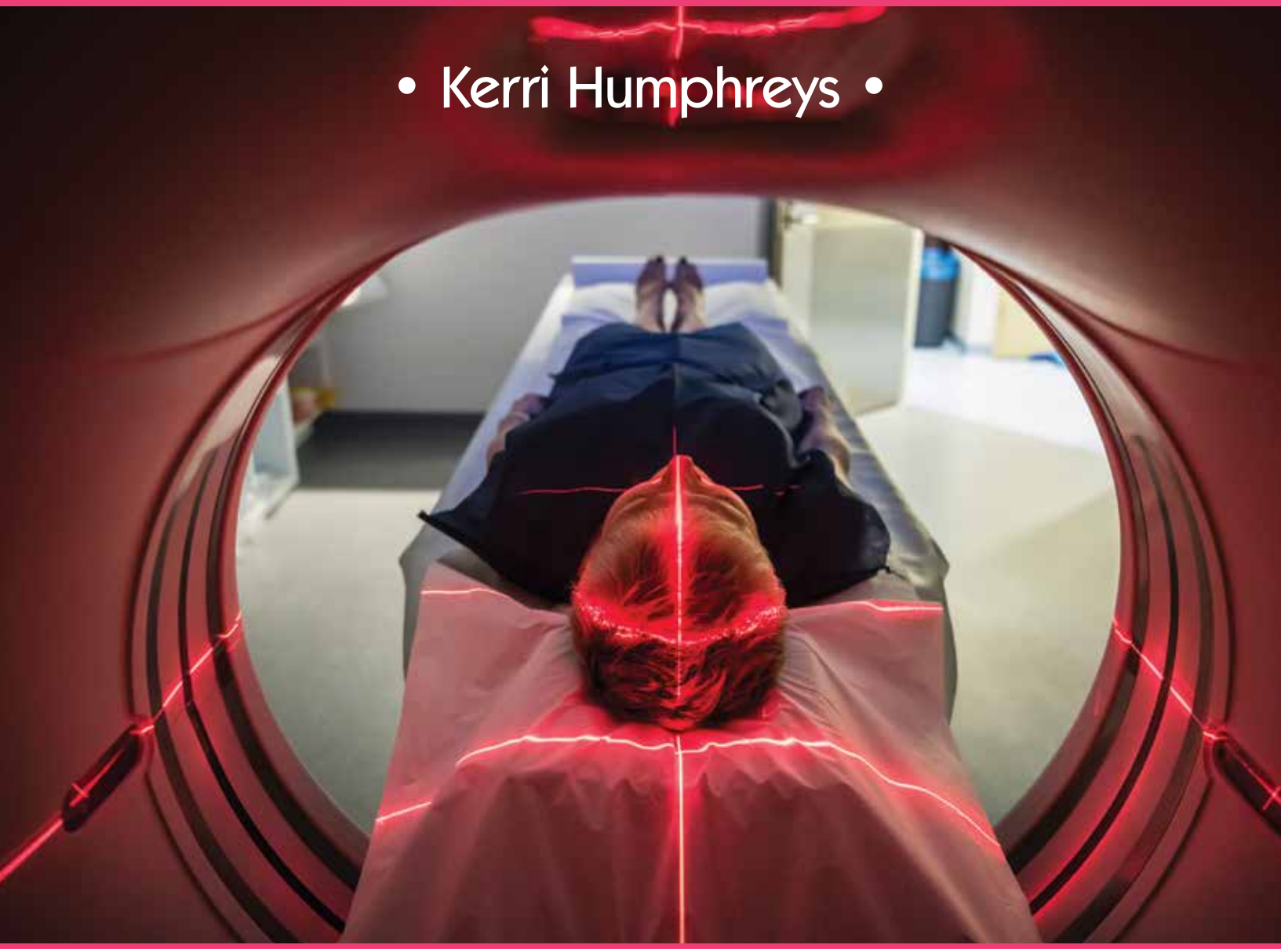
SURFING

WACE HUMAN BIOLOGY

Unit 3 Homeostasis and Disease

• Kerri Humphreys •



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Contents

Introduction

Each book in the *Surfing* series contains a summary, with occasional more detailed sections, of all the mandatory parts of the syllabus, along with questions and answers.

All types of questions – multiple choice, short response, structured response and free response – are provided. Questions are written in exam style so that you will become familiar with the concepts of the topic and answering questions in the required way.

Answers to all questions are included.

A topic test at the end of the book contains an extensive set of summary questions. These cover every aspect of the topic, and are useful for revision and exam practice.

Words To Watch

account, account for State reasons for, report on, give an account of, narrate a series of events or transactions.

analyse Interpret data to reach conclusions.

annotate Add brief notes to a diagram or graph.

apply Put to use in a particular situation.

assess Make a judgement about the value of something.

calculate Find a numerical answer.

clarify Make clear or plain.

classify Arrange into classes, groups or categories.

comment Give a judgement based on a given statement or result of a calculation.

compare Estimate, measure or note how things are similar or different.

construct Represent or develop in graphical form.

contrast Show how things are different or opposite.

create Originate or bring into existence.

deduce Reach a conclusion from given information.

define Give the precise meaning of a word, phrase or physical quantity.

demonstrate Show by example.

derive Manipulate a mathematical relationship(s) to give a new equation or relationship.

describe Give a detailed account.

design Produce a plan, simulation or model.

determine Find the only possible answer.

discuss Talk or write about a topic, taking into account different issues or ideas.

distinguish Give differences between two or more different items.

draw Represent by means of pencil lines.

estimate Find an approximate value for an unknown quantity.

evaluate Assess the implications and limitations.

examine Inquire into.

explain Make something clear or easy to understand.

extract Choose relevant and/or appropriate details.

extrapolate Infer from what is known.

hypothesise Suggest an explanation for a group of facts or phenomena.

identify Recognise and name.

interpret Draw meaning from.

investigate Plan, inquire into and draw conclusions about.

justify Support an argument or conclusion.

label Add labels to a diagram.

list Give a sequence of names or other brief answers.

measure Find a value for a quantity.

outline Give a brief account or summary.

plan Use strategies to develop a series of steps or processes.

predict Give an expected result.

propose Put forward a plan or suggestion for consideration or action.

recall Present remembered ideas, facts or experiences.

relate Tell or report about happenings, events or circumstances.

represent Use words, images or symbols to convey meaning.

select Choose in preference to another or others.

sequence Arrange in order.

show Give the steps in a calculation or derivation.

sketch Make a quick, rough drawing of something.

solve Work out the answer to a problem.

state Give a specific name, value or other brief answer.

suggest Put forward an idea for consideration.

summarise Give a brief statement of the main points.

synthesise Combine various elements to make a whole.

1 Assumed Knowledge

1. What is meant by the term 'metabolism'?
2. Distinguish between the internal and external environment of an organism.
3. Define receptor and effector.
4. List the five main senses found in humans.
5. Name the five sense organs found in humans.
6. Figure 1.1 shows most of the sense receptors found in the skin.

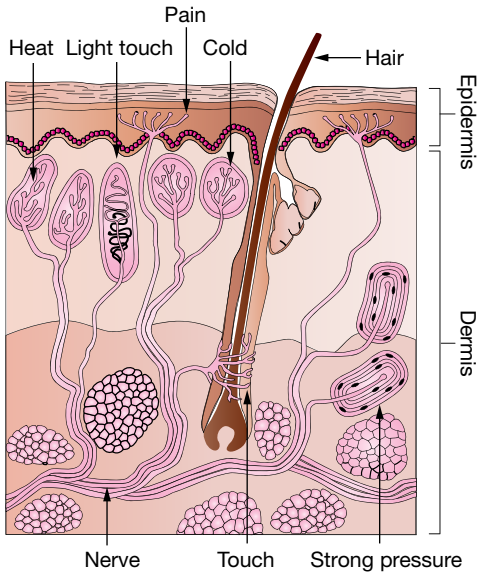


Figure 1.1 Senses in the skin.

Identify the different types of receptors found in the skin.

7. What is interstitial fluid?
8. Distinguish between an endotherm and an ectotherm.
9. Outline the function of the nervous system.
10. The nervous system is often divided into the central nervous system and the peripheral nervous system. Compare these two systems.
11. What is meant by ambient temperature?
12. Describe the function of the circulatory system.
13. The following diagram shows cellular components found in blood.

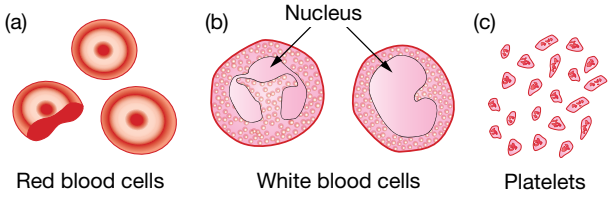


Figure 1.2 Blood cells.

Outline the function of each of the three types of cellular components shown in the diagram.

14. Define artery, vein and capillary.
15. Define diffusion.
16. In an experiment, what is a control?
17. Briefly describe the lymph system.
18. The following diagram shows a cross-section of the human brain.

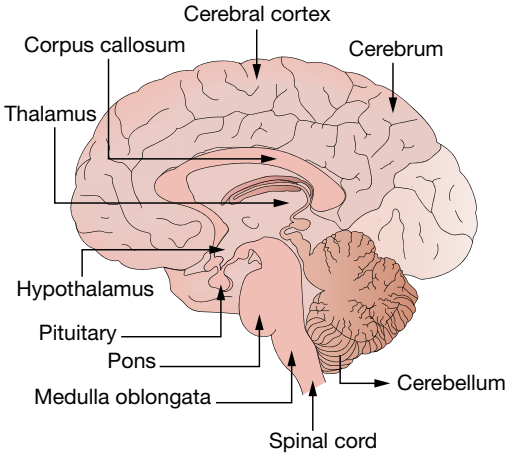


Figure 1.3 Cross-section of human brain.

Outline the function of the spinal cord and cerebrum.

19. The following diagram shows gas exchange in the lung.

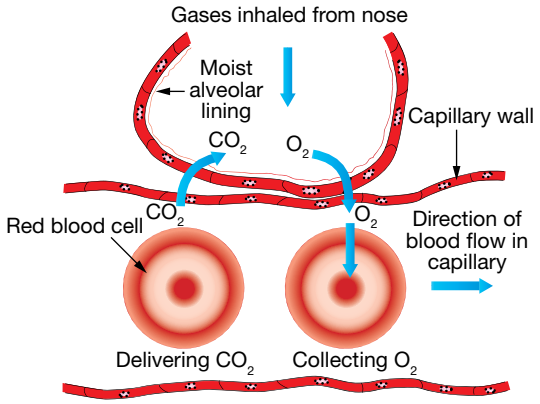


Figure 1.4 Gas exchange.

Describe the movement of gases in and out of the alveoli of the lungs.

