BP203T · B.PHARM THEORY

BP203T Human Anatomy, Physiology and Pathophysiology II

Unit IV — Endocrine System

Pills & Python Notes

From-zero teaching standard: every technical term is defined before use.

Syllabus coverage: Unit IV (10 hours).

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Infographic concept — "The Command Centre"

Draw a central command room labelled **Pituitary (master gland)**. From it, radio towers (arrows) broadcast to seven stations: thyroid (neck), parathyroid (four dots behind thyroid), adrenals (caps on kidneys), pancreas (behind stomach), pineal (tiny dot in brain), thymus (behind breastbone). Each station returns a "signal strength" arrow back to the command room — this is **negative feedback**, the master rule of the endocrine system. Under the picture, write one line per gland: its hormone → its job → what happens when it fails.

Chapter 15 — Hormones: What They Are, Types, and How They Work

15.1 Learning objectives

After studying this chapter you will be able to: (1) define hormone, endocrine gland, target cell and hormone receptor; (2) classify hormones by chemical nature; (3) explain the two mechanisms of hormone action — at the cell membrane and inside the cell; (4) explain negative and positive feedback with examples; (5) name the major endocrine glands of the body.

15.2 Definitions

Endocrine system. A collection of glands that release chemical messengers called hormones directly into the blood. It works slowly (minutes to hours) but its effects last long — unlike the nervous system, which works fast but briefly.

Hormone. A chemical messenger made by an endocrine gland, carried by blood to a distant part of the body, where it changes what the receiving cells do.

Endocrine gland. A gland with no tube (duct) to the outside; it pours its secretion straight into the blood. (Contrast: an *exocrine* gland, like a salivary gland, pours into a duct — a tube.)

Target cell / target organ. The cell or organ that has receptors for a hormone and therefore responds to it. Insulin's targets include liver, muscle and fat cells.

Receptor. A protein molecule, usually on or inside a cell, that fits one hormone like a lock fits one key. No receptor = no response.

> **KEY TAKEAWAY:** Glands release hormones into blood → hormones travel everywhere → only cells with the right receptor respond.

15.3 Concept first: how the body controls itself

Think of the body as a large factory. The nervous system is the telephone — instant messages, short conversations ("move your hand!"). The endocrine system is the postal service — slower letters, but they carry detailed instructions that last for hours ("grow taller over the next year"). Both systems talk to each other: the brain's hypothalamus links the nervous and endocrine systems.

> **Example:** You have not eaten for hours. Your blood sugar falls. Your pancreas releases the hormone **glucagon** into the blood. It travels to the liver and says "release stored sugar into the blood." Blood sugar rises. This whole loop runs without your brain thinking about it.

> **Analogy:** A hormone is like a radio broadcast — the station (gland) transmits everywhere, but only radios tuned to that frequency (cells with receptors) play the song.

> **KEY TAKEAWAY:** Endocrine = slow, long-lasting chemical control through the blood.

15.4 TERMINOLOGY ALERT

Word	Simple meaning	Don't confuse with
Hormone	Chemical messenger in blood	Enzyme (a chemical that speeds up reactions in one place — enzymes are not carried in blood as messengers)
Gland	A group of cells that makes and releases a substance	Ganglion (a cluster of nerve cells — totally different!)
Endocrine	Pours into blood (ductless)	Exocrine (pours into a duct/tube, e.g., sweat gland)
Secrete	To release a useful substance from a cell	Excrete (to throw out waste, e.g., urine)

15.5 Classification of hormones

Hormones are classified by what they are made of (chemical nature). There are three groups:

1. Protein/peptide hormones. Made of chains of amino acids (protein building blocks). They dissolve well in blood. Examples: insulin (from pancreas), growth hormone (from pituitary), parathyroid hormone, oxytocin. *Note for pharmacy:* because they are proteins, they are destroyed by stomach acid and digestive enzymes — so most are given as injections, not tablets.

2. Steroid hormones. Made from cholesterol (a fat-like substance). They dissolve poorly in water and travel in blood attached to carrier proteins. Examples: cortisol, aldosterone (adrenal cortex), oestrogen, progesterone, testosterone (sex hormones). They are made mainly in the adrenal cortex and the gonads (ovaries/testes).

3. Amine hormones. Made from a single amino acid (tyrosine or tryptophan). Examples: thyroid hormones (T3, T4) from the thyroid gland; adrenaline (epinephrine) from the adrenal medulla; melatonin from the pineal gland.

> **KEY TAKEAWAY:** Hormones = proteins/peptides (injected, e.g., insulin) | steroids (made from cholesterol) | amines (made from one amino acid).

Mnemonic for chemical classes — "PSA": Peptide, **S**teroid, **A**mine.

