a lower concentration of lymphocytes (white blood cells). Removing the thymus from older mice had no detrimental effect on their immune system, suggesting the thymus was essential in the development of the immune system.

**b** the role of the thymus in providing defence against disease.

*Answer:* The immune system consists of T and B lymphocytes which recognise specific antigens and develop highly specialised effector functions and have the ability to form long-term immunological memory. Both B and T cells are made in the bone marrow, and T cells development and maturation occurs in the thymus.

The thymus produces a hormone called thymosin, and its function is to stimulate the development of the T-lymphocytes. From childhood until puberty, thymosin is secreted and T-lymphocytes are matured, allowing for the establishment of your immune system. It also plays a role in helping the body protect itself against autoimmunity.

**20** New hormones are still being identified. One well-known example is the hormone leptin, discovered in 1994 through the study of obese mice. Leptin is secreted by fat storage tissues (adipose tissues).

Find out:

**a** how leptin was discovered

*Answer:* Leptin was discovered when researchers at The Jackson Laboratory in 1950, studied obese mice and isolated a recessive mutation on a gene (ob gene) that was having a large impact on the mice's body weight and feeding behaviour. In 1994, geneticist Jeffery Friedman cloned the ob gene in mice and its homologue in humans. In 1995 he purified the gene product – the hormone called leptin.

**b** the target cells for leptin

*Answer:* The hypothalamus

**c** the effect of the hormone.

*Answer:* Leptin is produced by the body's adipose tissue and the amount produced is directly correlated with the amount of adipose tissue a person has. Leptin sends a signal to the hypothalamus to inhibit hunger and regulate energy balance. This way the body does not trigger a hunger response when it does not need energy. It can be commonly known as the satiety or starvation hormone. It has other functions related to fertility, immunity and brain function.