20. The following diagram shows the distribution of body water.

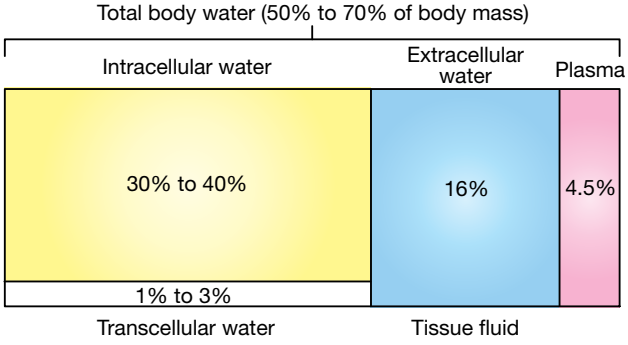


Figure 1.5 Distribution of body water.

Describe why water is an important molecule in organisms.

21. Define parasite.
22. Briefly describe bacteria.
23. Briefly describe viruses.
24. What is a pathogen?
25. Define a hormone.

2 The Endocrine System

The **endocrine system** is a body system composed of different endocrine glands that are ductless glands which secrete hormones directly into the bloodstream or body fluids. The glands are widely separated from each other.

Hormones are chemical signals that travel in the blood and body fluids and act on specific target cells to cause a specific response for internal communication and regulation and maintaining homeostasis. There are three main types of hormones – the peptide hormones, the steroid hormones and the amine hormones.

Many hormones are relatively slow acting with their effects being long lasting.

The **target cells** have **receptors** for that particular hormone which means that the hormone circulating in the bloodstream will only affect cells in particular locations. The receptors for water soluble hormones are on the cell membrane while the receptors for lipid soluble hormones are inside the cell. The binding of the hormone to the receptor initiates a chemical or metabolic reaction in the cell.

Hormone levels in the blood vary and are controlled by a feedback system.

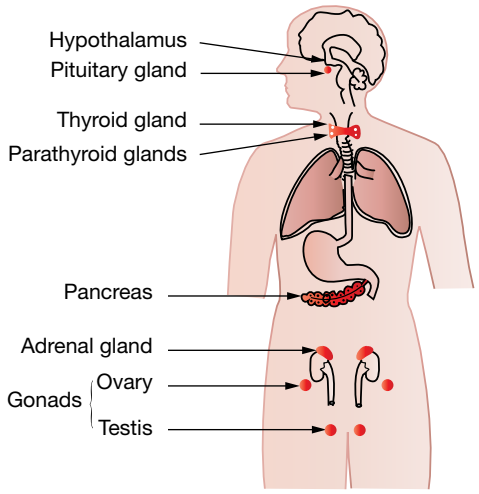


Figure 2.1 Endocrine system.

Homeostasis is the maintenance of a constant internal environment within narrow limits, e.g. homeostasis maintains constant conditions for blood pH, carbon dioxide concentration, blood glucose concentration, body temperature and water balance.

Table 2.1 Some human hormones.

Hormone	Synthesis site	Target cell/ organ	Effect
Prolactin	Anterior pituitary	Breast gland cells.	Milk production.
Growth hormone (GH)	Anterior pituitary	All body cells, e.g. liver	Growth, protein, carbohydrate and lipid metabolism.
Thyroid stimulating hormone (TSH)	Anterior pituitary	Thyroid.	Thyroid produces thyroxine.
Adrenocorticotrophic hormone (ACTH)	Anterior pituitary	Adrenal cortex.	Glucocorticoid production.
Follicle stimulating hormone (FSH)	Anterior pituitary	Male testes. Female follicles.	Male production of sperm. Maturation of primary follicle.
Luteinising hormone (LH)	Anterior pituitary	Male testes. Female Graafian follicle.	Male – production of testosterone. Female ovulation, formation of corpus luteum.
Antidiuretic hormone (ADH)	Hypothalamus	Kidney collecting ducts and distal tubule.	Water reabsorption when body water levels low.
Oxytocin	Hypothalamus	Ducts of breast. Uterus.	Milk ejection, labour contractions.
Testosterone	Testes	Testes, body cells.	Sperm production, male secondary sexual characteristics.
Oestrogen	Ovaries – follicles, corpus luteum	Uterus – endometrium. Body cells.	Development of endometrium, female secondary sexual characteristics.
Progesterone	Ovaries – corpus luteum	Uterus – endometrium.	Maintaining endometrium.
Thyroxine	Thyroid	Body cells.	Speeds up chemical reactions.
Calcitonin	Thyroid	Bone cells. Kidney.	Reduces loss of calcium from bones, inhibits reabsorption of calcium and phosphate.
Parathyroid hormone	Parathyroid	Bones. Kidneys. Intestines.	More reabsorption of calcium into blood, e.g. from urine and more absorption from intestines.
Adrenaline and noraderenaline	Adrenal medulla	Liver. Heart.	Prepares body for fight or flight .
Aldosterone	Adrenal cortex	Kidneys – nephron.	More reabsorption of Na^+ and water and more K^+ secretion.
Cortisol	Adrenal cortex	Liver.	Stimulates gluconeogenesis.
Insulin	Beta cells in pancreas	Body cells, e.g. liver muscle.	Lowers blood glucose levels with synthesis of glycogen.
Glucagon	Alpha cells in pancreas	Liver.	Raises blood glucose levels and glycogen breakdown.

Pituitary gland

The pituitary gland is often called the 'master gland' and has two lobes that secrete different hormones which can stimulate other endocrine glands to secrete hormones, e.g. anterior pituitary produces thyroid stimulating hormone that stimulates the thyroid gland to produce thyroxine.

QUESTIONS

1. What is the endocrine system?
2. Define a hormone.
3. Both the nervous system and the endocrine system are involved in coordination. Construct a table to compare these two systems comparing the speed of transmission, the mode of transmission, response time, response duration and specificity.
4. The diagram shows the some endocrine glands.

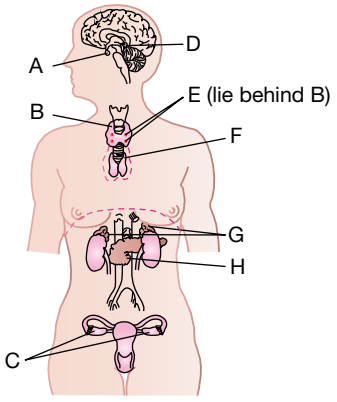


Figure 2.2 Some endocrine glands.

Identify the labelled glands.

5. The diagram shows the control and release of thyroid hormones.

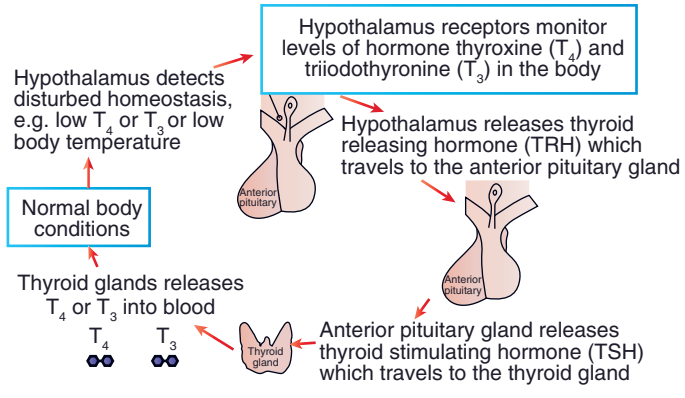


Figure 2.3 Control and release of thyroid hormones.

(a) Use the diagram to show how hormones control body functioning.
(b) Use the diagram to show how hormones travel in the body.

6. Explain why insulin and glucagon are antagonistic hormones.
7. Why is the pituitary gland often called the 'master' gland?
8. Which hormones are known as the 'fight or flight' hormones?
9. The diagram shows the anterior pituitary gland and some of its secretions.

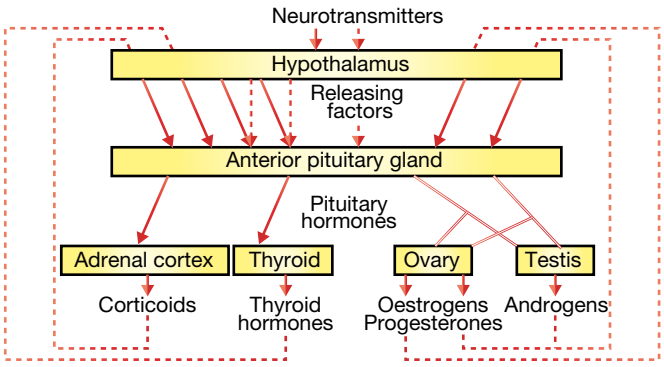


Figure 2.4 Anterior pituitary gland secretions.

(a) Outline the steps involved in the secretion of thyroxine from the thyroid gland.
(b) How is negative feedback involved in hormone secretion and shown in the diagram?
(c) The hypothalamus receives information from nerves throughout the body and is important in integrating the endocrine and nervous systems. Outline one way the hypothalamus interacts with the pituitary gland.

10. What are the three types of hormones?
11. Outline how the structure of a hormone affects its functioning.
12. A tropic hormone has an endocrine gland or cells as a target while non-tropic hormones do not regulate endocrine glands or cells. Classify each of the following hormones as tropic or non-tropic and explain your reasoning.
    (a) Thyroid stimulating hormone (TSH).
    (b) Prolactin.
    (c) Adrenocorticotropic hormone (ACTH).
13. What is a function of thyroxine?
    (A) Control biological rhythms.
    (B) Raise blood glucose level.
    (C) Stimulate ovaries and testes.
    (D) Speed up chemical pathways.
14. Adrenaline and noradrenaline are amine hormones synthesised from the amino acid tyrosine. They are produced in response to stress. What is a likely action of these hormones?
    (A) Increase heart rate and volume stroke.
    (B) Decrease heart rate and volume stroke.
    (C) Constriction of bronchioles in the lungs.
    (D) Increase blood flow to digestive organs.
15. Where is oxytocin synthesised?
    (A) Posterior pituitary gland.
    (B) Anterior pituitary gland.
    (C) Hypothalamus.
    (D) Ovaries.

3 Types of Hormones

The endocrine system consists of **endocrine glands** which are ductless glands and specialised cells that release chemical messengers, e.g. protein, amine or steroid molecules called **hormones** into the bloodstream. There are three main types of hormones – proteins and peptides (small polypeptides with up to 30 amino acids), and amines derived from amino acids and steroids.

Hormones act on specific target cells to change their functioning. Some hormones affect most cells of the body, e.g. growth hormone and thyroxine while other hormones are very specific, e.g. follicle stimulating hormone (FSH) stimulates the development of the follicles that contain eggs in females and the production and maturation of sperm in the testes of males. The target cells have specific receptor molecules on their surfaces. If a cell lacks an appropriate receptor site it will not respond to the hormone, e.g. the hormone prolactin acts on the milk producing cells of the breast.