15.6 Mechanism of hormone action — how a hormone actually changes a cell

A hormone floating in blood cannot push a cell around by itself. It must bind to its receptor. There are two main mechanisms:

Mechanism 1 — The hormone works at the cell surface (membrane). Protein/peptide hormones (like insulin) dissolve in water but cannot cross the fatty cell membrane. So they bind to a receptor **on the outside of the cell**. This is like ringing a doorbell: the visitor (hormone) never enters the house, but the bell (receptor) sends a signal inside — a chain of chemical steps called a **second messenger system** — which changes what the cell does.

> Flowchart: Hormone reaches cell → binds receptor on cell membrane → receptor changes shape → second messengers activated inside cell → cell's activity changes (e.g., takes up glucose)

Mechanism 2 — The hormone enters the cell. Steroid and thyroid hormones are fat-soluble, so they pass straight through the cell membrane. Inside, they bind a receptor and the hormone–receptor pair travels to the **nucleus** (the cell's control room), where it switches genes on or off. This is slower (takes hours) but long-lasting — it changes which proteins the cell makes.

> Flowchart: Hormone enters cell through membrane → binds receptor inside → hormone–receptor complex enters nucleus → turns genes on/off → new proteins made → cell behaviour changes over hours

Analogy: Mechanism 1 is knocking on the door and shouting instructions through it; Mechanism 2 is walking inside and rewriting the instruction manual.

KEY TAKEAWAY: Water-soluble hormones act at the membrane (fast, via second messengers); fat-soluble hormones enter the cell and change genes (slow, lasting).

15.7 Feedback control — the body's thermostat

The endocrine system regulates itself using **feedback**, most commonly **negative feedback**: when a hormone's effect reaches the right level, it signals the gland to slow down.

Negative feedback example: Low thyroid hormone in blood → pituitary releases TSH → thyroid makes more hormone → hormone level rises → high level tells pituitary "enough, stop TSH." Like a thermostat switching the heater off when the room is warm.

Positive feedback (rare): the effect boosts the cause. Example: in childbirth, the hormone oxytocin causes the uterus to contract → contractions push the baby down → more oxytocin released → stronger contractions. It stops only when the baby is born.

KEY TAKEAWAY: Negative feedback = "level is fine, stop"; this keeps hormones balanced.

15.8 The major endocrine glands — map of the territory

Gland	Where it is	Main hormones (preview)
Pituitary	Base of the brain, in a bony pocket	Growth hormone, TSH, ACTH, FSH, LH, prolactin, ADH, oxytocin
Thyroid	Front of the neck, around the windpipe	T3, T4, calcitonin
Parathyroid	Four tiny dots behind the thyroid	Parathyroid hormone (PTH)
Adrenal	Caps sitting on top of each kidney	Cortisol, aldosterone (cortex); adrenaline (medulla)
Pancreas	Behind the stomach	Insulin, glucagon
Pineal	Deep inside the brain	Melatonin
Thymus	Behind the breastbone, above the heart	Thymosin

Sketch guide (whole system): Draw a simple human outline. Mark: tiny dot in the brain (pituitary + pineal), butterfly in the neck (thyroid) with four dots behind it (parathyroid), small caps above the kidneys (adrenals), a leaf behind the stomach (pancreas), a small shield behind the breastbone (thymus). Label each with its hormones.

15.9 PHARMACY RELEVANCE

- Hormones are drugs too: insulin injections (diabetes), levothyroxine tablets (hypothyroidism), corticosteroid creams/injections (inflammation), oral contraceptives (sex hormones).
- Knowing that peptide hormones are destroyed in the stomach explains why insulin is injected — a classic viva question.
- Pharmacists counsel patients on hormone medicines: take thyroid tablets on an empty stomach, never stop steroids suddenly.

15.10 COMMON CONFUSIONS

- **Endocrine vs exocrine:** endocrine = into blood, no duct; exocrine = into a duct/tube. The pancreas is BOTH: its islet cells are endocrine (insulin into blood), its acinar cells are exocrine (digestive juice into the pancreatic duct).
- **Hormone vs enzyme:** a hormone travels in blood to distant targets; an enzyme works where it is made (mostly), speeding up one chemical reaction.
- **Gland vs ganglion:** gland makes secretions; ganglion is a nerve-cell cluster.

15.11 COMMON MISTAKES

- Writing that hormones are "secreted through ducts" — endocrine glands have NO ducts.
- Saying adrenaline is a steroid — it is an amine (made in adrenal *medulla*), while cortisol is the steroid (adrenal *cortex*).
- Confusing positive and negative feedback in exams — remember: negative = balancing, positive = amplifying (rare, e.g., oxytocin in labour).

15.12 ONE-MINUTE REVISION

Hormones are blood-borne chemical messengers from ductless (endocrine) glands, acting only on cells with receptors. Three chemical classes: peptide/protein (insulin — injected, destroyed in gut), steroid (from cholesterol — cortisol, sex hormones), amine (thyroid hormones, adrenaline, melatonin). Water-soluble hormones act at the membrane via second messengers (fast); fat-soluble hormones enter the cell and switch genes (slow, lasting). Control is mainly negative feedback. Major glands: pituitary, thyroid, parathyroid, adrenal, pancreas, pineal, thymus.