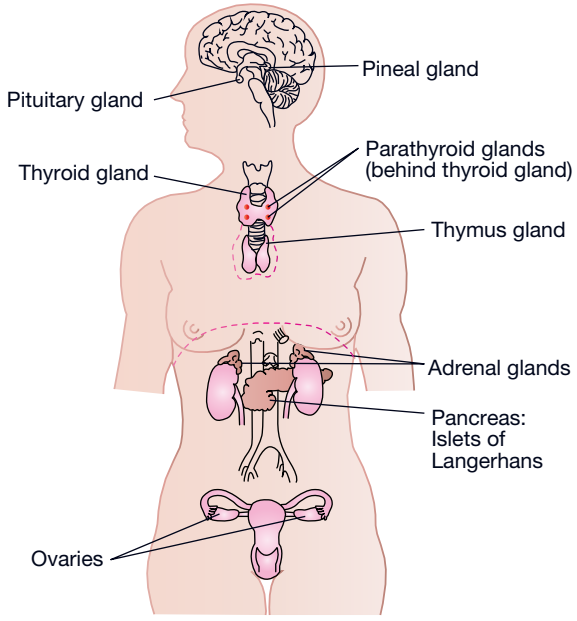


Figure 3.1 Main endocrine glands.

Steroid hormones

The **steroid hormones** are concerned with long term responses of the body, e.g. oestrogen, testosterone, aldosterone. The steroid hormones are lipids formed from cholesterol and travel around the body bound to carrier proteins. The steroid hormones are lipid soluble and can easily pass through cell membranes. The receptors for these hormones are usually in the cytoplasm or nucleus. Many steroid hormones directly regulate gene expression of target genes, e.g. oestrogen and cortisol.

Amine and peptide hormones

The **protein/peptide groups** include hormones secreted by the anterior and posterior pituitary gland, the pancreas (insulin and glucagon) and the parathyroid gland (parathyroid hormone PTH). **The amine hormones** are derivatives of the amino acid tyrosine and include hormones secreted by the thyroid gland, e.g. thyroxine and triiodothyronine and the adrenal medulla (adrenaline and noradrenaline). These hormones usually bring about a response within a few minutes and their actions are of relatively short duration. They are often made in advance and held in storage in the endocrine cells, available for immediate release. Some of these hormones are made in a longer form called a prehormone which is then broken down into the mature form. Most amine and protein/peptide hormones are water soluble and bind with receptors on the cell membrane. The water soluble hormones dissolve in the plasma to travel in the blood and can diffuse out of the capillaries into the interstitial fluid to reach their target cell.

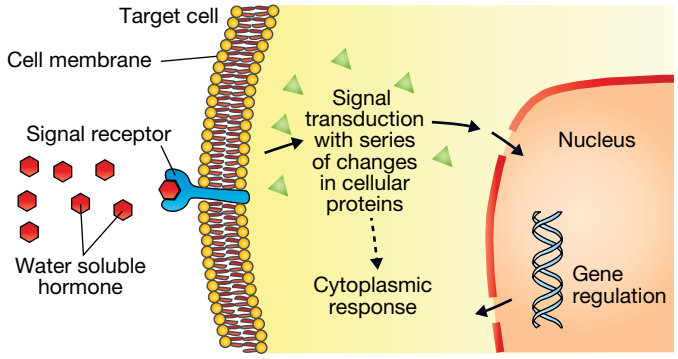


Figure 3.2 Signal transduction for a water soluble hormone.

Endocrine signalling

The hormones secreted by endocrine cells into the extracellular fluids move into the bloodstream and travel around the body. When they reach their specific target cells they bind to receptors to produce the desired response.

The water soluble hormones trigger signal receptors in the cell membrane which can activate an enzyme, change the uptake or secretion of specific molecules or rearrange the cytoskeleton in a signal transduction pathway. **Signal transduction** is the transmission of a molecular signal from the exterior of the cell into its interior using cell-surface receptors.

There are intracellular receptors for the lipid soluble hormones and signal transduction occurs entirely within the target cell.

Control of hormone secretion

The secretion of hormones from endocrine glands is highly controlled to regulate the concentrations of hormones in the blood and the rate of metabolic reactions. Stimulation can occur due to a hormone from another endocrine gland or by an impulse from the nervous system.

For most hormones there is a **negative feedback system** that stops further release of a hormone to prevent overactivity of the target cells.

Hormone secretion is also affected by other factors such as daily rhythms, seasonal changes, stages of development and ageing and sleep patterns, e.g. growth hormone has higher secretion rates during early sleep time than in later sleep time.

Hormones are produced in very small quantities but their effects can last for long periods of time.

Hypothalamus

The hypothalamus in vertebrates plays an important role in the functioning of the endocrine system. It is part of the ventral section of the forebrain and is involved in maintaining homeostasis especially in coordinating the endocrine and nervous systems.

The hypothalamus secretes the hormones of the posterior pituitary gland and the releasing factors that regulate the anterior pituitary gland.

QUESTIONS

1. What is the endocrine system?
2. What is a hormone?
3. Name some endocrine glands in vertebrates.
4. Give an example of hormones that can affect several types of cells.
5. Identify the three main types of hormones.
6. Describe steroid hormones.
7. Outline how steroid hormones travel in the body.
8. Where are the receptors for steroid hormones?
9. How do many steroid hormones, e.g. oestrogens and cortisol act?
10. Name some amine hormones.
11. Identify some protein/peptide hormones.
12. Compare the response time for steroid hormones and amine and peptide/protein hormones.
13. Compare how steroid hormones and peptide hormones travel in the body.
14. What is a prehormone?
15. Define signal transduction.
16. Outline how hormone secretion is controlled.
17. What is the hypothalamus?
18. Outline the function of the hypothalamus.
19. Study the diagram which shows the secretion of a peptide hormone.

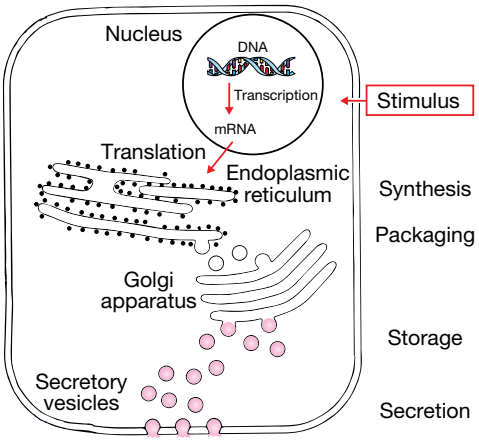


Figure 3.3 Hormone secretion.

From this diagram draw a flow chart to show the steps in the secretion of a peptide hormone.

20. The diagram shows the series of events that occur when a water soluble hormone contacts a target cell.

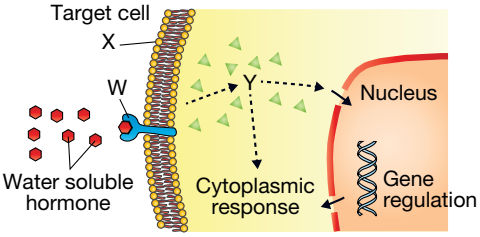


Figure 3.4 Hormone contacts target cell.

Identify W, X and Y.

	W	X	Y
(A)	Receptor	Membrane	Signal transcription
(B)	ATP	Receptor	Signal translation
(C)	Receptor	Membrane	Signal transduction
(D)	Membrane	Receptor	Signal translocation

21. The diagram shows a synapse between two neurons.

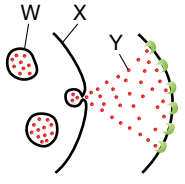


Figure 3.5 Hormone contacts target cell.

What is represented by W, X and Y?

	W	X	Y
(A)	Presynaptic terminal	Vesicle	Neurotransmitter
(B)	Presynaptic terminal	Lysosome	Acetylcholine
(C)	Postsynaptic terminal	Mitochondrion	Neurotransmitter
(D)	Postsynaptic terminal	Golgi Body	Acetylcholine

4 The Pituitary gland

The pituitary gland is a small gland that lies below the hypothalamus and is often called the 'master gland' as many pituitary hormones regulate the activity of other endocrine glands. It is connected to the hypothalamus by a stalk of nervous tissue. It is the size of a large pea and weighs about 0.5 gram.

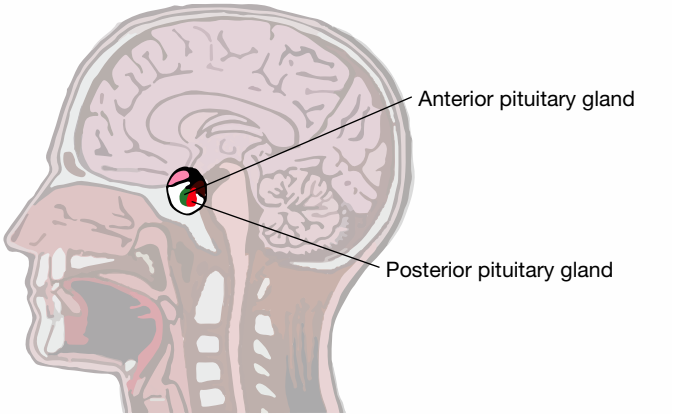


Figure 4.1 Location of the pituitary gland.

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

The pituitary gland is divided into two lobes – the anterior pituitary and the posterior pituitary. In the embryo the two parts of the pituitary gland arise from different sources.

Anterior pituitary

The anterior pituitary produces a number of hormones that regulate a range of body activities and other endocrine glands.

- **Growth hormone** (GH) acts on body tissues especially during childhood and adolescence increasing the rate at which amino acids are taken up by cells and built into proteins.
- **Prolactin** works with other hormones to initiate and maintain milk secretion in females and promotes development of female breasts**.**
- **Luteinising hormone** (LH) works with FSH in females to bring about ovulation and form the corpus luteum after ovulation. In males LH stimulates interstitial cells in the testes to secrete male sex hormones.
- **Thyroid stimulating hormone** (TSH) stimulates the production and release of hormones from the thyroid glands.
- **Adrenocorticotrophic hormone** (ACTH) controls the production and release of some of the hormones from the cortex of the adrenal glands, e.g. cortisol, androgens.

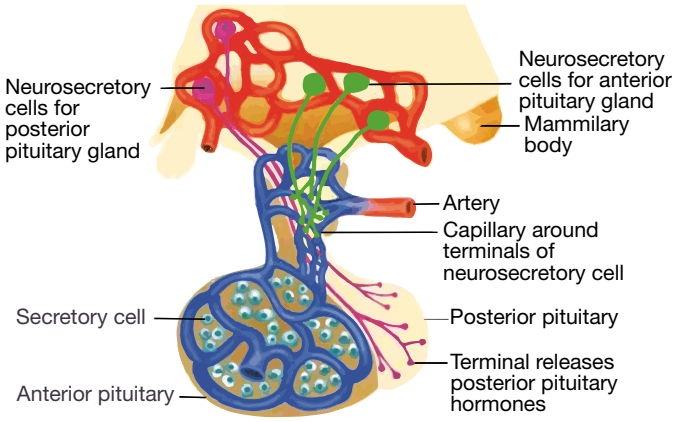


Figure 4.2 Pituitary gland.

Releasing hormones and inhibiting hormones produced by neurosecretory cells of the hypothalamus regulate the release of hormones from the anterior pituitary. These neurohormones enter capillaries that pass through special portal veins that connect two sets of capillaries and from the second set of capillaries the neurohormones pass into the anterior lobe.

Table 4.1 Neurohormones from the hypothalamus regulate the anterior pituitary gland.

From hypothalamus	Regulation of anterior pituitary
CRH	Causes anterior pituitary gland to secrete ACTH and beta-endorphins
TRH	Stimulates anterior pituitary to release TSH and prolactin
GnRH	Stimulates anterior pituitary to release FSH and LH
GHRH	Stimulates anterior pituitary to secrete GH
PRH	Stimulates anterior pituitary to produce prolactin
Dopamine	Inhibits the release of prolactin
Somatostatin	Inhibits the release of several hormones, e.g. GH, TSH.

Posterior pituitary

The posterior pituitary does not produce hormones but stores oxytocin and antidiuretic hormone (ADH) produced by the hypothalamus.

- **ADH** causes the kidneys to reabsorb more water to maintain body water balance and prevent dehydration.
- **Oxytocin** stimulates the contraction of muscles of the uterus, e.g. during childbirth and also stimulates contraction of cells in mammary glands in the release of milk while suckling.

Pituitary disorders

Pituitary disorders can involve **hyposecretion** (reduced amounts of hormone produced) or **hypersecretion** (increased amount of hormone produced). Pituitary gland tumours occur in many adults. They are not a brain tumour and are usually not cancerous (are benign tumours). Abnormal secretion of a hormone will interfere with normal body functioning. Secretory tumours cause hypersecretion of a particular hormone(s). If the tumour mass becomes large it can press against other areas, e.g. brain causing headaches, vision problems and other effects.

QUESTIONS

1. Where is the pituitary gland?
2. Why is the pituitary gland often called the 'master gland'?
3. What controls the release of many of the hormones of the pituitary gland?
4. Construct a table to summarise the hormones produced by the pituitary gland.
5. The diagram shows the hormones from the anterior pituitary.

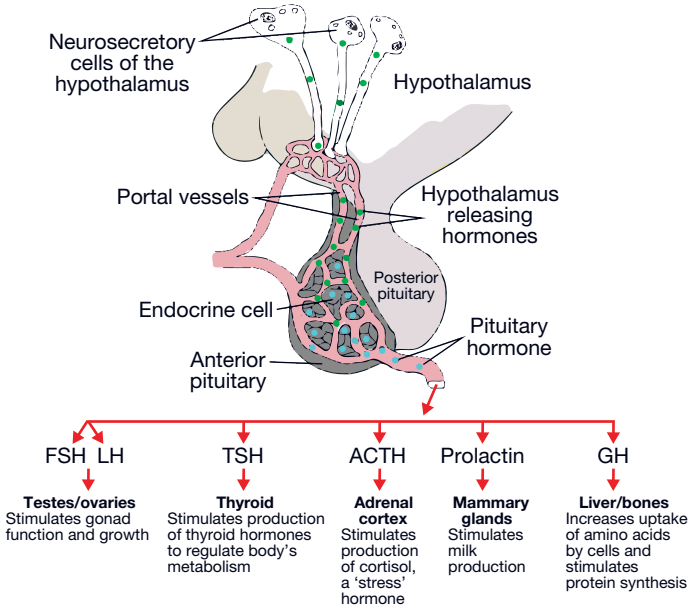


Figure 4.3 Anterior pituitary gland.

Draw a flow chart to show the sequence of events from stimulation of the hypothalamus to:

(a) Increase in uptake of amino acids by cells.
(b) Stimulation of milk production.
(c) Production of cortisol from adrenal cortex.

6. Distinguish between hyposecretion and hypersecretion.
7. Outline what happens when there is a secretory tumour of the pituitary gland.
8. Where is antidiuretic hormone (ADH) produced?
   (A) Anterior pituitary gland.
   (B) Posterior pituitary gland.
   (C) Adrenal gland.
   (D) Hypothalamus.
9. The diagram shows the glands of the endocrine system for males and females

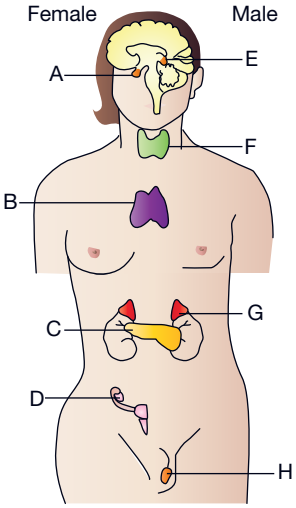


Figure 4.4 Endocrine system for males and females.

Which part is the pituitary gland?

(A) Part A
(B) Part E
(C) Part F
(D) Part B

10. The diagram shows the hormones released by the posterior pituitary gland.

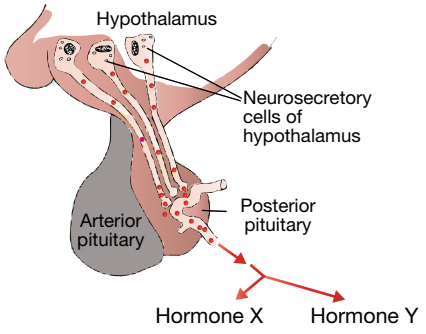


Figure 4.5 Posterior pituitary gland.

Identify hormones X and Y

(A) ADH and growth hormone.
(B) Oxytocin and ADH.
(C) Growth hormone and TSH.
(D) TSH and oxytocin.

11. What controls nearly all secretion by the pituitary gland?
    (A) Only hormonal signals from the hypothalamus.
    (B) Only nervous signals from the hypothalamus.
    (C) Either hormonal or nervous signals from the hypothalamus.
    (D) Signals from the sensory organs.

5 The Thyroid Gland

The thyroid gland lies below the larynx on each side of and anterior to the trachea. It consists of two lobes connected by an 'isthmus' and is one of the largest endocrine glands.

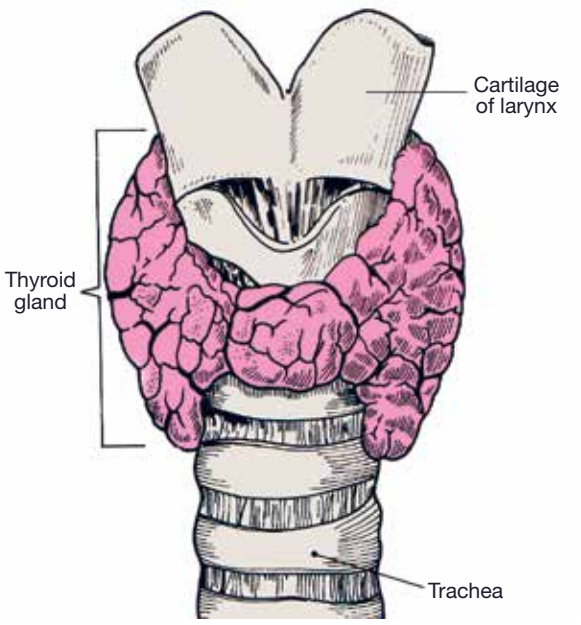


Figure 5.1 Thyroid gland.

Thyroid hormones

The thyroid gland secretes two main hormones:

- **Thyroxine** (T_4) which has four iodine atoms and **triiodothyronine** (T_3) which has three iodine atoms. T_4 and T_3 affect the metabolic rate of the body and bring about the release of energy when complex molecules are synthesised from simple molecules. They are also necessary for cellular differentiation. These hormones are synthesised from the amino acid tyrosine and from iodine and unlike many other hormones the thyroid hormones are stored in follicles in the gland. Iodine is needed in the diet to make the thyroid hormones and is the main site of iodine usage by the body. To prevent iodine deficiency common table salt is iodised.
- The thyroid gland also secretes **calcitonin** which is important in calcium metabolism as it inhibits the release of calcium ions from bone. Calcitonin works antagonistically to parathyroid hormone as parathyroid hormone stimulates the release of calcium from bones and calcium reabsorption from the kidney tubules.

Regulation of thyroid secretion

Thyroid secretion is mainly controlled by the hypothalamus and the pituitary gland by thyroid stimulating hormone (TSH). There is a negative feedback system between the anterior pituitary gland and the thyroid gland.

If there is a **low concentration** of thyroid hormones in the blood the anterior pituitary is stimulated to secrete more TSH.

If there is a **high concentration** level of thyroid hormones in the blood then the anterior pituitary is inhibited and will secrete less thyroid stimulating hormone (TSH). High thyroid hormone levels also affect the hypothalamus to inhibit the secretion of the releasing hormone THRH. Stressful cold weather can also stimulate the secretion of TSRH to raise body temperature by increased metabolism.

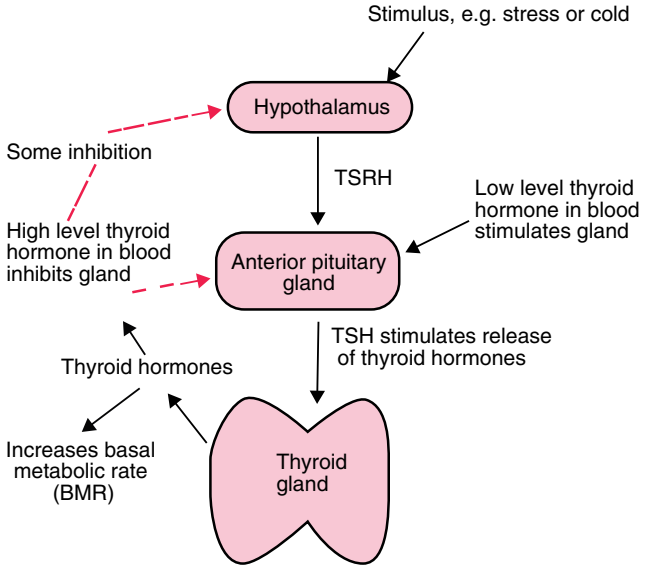


Figure 5.2 Regulation of the thyroid gland.