15.13 Practice questions

MCQs

1. Which of the following is an endocrine gland? (a) Salivary gland (b) Sweat gland (c) Thyroid gland (d) Sebaceous gland
2. Insulin is classified as a: (a) steroid hormone (b) peptide hormone (c) amine hormone (d) fatty acid
3. Steroid hormones act mainly by: (a) binding membrane receptors (b) entering the cell and acting on genes (c) blocking enzymes (d) forming clots
4. Negative feedback means: (a) hormone level rises endlessly (b) a rise in hormone level switches off its own release (c) no hormone is released (d) two glands cancel each other

Short answers

1. Define hormone, endocrine gland and target cell.
2. Classify hormones with one example each.
3. What is negative feedback? Give one example.

Long answer

1. Describe the two mechanisms of hormone action with flowcharts and examples.

Application-based

1. A patient asks why insulin cannot be taken as a tablet like other medicines. How would you explain this simply?

Viva

1. Why is the pancreas called both an endocrine and an exocrine gland?

Chapter 16 — The Pituitary Gland: The Master Gland

16.1 Learning objectives

After studying this chapter you will be able to: (1) describe the location and structure of the pituitary gland; (2) list the hormones of the anterior and posterior pituitary with their functions; (3) explain the role of the hypothalamus; (4) describe what happens in excess and deficiency of growth hormone.

16.2 Definitions

Pituitary gland. A pea-sized gland at the base of the brain. It is called the "master gland" because many of its hormones control other endocrine glands.

Hypothalamus. The part of the brain just above the pituitary. It links the nervous system to the endocrine system by sending releasing/inhibiting hormones to the pituitary.

Tropic hormones. Hormones whose target is another endocrine gland (e.g., TSH stimulates the thyroid; ACTH stimulates the adrenal cortex).

> **KEY TAKEAWAY:** Hypothalamus (brain) → commands pituitary (master gland) → pituitary hormones → other glands and tissues.

16.3 Structure — how to picture and sketch it

- **Location:** sits in a small bony pocket at the base of the brain called the **sella turcica** ("Turkish saddle" — imagine a tiny saddle holding the gland).
- **Size:** about the size of a pea (roughly 1 cm).
- **Two lobes:** the **anterior pituitary** (front lobe — makes its own hormones) and the **posterior pituitary** (back lobe — stores and releases hormones actually made by the hypothalamus).
- **Connection:** joined to the hypothalamus by a stalk (the infundibulum). Blood vessels carry hypothalamic signals down the stalk to the anterior pituitary; nerve fibres carry hypothalamic hormones to the posterior pituitary.

> **Sketch guide:** Draw a side view of a head outline. Draw the brain as a blob. Under the brain's centre, draw a small pea in a cup (sella turcica). Draw a stalk connecting the pea upward to the brain — label "hypothalamus above, stalk, pituitary below." Divide the pea into front (anterior) and back (posterior) halves.

> **Example:** Think of the hypothalamus as the company chairman and the pituitary as the managing director — the chairman sets policy, the MD runs the departments (the other glands).

16.4 Hormones of the anterior pituitary

Hormone	Short name	Target	Main action
Growth hormone	GH	Bones, muscles, most tissues	Stimulates growth of body tissues
Thyroid-stimulating hormone	TSH	Thyroid gland	Tells thyroid to make T3/T4
Adrenocorticotropic hormone	ACTH	Adrenal cortex	Tells adrenal cortex to make cortisol
Follicle-stimulating hormone	FSH	Ovaries/testes	Stimulates egg/sperm development
Luteinizing hormone	LH	Ovaries/testes	Triggers ovulation; stimulates sex hormone production
Prolactin	PRL	Breasts	Stimulates milk production after childbirth

Mnemonic — "FLAT PiG" for the six anterior pituitary hormones: **F**SH, **L**H, **A**CTH, **T**SH, **P**rolactin, **G**rowth hormone. ("Go Look For The Adenohypophysis" is another, but FLAT PiG is easier.)

16.5 Hormones of the posterior pituitary

These are made by the hypothalamus and only stored/released by the posterior pituitary:

- **ADH (antidiuretic hormone / vasopressin):** tells the kidneys to save water — "anti-diuretic" = against urine loss. Less water lost in urine = more concentrated urine. Also narrows blood vessels (hence "vasopressin") when blood pressure is very low.
- **Oxytocin:** contracts the uterus during childbirth and squeezes milk out of the breast during breastfeeding ("milk let-down").

> **KEY TAKEAWAY:** Anterior pituitary MAKES six hormones (FLAT PiG); posterior pituitary only RELEASES two made by the hypothalamus (ADH, oxytocin).

16.6 Growth hormone — excess and deficiency (simple clinical picture)

- **Deficiency in childhood → dwarfism (short stature):** the child grows much more slowly than normal but body proportions stay normal. Treated with growth hormone injections.
- **Excess in childhood (before growth plates close) → gigantism:** the child grows abnormally tall.
- **Excess in adults (after growth plates close) → acromegaly:** bones of the hands, feet and jaw enlarge (the person cannot grow taller, so bones thicken). Usually caused by a pituitary tumour.