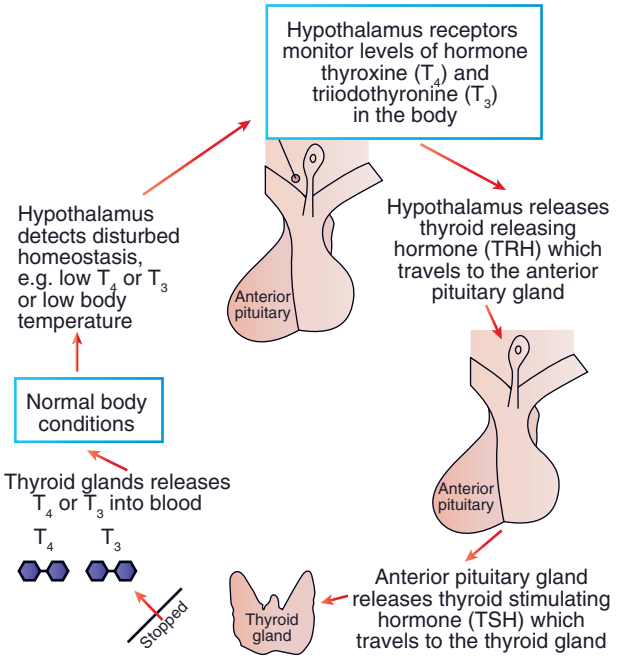
About 93% of metabolically active hormones secreted by the thyroid gland is thyroxine (T_4) and 7% triiodothyronine (T_3). But nearly all the thyroxine is converted to triiodiothyronine in the tissues. Both are important hormones with T_3 about four times more potent than T_4. The thyroid hormones activate gene expression and the transcription of a large number of genes, e.g. to cause the synthesis of protein enzymes, structural proteins and transport proteins.

Disorders of the thyroid gland

Hyperthyroidism is the overproduction of thyroxine and causes nervousness, insomnia and excessive excitability; heat intolerance and excessive sweating; increased heart rate and blood pressure; and weight loss. Most effects of hyperthyroidism are observable with the thyroid gland increasing in size to two or three times its normal size. Many patients have extreme fatigue with an inability to sleep.

Hypothyroidism is the underproduction of thyroxine. If it occurs during infancy it affects the development of brain cells and can lead to permanent mental deficiency and dwarfism. In adults it causes dry skin, intolerance to cold and lack of energy. If there is insufficient iodine in the diet, thyroxine cannot be produced causing the pituitary to make large amount of TSH which stimulate the thyroid gland which grows in size to form a goitre.

(a)



Lack of iodine means the thyroid gland cannot make T_4 or T_3. This means the body cannot return to normal conditions and more TSH is produced to stimulate the thyroid. The thyroid grows in size to form a goitre.

(b)

Figure 5.3 (a) Lack of thyroid hormones forms a goitre. (b) Goitre.

Cretinism is caused by extreme hypothyroidism during foetal development, infancy or childhood. The low levels of thyroid hormones cause failure of body growth and mental retardation and can be due to lack of iodine in the diet or a genetic defect of the gland. As skeletal growth is more affected by low thyroid hormones than soft tissue growth a child with cretinism will be stocky, short and obese.

QUESTIONS

1. Describe the location of the thyroid gland.
2. Name the hormones produced by the thyroid gland.
3. Describe thyroxine.
4. Outline the main functions of T_4 and T_3.
5. Draw a flow chart to show what happens if there is a low concentration of thyroid hormones in the blood.
6. (a) What is hyperthyroidism?
   (b) Describe some symptoms of hyperthyroidism.
7. (a) What is hypothyroidism?
   (b) Describe some symptoms of hypothyroidism.
8. What directly controls the secretion of thyroxine?
9. Explain why common salt is iodised.
10. Describe cretinism.
11. Outline how thyroid hormones affect gene expression.
12. Which element deficiency causes hypothyroidism?
    (A) Iodine deficiency. (B) Fluorine deficiency.
    (C) Potassium deficiency. (D) Bromine deficiency.
13. The diagram shows the glands of the endocrine system for males and females.

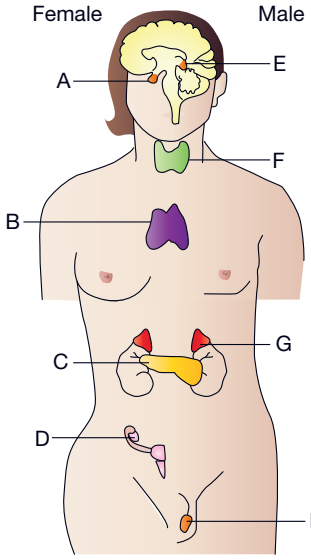


Figure 5.4 Endocrine system for males and females.

Which part is the thyroid gland?
(A) Part A (B) Part E (C) Part F (D) Part B

14. The graph shows the effect of a large dose of thyroxine on the basal metabolic rate.

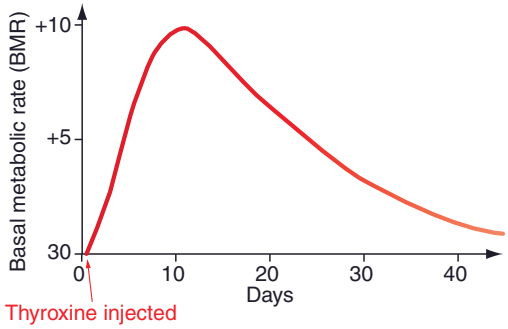


Figure 5.5 Effect of thyroxine on BMR.

From the graph, when is the BMR most affected by the injection of a large dose of thyroxine?
(A) Day 0 (B) Day 10
(C) Day 20 (D) Day 40

15. Which of the following would indicate hyperthyroidism?
    (A) Low level of free thyroxine in the blood.
    (B) High level of adrenaline in the blood.
    (C) Decrease of 60% of basal metabolic rate.
    (D) Increase of 60% of basal metabolic rate.
16. Where is the thyroid gland?
    (A) Immediately below the larynx.
    (B) Immediately above the kidneys.
    (C) At the base of the brain.
    (D) Next to the stomach.

6 The Adrenal Glands

The adrenal glands are small yellow masses of endocrine tissue on either side of the spinal column above each kidney. Each adult adrenal gland weighs around 4 grams.

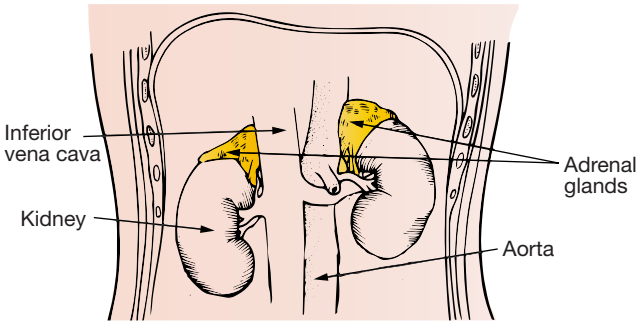


Figure 6.1 Adrenal glands.

Each adrenal gland consists of two distinct parts – an **adrenal cortex** which is the outer section and the **adrenal medulla** which is the central section.

The adrenal glands produce a range of hormones. The two parts of the adrenal gland are joined but develop from different tissue types in the embryo and function as distinct glands.

Adrenal cortex

The adrenal cortex is composed of three distinct layers, and it responds to endocrine signals and produces corticosteroid and androgen hormones. Stressful signals cause the hypothalamus to secrete a releasing hormone that stimulates the anterior pituitary to release adrenocorticotropic hormone (ACTH). ACTH causes the adrenal cortex to secrete the corticosteroids. In humans there are two main corticosteroids – the **glucocorticoids** which affect glucose metabolism and **mineralocorticoids** which affect mineral metabolism, maintaining salt and water balance. The adrenocortical hormones are steroids derived from cholesterol. More than 30 steroids have been isolated from the adrenal cortex.

The two most important hormones are **cortisol** which is the main glucocorticoid and **aldosterone** which is the main mineralocorticoid. Cortisol and aldosterone are regulated by independent mechanisms.

Cortisol has multiple metabolic functions and is involved in the metabolism of proteins, carbohydrates and fats. It also has anti-inflammatory effects. It responsible for about 95% of the glucocorticoid activity of the adrenal cortex. Glucocorticoids are used in medical treatments in allergic reactions, infections, arthritis and some types of cancer.

Aldosterone increases the reabsorption of sodium in the kidney nephrons and increases the secretion of potassium and hydrogen ions from the kidney.

Addison's disease is caused by insufficient production of adrenocortical hormones, e.g. lack of aldosterone. This causes a loss of sodium ions, chloride ions and water in urine and a drop in plasma volume. Cardiac output decreases and the person can die of shock within two weeks from the time when mineralocorticoid production stopped.

Cushing's syndrome occurs when there is hypersecretion of the adrenal cortex leading to excess cortisol in the blood. It is often caused by excess ACTH secretion. It causes fat from the lower body to mobilise and deposit in the upper abdomen and thorax causing a buffalo torso appearance. The excess steroids also cause increased facial hair and fat deposits on the face giving the face a full-moon appearance.

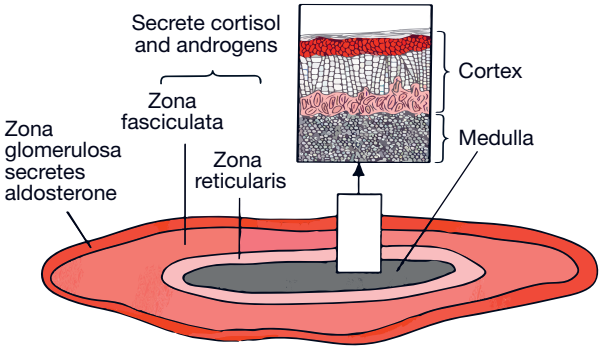


Figure 6.2 Cross-section of adrenal gland.

Adrenal medulla

The secretory cells of the adrenal medulla derive from neural tissue during embryonic development and are the main source of **adrenaline** (epinephrine) and **noradrenaline** (norepinephrine). These hormones are chemically similar and are derived from amino acids.

These hormones increase the amount of energy available for immediate use and are secreted in response to stress. They increase the rate of glycogen breakdown in the liver and skeletal muscles, increase heart rate, promote glucose release by liver cells and dilate the bronchioles in the lungs to increase oxygen uptake. This prepares the body for action and is sometimes called the 'fight or flight' response. The hormones can increase metabolic rate by 100%.

Noradrenaline is the same substances as secreted by neurons in the sympathetic nervous system and some neurons in the CNS to be a neurotransmitter. Its effect on the body is similar but longer lasting as it is only slowly removed from the body.

Regulation of the adrenal glands

The adrenal cortex is stimulated from the pituitary gland. Adrenocorticotropin (ACTH) stimulates the adrenal cortex to produce cortisol. The adrenal medulla is stimulated by the sympathetic nervous system. The sympathetic nervous system increases cardiac output, increases blood pressure and increases ventilation rate.