> **Example:** A basketball-player-tall teenager with a pituitary tumour making extra GH = gigantism; the same excess starting at age 40 = acromegaly (big jaw, big hands, same height).

> **KEY TAKEAWAY:** GH too little in childhood = short stature; GH too much in childhood = gigantism; GH too much in adulthood = acromegaly.

16.7 PHARMACY RELEVANCE

- Growth hormone (somatropin) is given by injection for GH deficiency in children.
- Desmopressin (a synthetic ADH-like drug) is used for bedwetting and diabetes insipidus (a condition of passing large volumes of dilute urine due to ADH lack).
- Oxytocin injections are used to induce/augment labour and control bleeding after delivery.
- Dopamine-blocking drugs (e.g., some antipsychotics) can raise prolactin — pharmacists watch for this

16.8 India context

- Short stature in children is often first noticed at school health check-ups; timely referral for GH testing matters because treatment works best before growth plates close.
- Government hospitals provide endocrine clinics where pituitary disorders are evaluated.

16.9 COMMON CONFUSIONS

- **Anterior vs posterior pituitary:** anterior makes its own hormones; posterior only stores/releases ADH and oxytocin made by the hypothalamus.
- **ADH vs aldosterone:** both save water/salt, but ADH comes from the posterior pituitary and saves *water*; aldosterone comes from the adrenal cortex and saves *sodium* (water follows sodium).
- **Gigantism vs acromegaly:** gigantism = GH excess *before* growth plates close (taller); acromegaly = GH excess *after* (thicker bones, same height).

16.10 COMMON MISTAKES

- Listing ADH and oxytocin as "made by the pituitary" — they are made by the hypothalamus.
- Writing that the pituitary is "in the neck" — it is at the base of the brain; the thyroid is in the neck.

16.11 ONE-MINUTE REVISION

Pea-sized pituitary sits in the sella turcica at the brain's base, under hypothalamic control. Anterior lobe makes FLAT PiG (FSH, LH, ACTH, TSH, prolactin, growth hormone); posterior lobe releases ADH (saves water) and oxytocin (uterus contraction, milk let-down) made by the hypothalamus. GH deficiency in childhood = short stature; excess in childhood = gigantism; excess in adults = acromegaly.

16.12 Practice questions

MCQs

1. The "master gland" is: (a) thyroid (b) pituitary (c) adrenal (d) pineal
2. Which hormone is released by the posterior pituitary? (a) GH (b) TSH (c) Oxytocin (d) Prolactin
3. Acromegaly is caused by excess growth hormone: (a) in childhood (b) in adults after growth plates close (c) in the elderly only (d) during pregnancy

Short answers

1. Name the six anterior pituitary hormones with one function each.
2. Differentiate between gigantism and acromegaly.
3. What are the functions of ADH and oxytocin?

Long answer

1. Describe the structure of the pituitary gland and the hormones of its two lobes.

Application-based

1. A 35-year-old man notices his rings no longer fit and his jaw looks larger in photos over two years. Which pituitary disorder could this suggest, and why does his height stay the same?

Viva

1. Why is the posterior pituitary not a true endocrine gland?

Chapter 17 — Thyroid and Parathyroid Glands

17.1 Learning objectives

After studying this chapter you will be able to: (1) describe the structure of the thyroid and parathyroid glands; (2) list thyroid hormones and their functions; (3) explain how T3/T4 control body metabolism; (4) explain the role of calcitonin and parathyroid hormone in calcium balance.

17.2 Definitions

Thyroid gland. A butterfly-shaped endocrine gland in the front of the neck that makes hormones controlling the body's speed of working (metabolic rate).

Metabolic rate. How fast the body's cells burn fuel (food) to make energy. High metabolic rate = body works fast, feels warm, heart beats faster.

Parathyroid glands. Four tiny glands stuck on the back of the thyroid that control calcium levels in blood.

Calcium balance. Keeping blood calcium in a narrow safe range — needed for bones, muscle contraction and nerve signals.

> **KEY TAKEAWAY:** Thyroid = body's speed controller; parathyroids = blood calcium guards.

17.3 Structure — thyroid

- **Location and shape:** lies in the front of the neck, wrapped around the upper part of the trachea (windpipe), just below the Adam's apple. It has two lobes (left and right) joined by a bridge called the **isthmus** — like a butterfly with its body across the windpipe.
- **Inside:** made of tiny hollow balls called **follicles**. Each follicle is filled with a jelly-like substance called **colloid**, which stores thyroid hormone — the thyroid is unusual because it stores weeks of hormone supply.
- **Blood supply:** very rich — you can feel it enlarge (goitre) easily in the neck.

> **Sketch guide:** Draw the neck in front view. Draw the windpipe as a vertical tube with rings. Draw a butterfly shape hugging the tube — two wings (lobes) and a band across (isthmus). Zoom into one wing: draw circles (follicles) filled with dots (colloid). Behind the butterfly, draw four tiny dots (parathyroids).

17.4 Thyroid hormones and their functions

The thyroid makes two main hormones, T3 and T4, plus calcitonin:

- **Thyroxine (T4):** the main product; mostly converted to T3 in tissues. Contains iodine — the thyroid needs iodine from food (iodised salt) to make it.
- **Triiodothyronine (T3):** the more active form.
- **Calcitonin:** made by special C-cells of the thyroid; lowers blood calcium by telling bones to take calcium in.

What T3/T4 do (in simple words): they set the body's working speed — they increase oxygen use, heat production, heart rate, and are essential for normal growth and brain development in children.

> **Example:** A child with too little thyroid hormone grows slowly and learns slowly (cretinism if severe from birth); an adult with too little feels cold, tired, and gains weight; with too much, the person feels hot, nervous, loses weight and the heart races.

> **KEY TAKEAWAY:** T3/T4 = speed up body processes, need iodine; calcitonin = lowers blood calcium.

17.5 Structure and function — parathyroid glands

- **Structure:** usually four tiny glands, each about the size of a grain of rice, stuck on the back surface of the thyroid.
- **Hormone: parathyroid hormone (PTH).**
- **Function:** raises blood calcium when it falls. It does three things: (1) tells bones to release calcium into blood; (2) tells kidneys to save calcium (lose less in urine); (3) helps the gut absorb more calcium from food (by activating vitamin D).

Calcitonin vs PTH — the calcium see-saw:

Situation	Gland acts	Hormone	Effect
Blood calcium too HIGH	Thyroid C-cells	Calcitonin	Puts calcium into bones → blood calcium falls
Blood calcium too LOW	Parathyroid	PTH	Pulls calcium from bones, saves it in kidneys, absorbs more from gut → blood calcium rises

> **Flowchart (calcium control):** Low blood Ca^{2+} → parathyroid senses it → releases PTH → bones release Ca^{2+} + kidneys retain Ca^{2+} + gut absorbs more → blood Ca^{2+} rises → PTH switches off (negative feedback)

> **KEY TAKEAWAY:** Calcitonin and PTH oppose each other to keep blood calcium steady — a classic negative-feedback pair.

17.6 PHARMACY RELEVANCE

- **Levothyroxine** (synthetic T4) tablets treat hypothyroidism — counsel: take on an empty stomach, same time daily, don't stop suddenly.
- **Carbimazole / methimazole** reduce thyroid hormone production in hyperthyroidism.
- **Iodised salt** is a public-health pharmacy topic — iodine deficiency causes goitre.
- Calcium + vitamin D supplements relate to PTH physiology; pharmacists explain why vitamin D helps calcium absorption.

17.7 India context

- India made iodised salt widely available to prevent iodine-deficiency goitre; pharmacists still see goitre in some hilly regions where iodine was historically low in soil and water.
- Hypothyroidism is commonly diagnosed in Indian clinics; many patients take lifelong levothyroxine.

17.8 COMMON CONFUSIONS

- **T3/T4 vs calcitonin:** T3/T4 control metabolic speed; calcitonin only handles calcium. Different jobs, same gland.
- **Thyroid vs parathyroid:** thyroid = big butterfly in neck (metabolism); parathyroid = four rice-grain dots behind it (calcium).
- **Hyper vs hypo:** hyperthyroidism = too much (hot, thin, fast heart); hypothyroidism = too little (cold, tired, weight gain).

17.9 COMMON MISTAKES

- Saying the thyroid "makes insulin" — no, that's the pancreas.
- Forgetting that thyroid hormones need iodine — this is why iodised salt matters.
- Mixing up calcitonin (lowers calcium) and PTH (raises calcium).

17.10 ONE-MINUTE REVISION

Butterfly-shaped thyroid in the front of the neck makes T3/T4 (need iodine; set metabolic speed, growth, brain development) and calcitonin (lowers blood calcium). Four rice-grain parathyroids behind it make PTH, which raises blood calcium via bones, kidneys and gut. Calcitonin and PTH are opposing partners in calcium balance.

17.11 Practice questions

MCQs

1. The thyroid gland is located in the: (a) abdomen (b) front of the neck (c) chest (d) brain
2. Which mineral is needed to make thyroid hormones? (a) Iron (b) Iodine (c) Zinc (d) Calcium
3. Parathyroid hormone: (a) lowers blood calcium (b) raises blood calcium (c) lowers blood sugar (d) raises blood pressure

Short answers

1. Describe the structure of the thyroid gland.
2. List the functions of T3/T4.
3. How do calcitonin and PTH control blood calcium?

Long answer

1. Describe the structure of the thyroid and parathyroid glands and explain calcium regulation with a flowchart.

Application-based

1. A pharmacist sees a prescription for levothyroxine with the instruction "take on empty stomach." Explain the reason simply, linking it to what you know about thyroid hormone absorption.