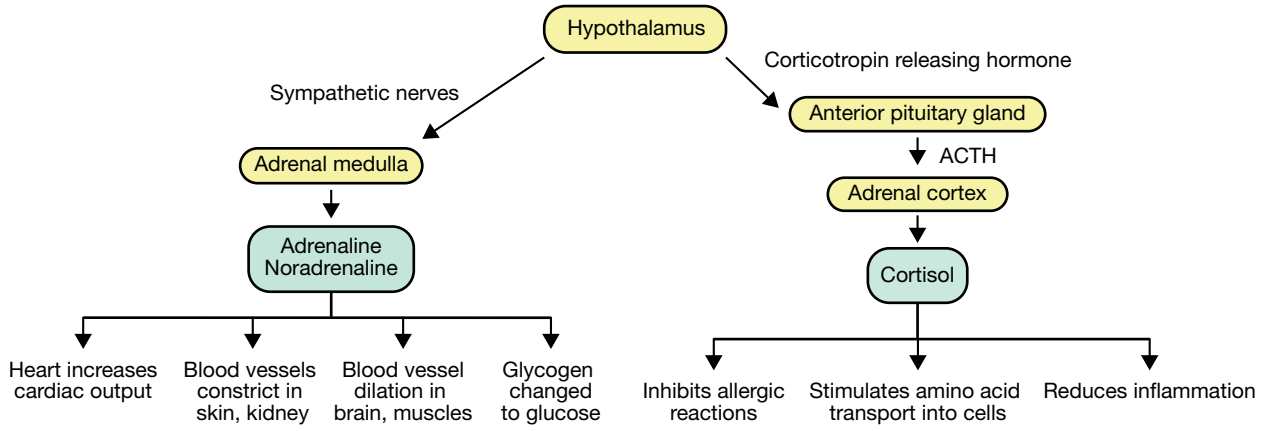


Figure 6.3 Action of adrenal gland hormones.

QUESTIONS

1. Describe the location of the adrenal glands.
2. Identify the two areas of the adrenal gland.
3. Distinguish between glucocorticoids and mineralocorticoids.
4. Outline the signal that causes the release of adrenocorticotrophic hormones.
5. Why is cholesterol important for normal functioning of the adrenal gland?
6. Outline the functions of:
   (a) Cortisol.
   (b) Aldosterone.
7. Name the main two hormones secreted by the adrenal medulla.
8. Outline the function of the main hormones of the adrenal medulla.
9. Construct a table to summarise the hormones produced by the adrenal gland.
10. Describe Addison's disease.
11. Compare the regulation of the adrenal cortex and the adrenal medulla.
12. Describe Cushing's syndrome.
13. Draw a flow chart to show the steps involved when a stress stimulus causes the hypothalamus to release CRF.
14. Which hormone is secreted by the adrenal medulla?
   (A) Aldosterone.
   (B) Cortisol.
   (C) Insulin.
   (D) Adrenaline.
15. About 95% of activity due to glucocorticoid activity is due to the hormone cortisol. What of the following is due to cortisol?
   (A) Development of follicles in the ovary.
   (B) Formation of glucose from proteins.
   (C) Build up of muscle tissue.
   (D) Clotting of blood.
16. The diagram shows the glands of the endocrine system for males and females.
   Which part is the adrenal gland?
   (A) Part B
   (B) Part C
   (C) Part G
   (D) Part D

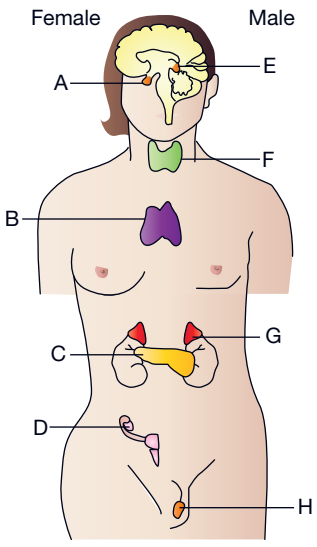


Figure 6.4 Endocrine system for males and females.

17. The diagram shows a flow chart for the release of some hormones.

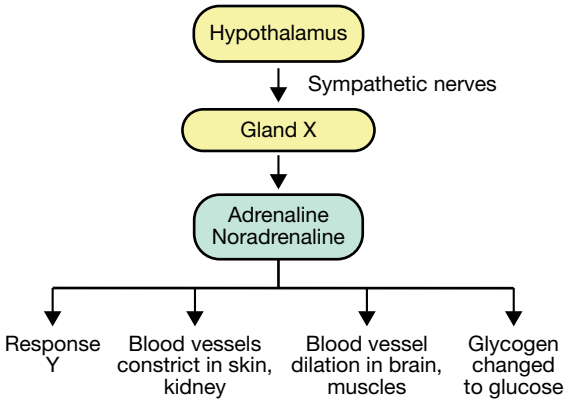


Figure 6.5 Release of some hormones.

Identify gland X and response Y.

	Gland X	Response Y
(A)	Adrenal medulla	Heart rate rises
(B)	Adrenal cortex	Fat metabolises
(C)	Thyroid	Basal metabolic rate rises
(D)	Pituitary	Blood sugar rises

7 The Pancreas

The pancreas is a gland located behind and parallel to the stomach. The pancreas has both endocrine and exocrine tissue.

Pancreas as an exocrine gland

Exocrine glands secrete their products into ducts. The **exocrine section** of the pancreas is involved in digestion and secreting enzymes in an alkaline solution into the small intestine. The acinar cells produce the digestive enzymes and the duct cells produce the bicarbonate ions and both products are released into the small ducts that empty into the pancreatic duct. The pancreatic duct empties into the duodenum.

Pancreas as endocrine gland

The **endocrine section** of the pancreas is involved in homeostasis with the secretion of the hormones insulin and glucagon into the blood. The islets of Langerhans are patches of endocrine tissue within the pancreas. They were discovered in 1869 by the German histologist Paul Langerhans. There are about a million islets in an adult human pancreas making up 1% to 2% of pancreatic mass. The islets are composed of **alpha cells** (produce glucagon), **beta cells** (produce insulin), **delta cells** (produce somatostatin), **gamma cells** (produce pancreatic polypeptide and sometimes called PP cells) and **epsilon cells** (produce ghrelin).

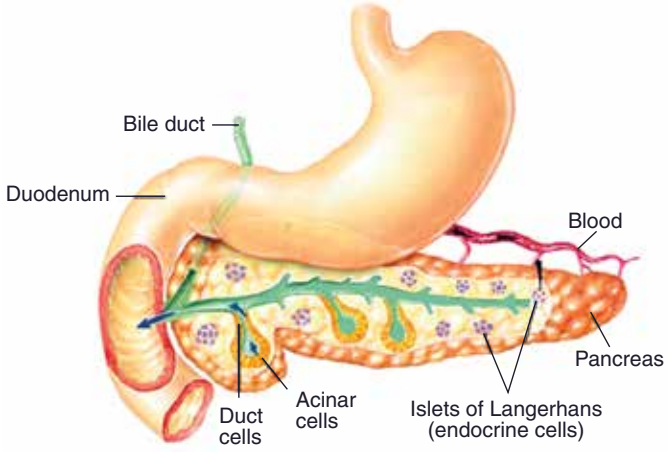


Figure 7.1 Pancreas.

Blood glucose

In humans blood glucose concentration should be 70 to110 mg/100 mL for optimal metabolism. Glucose is needed for cellular respiration and biosynthesis uses the carbon from glucose to build macromolecules. Blood glucose levels are closely regulated by homeostatic processes. Glucose levels in most humans is lowest in the morning before the first meal of the day.

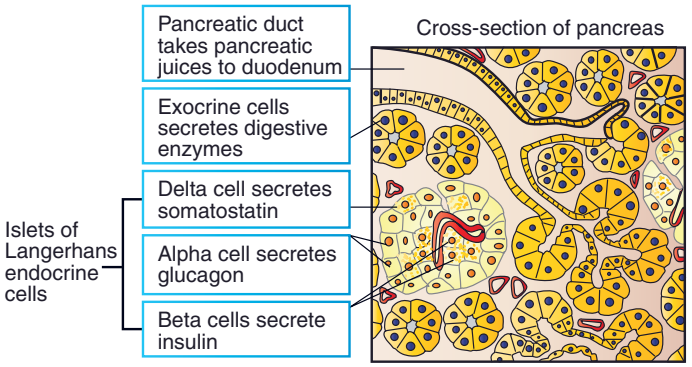


Figure 7.2 Cross-section of the pancreas.

Pancreatic hormones

Insulin and glucagon are two opposing (antagonistic) hormones that control blood glucose concentration. Insulin causes glucose in the blood to be taken up by body cells to lower blood glucose concentration while glucagon causes the release of glucose into the blood from energy stores, e.g. glycogen from the liver.

Insulin is a small protein composed of two amino acid chains. It acts by slowing down glycogen breakdown in the liver and stopping the conversion of glycerol and amino acids to glucose. It stimulates nearly all body cells to take up glucose. Within seconds after insulin binds with the membrane receptors of a target cell there is a marked increase in the uptake of glucose. Large amounts of insulin are secreted when there is a high intake of energy-giving foods, e.g. carbohydrates and proteins.

Glucagon is a polypeptide consisting of a chain of 29 amino acids. It acts mainly on target cells in the liver signalling an increase in glycogen hydrolysis with the conversion of glycerol and amino acids to glucose. Skeletal muscle cells and adipose tissues that store glycogen will also respond to glucagon.

Somatostatin is a small polypeptide consisting of 14 amino acids with a very short half-life of only 3 minutes in the circulating blood. It is secreted after eating food and its secretion is stimulated by increased blood glucose, increased amino acids and increased fatty acids. It extends the period of time that nutrients are assimilated into the blood and has several inhibitory actions, e.g. it acts locally in the pancreas to inhibit the secretion of both insulin and glucagon.

Regulation of blood glucose levels

If blood glucose levels are too high, the beta cells of the islets of Langerhans are stimulated to increase insulin secretion. The insulin stimulates cells, e.g. skeletal and fat cells to take up glucose from the blood. In muscle cells the glucose is either used immediately in respiration or stored as glycogen.

If blood glucose levels are too low the alpha cells of the islets of Langerhans are stimulated to increase glucagon secretion. The glucagon causes the liver to release stored glucose and mobilises fats and amino acids.

The regulation is a fast acting mechanism.

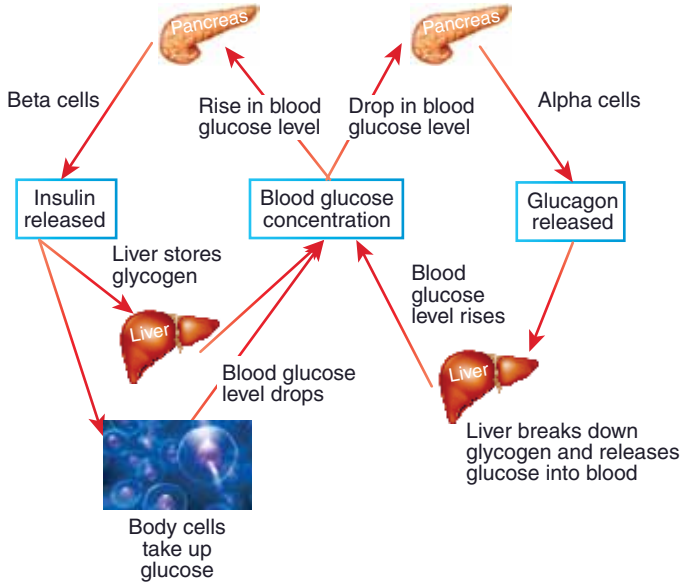


Figure 7.3 Regulation of blood glucose levels.