Viva

1. Why can the thyroid store hormone for weeks while most glands cannot?

Chapter 18 — The Adrenal Glands: Cortex and Medulla

18.1 Learning objectives

After studying this chapter you will be able to: (1) describe the structure of the adrenal glands; (2) distinguish cortex from medulla; (3) list the three groups of cortical hormones and their functions; (4) explain the fight-or-flight response; (5) describe Addison's disease and Cushing's syndrome in simple terms.

18.2 Definitions

Adrenal glands. Two small glands sitting like caps on top of each kidney ("ad-renal" = near the kidney). Each has an outer **cortex** and an inner **medulla** — two glands in one.

Adrenal cortex. The outer layer; makes steroid hormones (cortisol, aldosterone, small amounts of sex hormones). Controlled by ACTH from the pituitary.

Adrenal medulla. The inner core; makes adrenaline (epinephrine) and noradrenaline. Controlled directly by nerves (sympathetic nervous system).

Stress hormones. Hormones released during stress — mainly cortisol (slow, long) and adrenaline (fast, short).

> **KEY TAKEAWAY:** One gland, two parts: cortex = steroids (slow, via ACTH); medulla = adrenaline (fast, via nerves).

18.3 Structure — how to picture and sketch it

- **Location:** one cap on top of each kidney, in the upper abdomen.
- **Cortex (outer):** yellowish, makes up most of the gland; has three layers making three hormone groups.
- **Medulla (inner):** reddish-brown core; nerve-like cells that release adrenaline into blood.

> **Sketch guide:** Draw a kidney as a bean. Draw a small cap/triangle on top — label "adrenal gland." Cut it open: shade the outer rim (cortex, three layers) and the inner core (medulla). Draw an arrow from the pituitary labelled ACTH pointing to the cortex, and a lightning-bolt (nerve) pointing to the medulla.

18.4 Hormones of the adrenal cortex — three groups

Group	Main hormone	Main job (simple words)
Glucocorticoids	Cortisol	Raises blood sugar in stress; reduces inflammation; helps body handle long stress
Mineralocorticoids	Aldosterone	Saves sodium (and therefore water) in kidneys; raises blood pressure
Sex corticoids (androgens)	DHEA (small amounts)	Minor sex-hormone effects

Mnemonic — "Salt, Sugar, Sex": cortex controls **salt** (aldosterone), **sugar** (cortisol), **sex** (androgens) — the three S's from outside to inside layers.

Cortisol — the stress manager: released in long-term stress (illness, injury, exams!). It raises blood sugar (so the brain has fuel), reduces inflammation, and suppresses the immune response. Follows a daily rhythm — highest in the morning.

Aldosterone — the salt saver: acts on kidneys to reabsorb sodium; water follows sodium, so blood volume and blood pressure rise.

KEY TAKEAWAY: Cortisol = handles sugar and stress; aldosterone = handles salt and blood pressure.

18.5 Hormones of the adrenal medulla — fight or flight

- **Adrenaline (epinephrine)** and **noradrenaline (norepinephrine)** — amine hormones released within seconds of fright, danger or excitement.
- **Fight-or-flight effects:** heart beats faster and stronger, airways widen, pupils widen, blood goes to muscles, digestion slows, blood sugar rises. The body prepares to fight or run.

Example: You hear a loud bang behind you — your heart pounds, palms sweat, you feel alert. That is adrenaline, released before you even decide to be afraid.

Analogy: The medulla is the fire alarm (instant, loud, short); the cortex is the emergency committee that meets afterwards and manages the crisis for days (cortisol).

Flowchart (stress response): Danger perceived → brain signals adrenal medulla via nerves → adrenaline released in seconds → heart/lungs/muscles activated (fight or flight) → meanwhile ACTH → cortex releases cortisol → blood sugar maintained for prolonged effort

18.6 When things go wrong — simple clinical pictures

- **Addison's disease (too little cortisol + aldosterone):** tiredness, weakness, weight loss, low blood pressure, darkening of skin. Needs lifelong hormone replacement — a pharmacy counselling point (never stop steroids suddenly).
- **Cushing's syndrome (too much cortisol):** weight gain in face ("moon face") and trunk, thin limbs, high blood sugar, high blood pressure, fragile skin. Often caused by long-term steroid medicines — which is why pharmacists warn against unsupervised steroid use.

KEY TAKEAWAY: Too little adrenal hormone = Addison's (weak, low BP, dark skin); too much cortisol = Cushing's (round face, trunk weight, high sugar/BP).

18.7 PHARMACY RELEVANCE

- **Corticosteroid drugs** (prednisolone, dexamethasone, hydrocortisone creams) mimic cortisol — used for asthma, allergies, inflammation. Counsel: taper the dose, don't stop abruptly; watch blood sugar.
- **Adrenaline injections** are life-saving in anaphylaxis (severe allergy) — pharmacists must know this emergency use.
- **Fludrocortisone** replaces aldosterone in Addison's disease.
- Long unsupervised steroid use can cause Cushing-like features — a key counselling warning.

18.8 India context

- Steroid creams are sometimes misused in India for skin fairness — pharmacists can counsel against this (thinning of skin, dependence).
- Addison's disease needs lifelong medicines; adherence counselling by pharmacists keeps these patients safe.

18.9 COMMON CONFUSIONS

- **Cortex vs medulla:** cortex = outer, steroids, slow, ACTH-controlled; medulla = inner, adrenaline, fast, nerve-controlled.

18.10 COMMON MISTAKES

- Saying adrenaline comes from the cortex — it comes from the medulla.
- Saying aldosterone raises blood sugar — it handles sodium/water; cortisol handles sugar.
- Confusing "adrenal" (gland) with "adrenaline" (its medulla hormone).

18.11 ONE-MINUTE REVISION

Adrenal caps on kidneys: outer cortex makes three steroid groups — glucocorticoids (cortisol: sugar + stress), mineralocorticoids (aldosterone: salt + water + BP), sex corticoids ("Salt, Sugar, Sex"). Inner medulla makes adrenaline/noradrenaline for instant fight-or-flight. Too little = Addison's disease; too much cortisol = Cushing's syndrome.

18.12 Practice questions

MCQs

1. The adrenal medulla secretes: (a) cortisol (b) aldosterone (c) adrenaline (d) insulin
2. Cortisol is controlled by: (a) TSH (b) ACTH (c) FSH (d) ADH
3. "Moon face" and trunk obesity suggest: (a) Addison's disease (b) Cushing's syndrome (c) diabetes (d) goitre

Short answers

1. Distinguish between adrenal cortex and medulla.
2. List the three groups of cortical hormones with one function each.
3. Describe the fight-or-flight response.

Long answer

1. Describe the structure of the adrenal gland and the functions of its hormones. Add a note on Addison's disease and Cushing's syndrome.

Application-based

1. A patient on long-term prednisolone asks why the doctor insists on "reducing the dose slowly" instead of stopping at once. Explain using Addison's disease logic.

Viva

1. Why is adrenaline used in anaphylaxis?

Chapter 19 — Pancreas (Endocrine Part), Pineal Gland and Thymus

19.1 Learning objectives

After studying this chapter you will be able to: (1) describe the endocrine structure of the pancreas (islets of Langerhans); (2) explain the opposing actions of insulin and glucagon; (3) describe the functions of the pineal gland and thymus; (4) explain blood sugar regulation with a flowchart.

19.2 Definitions

Islets of Langerhans. Tiny clusters of hormone-making cells scattered in the pancreas — like raisins in a cake. The "cake" is the exocrine pancreas (digestive juices); the "raisins" are the endocrine part.

Insulin. Hormone from beta cells of the islets that LOWERS blood sugar by moving glucose into cells.

Glucagon. Hormone from alpha cells of the islets that RAISES blood sugar by releasing stored glucose from the liver.

Pineal gland. A tiny pine-cone-shaped gland deep in the brain that makes melatonin, the sleep hormone.

Thymus. A gland behind the breastbone that trains immune cells (T-cells) in childhood; shrinks after puberty.

> **KEY TAKEAWAY:** Pancreas islets = insulin (down) + glucagon (up); pineal = sleep; thymus = trains immunity.

19.3 Pancreas — structure

- **Location:** lies behind the stomach, stretching across the upper abdomen; head tucked in the curve of the duodenum (first part of small intestine), tail pointing toward the spleen.
- **Dual nature:** mostly exocrine (acinar cells make digestive enzymes into the pancreatic duct) with about a million tiny islets of Langerhans as the endocrine part.
- **Islet cells:** beta cells make insulin; alpha cells make glucagon; delta cells make somatostatin (a hormone that slows down both insulin and glucagon — a local brake).

> **Sketch guide:** Draw the stomach as a J-shape. Behind it draw a long horizontal leaf (pancreas). Zoom in: draw the leaf tissue with scattered small circles (islets). Inside one islet, label beta cells (insulin) and alpha cells (glucagon).

19.4 Insulin and glucagon — the blood sugar see-saw

	Insulin (beta cells)	Glucagon (alpha cells)
Released when	Blood sugar HIGH (after meals)	Blood sugar LOW (between meals, fasting)
Main target	Liver, muscle, fat	Liver
Action	Pushes glucose into cells; liver stores glucose as glycogen	Liver breaks glycogen into glucose and releases it
Net effect	Blood sugar FALLS	Blood sugar RISES

> **Flowchart — after a meal:** Eat food → blood glucose rises → beta cells release insulin → glucose enters muscle/fat cells; liver stores glycogen → blood glucose falls to normal → insulin switches off

> **Flowchart — during fasting:** No food for hours → blood glucose falls → alpha cells release glucagon → liver releases stored glucose → blood glucose rises to normal → glucagon switches off

Analogy: Insulin and glucagon are like the accelerator and the fuel reserve of a car — insulin parks excess fuel in the tank (stores), glucagon opens the reserve tank when fuel runs low.