Diabetes mellitus

Diabetes mellitus is caused by a deficiency of insulin or a reduced response of target cells to insulin. There are two types of diabetes with both having a high blood glucose level.

Type 1 diabetes is insulin dependent diabetes and appears in childhood and is an autoimmune disease where the immune system destroys the beta cells of the pancreas.

Type 2 diabetes is non-insulin dependent where target cells do not correctly respond to insulin and usually appears in older people or people who are overweight and live a sedentary lifestyle.

QUESTIONS

1. Describe the location of the pancreas.
2. Explain why the pancreas is an exocrine gland.
3. Explain why the pancreas is an endocrine gland.
4. What are the islets of Langerhans?
5. Construct a table to summarise the five types of cells found in the islets of Langerhans and identify the substance produced by each type of cell.
6. Identify some uses of glucose in the body.
7. For most humans, when is their blood glucose level the lowest?
8. Discuss why blood glucose concentration is part of the homeostatic mechanism.
9. Explain why insulin and glucagon are antagonistic hormones.
10. How is the pancreas involved in homeostasis?
11. (a) Which cells produce insulin?
    (b) Which cells produce glucagon?
12. Explain why insulin secretion is linked with energy abundance.
13. Draw a flow chart to show the sequence of events when blood glucose levels become too low.
14. Draw a flow chart to show the sequence of events when blood glucose levels become too high.
15. Outline the function of somatostatin.
16. (a) What is diabetes mellitus?
    (b) Construct a table to compare type 1 diabetes and type 2 diabetes.
17. What is secreted by the alpha cells of the islets of Langerhans?
    (A) Pancreatic protease. (B) Insulin.
    (C) Glucagon. (D) Glucose.
18. The diagram shows the glands of the endocrine system for males and females. Which part is the pancreas?
    (A) Part B
    (B) Part C
    (C) Part G
    (D) Part D

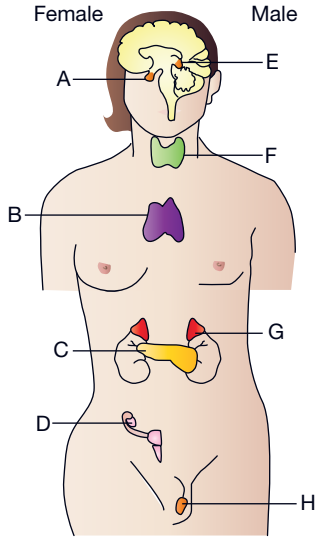


Figure 7.4 Endocrine system for males and females.

19. Which of the following gives the correct function of insulin and glucagon?

	Insulin	Glucagon
(A)	Inhibits secretion of glucagon	Inhibits secretion of insulin
(B)	Decreases absorption of amino acids	Increases absorption of amino acids
(C)	Increases blood glucose	Decreases blood glucose
(D)	Reduces blood glucose	Increases blood glucose

20. What will happen when glucose concentration in the blood falls?
    (A) Glucagon is produced to cause the release of glucose from the liver.
    (B) Insulin is produced to cause the release of glucose from the liver.
    (C) More glucose will be absorbed by the villi.
    (D) Liver cells spontaneously release glucose.

Answers

1 Assumed Knowledge

1. Metabolism is the sum of all the chemical reactions occurring within a cell or other parts of an organism.
2. The environment is everything, both living and non-living, around an organism. The external environment refers to anything outside the body; the internal environment refers to anything inside the body.
3. A receptor is a cell or organ that can detect variations of some kind in an organism's environment. An effector is a structure that causes a response to counteract changes from the stable state.
4. Five senses are hearing, sight, touch, taste and smell.
5. Five sense organs are eyes, ears, tongue, nose and skin.
6. Skin has heat and cold receptors, light touch, pain and strong pressure receptors.
7. Interstitial fluid is the intercellular fluid which fills the spaces between the cells.
8. Endotherms, e.g. humans and other mammals maintain a constant internal environment because of internal processes.
9. The nervous system coordinates sensory information with the body's responses.
10. Both the CNS and PNS are composed of neurons and together make up the nervous system. The CNS consists of the brain and spinal cord and is mainly composed of interneurons, while the PNS consists of the nerves branching from the CNS and passing to all other body parts.
11. Ambient temperature is the temperature of surroundings.
12. The circulatory system transports materials around the body.
13. Red blood cells transport oxygen from the lungs to needy tissues in the body. White blood cells are part of the body's defence against infection and platelets are involved in clotting the blood.
14. Arteries are vessels which carry blood away from the heart; veins are vessels which carry blood towards the heart; capillaries are vessels which connect arteries to veins.
15. Diffusion is the movement of particles from an area of high concentration of particles to an area of low concentration of particles.
16. A control is part of an experiment that has the identical situation but often without the variable, and is used for comparison.
17. The lymph system is a network of nodes, veins and blind-end capillaries which carry lymph from body tissues and drain into blood vessels.
18. The cerebrum controls conscious thought, memory, sensory reception and motor activities. The spinal cord is involved in reflex actions involving body structures below the neck and sending sensory impulses to the brain and carrying motor impulses from the brain.
19. Carbon dioxide diffuses out of the capillary into the alveoli and oxygen diffuses into the capillary from the alveoli. Both move down a concentration gradient.
20. Water is an important molecule because of its unique properties as a solvent; many solutes dissolve in water. It also enters such reactions as photosynthesis, respiration and digestion. It can also act as a cooling agent, e.g. water evaporates from the skin and removes heat from the body.
21. A parasite lives on or in a host, gaining food, shelter and protection and causing harm to the host.
22. Bacteria are prokaryotes; they are microscopic with a cell wall and a single coiled strand of DNA.
23. Viruses are very small, are not cellular, consist of nucleic acid (either RNA or DNA) and are enclosed in a protein coat.
24. A pathogen is an organism capable of producing a disease.
25. A hormone is an organic chemical produced by one part of the body and transported to another part where it affects the metabolism of the target cells.

2 The Endocrine System

1. The endocrine system is a body system composed of different endocrine glands that are ductless glands which secrete hormones directly into the bloodstream or body fluids.
2. Hormones are chemical signals that travel in the blood and body fluids and act on specific target cells to cause a specific response for internal communication and regulation and maintaining homeostasis.
3.

Feature	Nervous system	Endocrine system
Speed of transmission	Rapid	Slower
Mode of transmission	Electrochemical impulse along nerve fibres	Hormones travelling in bloodstream and tissue fluids
Response time	Immediate	Slower acting
Response duration	Short time	Long time – up to years
Specificity	One effector	Several organs or target cells

4. A = pituitary gland
   B = thyroid gland
   C = ovaries
   D = pineal gland
   E = parathyroid glands
   F = thymus gland
   G = adrenal glands
   H = pancreas – islets of Langerhans
5. (a) The diagram shows how the hypothalamus (releasing TRH) and anterior pituitary gland (releasing TSH) control the secretion of the thyroid hormones. The release of hormones from several glands is controlled by the release of other hormones. The thyroid hormones are important in controlling many body functions, e.g. maintaining normal blood pressure, heart rate, muscle tone and digestion. The diagram also shows how hormone control is a feedback mechanism.
   (b) To reach their target organ, e.g. travelling from the anterior pituitary gland to the thyroid gland, the hormone travels in the blood.
6. Insulin and glucagon are antagonistic hormones as they both regulate the concentration of glucose in the blood but have opposite effects. Low blood glucose levels will cause the alpha cells of the pancreas to release glucagon into the blood which will cause liver cells to break down glycogen and release glucose into the blood. High blood glucose levels will cause the beta cells of the pancreas to release insulin into the blood which will cause the liver to take up glucose and store it as glycogen as well as body cells to take up more glucose.
7. The pituitary gland is often called the 'master gland' as its hormones stimulate other endocrine glands to secrete hormones, e.g. anterior pituitary produces thyroid stimulating hormone that stimulates the thyroid gland to produce thyroxine.
8. Adrenaline and noradrenaline are the flight or fight hormones.
9. (a) Neurotransmitters (e.g. when metabolic rate is slow) trigger the hypothalamus to secrete releasing factors (e.g. thyroid releasing factor – TRF) which will stimulate the pituitary gland to secrete thyroid stimulating hormone (TSH) that will then stimulate the thyroid gland to produce the hormone thyroxine.
   (b) Negative feedback is a type of regulation where a change is monitored and there is a response that will counteract the initial change. The dotted lines show the negative feedback. For hormone secretion negative feedback will inhibit the production of the hormone if the hormone concentration becomes too high, e.g. by controlling the amount of releasing factor and secretions of the pituitary gland.
   (c) The hypothalamus produces hormones and releasing factors which stimulate the pituitary gland to produce hormones.
10. There are three main types of hormones – the peptide hormones, the steroid hormones and the amine hormones.
11. The structure of the hormone determines if it is water soluble (hydrophilic) or fat soluble (hydrophobic), e.g. polypeptide hormones such as insulin are water soluble while steroid hormones such as cortisol are lipid soluble.
12. (a) TSH is a tropic hormone as it stimulates the thyroid gland.
    (b) Prolactin is a non-tropic hormone as it stimulates milk production and secretion.
    (c) ACTH is a tropic hormone as it stimulates the adrenal cortex to secrete glucocorticoids.
13. D
14. A
15. C

3 Types of Hormones

1. The endocrine system consists of endocrine glands which are ductless glands that release chemical messengers called hormones into the bloodstream.
2. A hormone is a chemical messenger, e.g. protein, amine or steroid molecule formed in specialised cells that travel in body fluids to act on specific target cells to change their functioning.
3. In vertebrates the endocrine glands can include the pituitary, sex glands, adrenal gland, thyroid gland, parathyroid gland, pancreas, islets of Langerhans and pineal gland.
4. Growth hormone causes growth of many parts of the body and thyroxine increases the rate of many chemical reactions in nearly all body cells.
5. The three main types of hormones are proteins and peptides (small polypeptides with up to 30 amino acids), amines derived from amino acids and steroids.
6. Steroid hormones are lipid soluble and can easily pass through cell membranes. They are usually concerned with long term responses of the body, e.g. oestrogen, testosterone and aldosterone.
7. As steroid hormones are lipid soluble they need to travel around the body bound to carrier proteins.
8. The receptors for steroid hormones can be in the cytoplasm or in the nucleus.
9. Many steroid hormones, e.g. oestrogens and cortisol act by directly regulating gene expression of target genes.
10. The amine hormones are derivatives of the amino acid tyrosine and include hormones secreted by the thyroid gland, e.g. thyroxine and triiodothyronine and the adrenal medulla (adrenaline and noradrenaline).
11. The protein/peptide groups include hormones secreted by the anterior and posterior pituitary gland, e.g. thyroid stimulating hormone (TSH) and antidiuretic hormone ADH), the pancreas (insulin and glucagon) and the parathyroid gland, e.g. parathyroid hormone (PTH).
12. In general the response time is much faster for amine and protein/peptide hormones than for steroid hormones. The amine/protein/peptide hormones such as ADH, TSH and insulin bring about a response within a few minutes and their actions are usually short lived while steroid hormones such as testosterone and oestrogen have long term responses that are longer lived.
13. Both steroid hormones and amine/protein/peptide hormones travel in the blood in the circulatory system around the body. Steroid hormones are formed from cholesterol and need to be bound to plasma proteins whereas amine/protein/peptide hormones can dissolve in the plasma.
14. A prehormone is a chemical produced by a gland that is converted into an active hormone in a mature form in peripheral tissues.
15. Signal transduction is the transmission of a molecular signal from the exterior of the cell into its interior using cell-surface receptors.
16. Hormone secretion is mainly controlled by a negative feedback system that will stop hormone secretion to prevent overactivity of the target cells. Hormone secretion is also affected by other factors such as daily rhythms, seasonal changes, stages of development and ageing and sleep patterns, e.g. growth hormone has higher secretion rates during early sleep time than in later sleep time.
17. The hypothalamus is part of the ventral section of the forebrain.
18. The hypothalamus plays an important role in the functioning of the endocrine system, e.g. secreting the hormones oxytocin and ADH which are stored in the posterior pituitary gland and secreting the releasing factors that regulate the anterior pituitary gland. The hypothalamus is also important as it maintains homeostasis by coordinating the endocrine system with the nervous system.
19. Stimulus → transcription → translation → synthesis of peptide hormone at ribosome on endoplasmic reticulum → packaging of hormone by Golgi apparatus → storage in vesicle → secretion by exocytosis from cell.
20. C
21. A

4 The Pituitary Gland

1. The pituitary gland lies below the hypothalamus.
2. The pituitary gland is often called the 'master gland' as it regulates the activity of other endocrine glands.
3. The hypothalamus controls the release of many of the hormones from the pituitary gland.
4.

Anterior pituitary hormone	Function
Growth hormone	Acts on body tissues especially during childhood and adolescence increasing the rate at which amino acids are taken up by cells and built into proteins.
Prolactin	Helps initiate and maintain milk secretion in females and promotes development of female breasts.
Luteinising hormone	Works with FSH in females to bring about ovulation and form the corpus luteum after ovulation. In males stimulates interstitial cells in testes to secrete male sex hormones.
Thyroid stimulating hormone	Stimulates the production and release of hormones from the thyroid gland.
Adrenocorticotrophic hormone	Controls the production and release of some of the hormones from the cortex of the adrenal glands.
Posterior pituitary gland	**Functions**
ADH	Causes the kidneys to reabsorb water to maintain body water balance.
Oxytocin	Stimulates the contraction of muscles of the uterus, e.g. during childbirth and stimulates the contraction of cells in mammary glands in the release of milk while suckling.

5. (a) Stimulation hypothalamus → secretion of growth hormone releasing hormone (GHRH) → anterior pituitary secretes growth hormone → increase in uptake of amino acids by cells.
   (b) Stimulation of hypothalamus → secretion of prolactin releasing hormone (PRH) → anterior pituitary secretes prolactin → mammary glands stimulated to produce milk.
   (c) Stimulation of hypothalamus → secretion of corticotropin releasing hormone (CRH) → anterior pituitary gland secretes adrenocorticotropic hormone (ACTH) → adrenal glands synthesise cortisol.
6. Hyposecretion involves reduced amounts of hormone produced whereas hypersecretion involves increased amount of hormone produced.
7. A secretory tumour of the pituitary gland leads to hypersecretion of a particular hormone. Overproduction of a hormone will interfere with normal body functioning and if the tumour mass becomes large and presses against other areas it can cause headaches and vision problems.
8. D
9. A
10. B
11. C

5 The Thyroid Gland

1. The thyroid gland lies below the larynx on each side and anterior to the trachea.
2. The thyroid gland produces thyroxine (T_4), tiiodothyronine (T_3) and calcitonin.
3. Thyroxine is an amino acid with four iodine atoms.
4. T_4 and T_3 affect the metabolic rate of the body and bring about the release of energy when complex molecules are synthesised from simple molecules. They are also necessary for cellular differentiation.
5. Low concentration of thyroid hormones in the blood → anterior pituitary gland is stimulates to secrete more TSH → thyroid gland is stimulated to secrete more thyroid hormones → concentration of thyroid hormones in blood increases.

6. (a) Hyperthyroidism is the overproduction of thyroxine.
   (b) Hyperthyroidism causes nervousness, insomnia and excessive excitability; heat intolerance and excessive sweating; increased heart rate and blood pressure; and weight loss.
7. (a) Hypothyroidism is the underproduction of thyroxine.
   (b) Hypothyroidism during infancy affects the development of brain cells and can lead to permanent mental deficiency and dwarfism. In adults it causes dry skin, intolerance to cold and lack of energy.
8. TSH (thyroid stimulating hormone) from the anterior pituitary gland stimulates the release of thyroxine from the thyroid gland.
9. Common salt is iodised to make sure people do not have an iodine deficiency which would lead to an inability to make thyroxine and hypothyroidism. This can lead to a constant production of TSH which causes the thyroid gland to grow and form a goitre.
10. Cretinism is caused by extreme hypothyroidism during foetal development, infancy or childhood. The low levels of thyroid hormones cause failure of body growth and mental retardation and can be due to lack of iodine in the diet or a genetic defect of the gland. A child with cretinism will be stocky, short and obese.
11. The thyroid hormones activate gene expression and the transcription of a large number of genes, e.g. to cause the synthesis of protein enzymes, structural proteins and transport proteins.
12. A
13. C
14. B
15. D
16. A

6 The Adrenal Glands

1. The adrenal glands are on either side of the spinal column above each kidney.
2. The adrenal gland consists of the adrenal cortex and the adrenal medulla.
3. Both corticosteroids are secreted by the adrenal cortex with glucocorticoids affecting glucose metabolism while mineralocorticoids affect mineral metabolism maintaining salt and water balance.
4. Stressful signals cause the hypothalamus to secrete a releasing hormone that stimulates the anterior pituitary to release adrenocorticotropic hormone (ACTH). ACTH causes the adrenal cortex to secrete the corticosteroids.
5. Cholesterol is needed for normal functioning of the adrenal glands as the adrenocortical hormones are steroids derived from cholesterol.
6. (a) Cortisol has multiple metabolic functions and is involved in the metabolism of proteins, carbohydrates and fats. It also has anti-inflammatory effects.
   (b) Aldosterone increases the reabsorption of sodium in the kidney nephrons and increases the secretion of potassium and hydrogen ions from the kidney.
7. The main two hormones of the adrenal medulla are adrenaline (epinephrine) and noradrenaline (norepinephrine).
8. The main hormones of the adrenal medulla are secreted in response to stress and increase the rate of glycogen breakdown in the liver and skeletal muscles, increase heart rate, promote glucose release by liver cells and dilate the bronchioles in the lungs to increase oxygen uptake. This prepares the body for action and is sometimes called the 'fight or flight' response.
9.

Adrenal cortex hormone	Function
Cortisol	Metabolism of proteins, carbohydrates and fats; has anti-inflammatory effects.
Aldosterone	Increases the reabsorption of sodium in the kidney nephrons and increases the secretion of potassium and hydrogen ions from the kidney.
Adrenal medulla hormone	**Function**
Adrenaline and noradrenaline	Increase the rate of glycogen breakdown in the liver and skeletal muscles, increase heart rate, promote glucose release by liver cells and dilate the bronchioles in the lungs to increase oxygen uptake.

10. Addison's disease is caused by insufficient production of adrenocortical hormones, e.g. lack of aldosterone. This causes a loss of sodium ions, chloride ions and water in urine and a drop in plasma volume. Cardiac output decreases and the person can die of shock within two weeks from the time when mineralocorticoid production stopped.
11. The adrenal cortex is stimulated from the pituitary gland, e.g. adrenocorticotropin (ACTH) stimulates the adrenal cortex to produce cortisol. Whereas the adrenal medulla is stimulated by the sympathetic nervous system, e.g. to increase cardiac output, increase blood pressure and increase ventilation rate.
12. Cushing's syndrome occurs when there is hypersecretion of the adrenal cortex leading to excess cortisol in the blood. It is often caused by excess ACTH secretion. It causes fat from the lower body to mobilise and deposit in the upper abdomen and thorax causing a buffalo torso appearance. The excess steroids also cause increased facial hair and fat deposits on the face.
13. Stress stimulus → hypothalamus secretes CRF → anterior pituitary secretes ACTH → adrenal cortex secretes cortisol → increased glucose and fuel supplies in the blood for body cells under stress.
14. D
15. C
16. C
17. B

7 The Pancreas

1. The pancreas is located behind and parallel to the stomach.
2. Exocrine glands secrete their products into ducts. The pancreas has acinar cells that produce digestive enzymes and duct cells that secrete sodium bicarbonate solution into the ducts that empty into the pancreatic duct. Thus the acinar cells and duct cells are part of the exocrine section of the pancreas.
3. Endocrine glands are ductless glands that secrete hormones into extracellular spaces and then diffuse into the circulatory system. The pancreas secretes the hormones insulin and glucagon and this section of the pancreas is thus an endocrine gland.
4. The islets of Langerhans are patches of endocrine tissue within the pancreas that were first discovered by Paul Langerhans in 1869.
5. Islets of Langerhans.

Cell type	Product
Alpha cells	Glucagon
Beta cells	Insulin
Delta cells	Somatostatin
Gamma cells	Pancreatic polypeptide
Epsilon cells	Ghrelin

6. Glucose is needed for cellular respiration and biosynthesis of macromolecules.
7. For most humans blood glucose levels are the lowest first thing in the morning before breakfast.
8. Homeostasis is the maintenance of a constant internal environment within narrow limits. Blood glucose levels need to be maintained within narrow limits so that normal metabolic processes can function properly. Changes in solute concentrations will affect diffusion rates, osmotic pressure and the need for active transport across membranes.
9. Glucose and glucagon are antagonistic hormones as they have opposing effect – insulin causes glucose in the blood to be taken up by body cells to lower blood glucose concentration while glucagon causes the release of glucose into the blood from energy stores, e.g. glycogen from the liver.
10. Homeostasis is the maintenance of a constant internal environment within narrow limits. The hormones produced by the pancreas – insulin and glucagon control blood glucose concentration keeping the concentration within narrow limits for optimal metabolism. Thus the pancreas is important in maintaining homeostasis.
11. (a) Insulin is produced by the beta cells within the islets of Langerhans.
    (b) Glucagon is produced by the alpha cells within the islets of Langerhans.