KEY TAKEAWAY: Insulin = stores sugar (fed state); glucagon = releases sugar (fasted state). Together they hold blood sugar steady.

19.5 TERMINOLOGY ALERT

Word	Meaning
Glycogen	Stored form of glucose in liver and muscle ("animal starch")
Glycogenesis	Making glycogen (storing) — insulin promotes it
Glycogenolysis	Breaking glycogen into glucose (releasing) — glucagon promotes it
Hyperglycaemia	Blood sugar too high
Hypoglycaemia	Blood sugar too low — dangerous, brain needs constant sugar

19.6 Pineal gland

- **Structure:** tiny, pine-cone-shaped, deep in the centre of the brain.
- **Hormone: melatonin** — the "darkness hormone." Released at night; tells the body it is time to sleep.
- **Function:** sets the sleep–wake rhythm (circadian rhythm). Light suppresses melatonin — which is why bright screens late at night disturb sleep.

Example: Jet lag happens because your pineal gland still releases melatonin on home time — your body thinks it is night when the new place says day.

19.7 Thymus

- **Structure:** a soft, two-lobed gland behind the breastbone (sternum), large in children, shrinking after puberty.
- **Hormone: thymosin** and related factors.
- **Function:** trains young immune cells (T-lymphocytes) to recognise the body's own cells versus germs. This is why it matters most in childhood, when the immune system is learning.

Analogy: The thymus is the training academy for soldier cells — recruits (young T-cells) graduate knowing whom to attack (germs) and whom to protect (self).

KEY TAKEAWAY: Pineal = melatonin = sleep timing; thymus = trains T-cells in childhood.

19.8 PHARMACY RELEVANCE

- **Insulin** (many types: regular, NPH, glargine) is the mainstay of type 1 diabetes — pharmacists teach injection technique, storage (refrigerator, not freezer), and hypoglycaemia warning signs.
- **Oral antidiabetics** (metformin, sulfonylureas like glimepiride) work through insulin pathways — pharmacists counsel on timing with meals.
- **Glucagon injection kits** are emergency treatment for severe hypoglycaemia.
- **Melatonin** tablets are used for sleep rhythm problems; pharmacists advise on light habits too.
- Never adjust insulin doses without medical advice — a core counselling rule

19.9 India context

- Diabetes is very common in India; pharmacists are often the first to spot warning signs (excess thirst, frequent urination, slow-healing wounds) and refer patients for testing.
- Insulin storage during power cuts and travel in hot weather is a practical counselling topic.

19.10 COMMON CONFUSIONS

- **Insulin vs glucagon:** insulin lowers, glucagon raises. (Mnemonic: **I**nsulin = **I**nto cells — pushes sugar *into* cells.)
- **Pineal vs pituitary:** pineal = tiny, deep brain, melatonin/sleep; pituitary = base of brain, master gland.
- **Thymus vs thyroid:** thymus = behind breastbone, immunity; thyroid = neck, metabolism. Similar names, totally different!

19.11 COMMON MISTAKES

- Saying "insulin raises blood sugar" — it lowers it.
- Saying the pancreas is only endocrine — it is mostly exocrine (digestive enzymes); islets are the small endocrine part.
- Confusing melatonin (sleep) with melanin (skin pigment) — different substances!

19.12 ONE-MINUTE REVISION

Pancreas behind the stomach has islets of Langerhans: beta cells make insulin (lowers blood sugar after meals), alpha cells make glucagon (raises it during fasting) — a balanced see-saw. Pineal gland deep in the brain makes melatonin for sleep timing. Thymus behind the breastbone trains T-cells in childhood via thymosin. Mnemonic: **I**nsulin puts sugar **I**nto cells.

19.13 Practice questions

MCQs

1. Insulin is secreted by: (a) alpha cells (b) beta cells (c) delta cells (d) acinar cells
2. Glucagon: (a) lowers blood sugar (b) raises blood sugar (c) lowers BP (d) causes sleep
3. Melatonin is secreted by the: (a) pituitary (b) pineal (c) thymus (d) thyroid

Short answers

1. Describe the islets of Langerhans and their hormones.
2. Explain blood sugar regulation by insulin and glucagon with flowcharts.
3. Write the functions of the pineal gland and thymus.

Long answer

1. Describe the endocrine pancreas. Explain how insulin and glucagon maintain blood glucose, with flowcharts.

Application-based

1. A diabetic patient on insulin skips lunch and feels shaky, sweaty and confused. What is likely happening, and what immediate advice would a pharmacist give? (General guidance, not a dose change.)

Viva

1. Why is the pancreas called a dual (mixed) gland?

Chapter 20 — Pathophysiology of Endocrine Disorders: Diabetes, Thyroid Disorders, Goitre and PCOS

20.1 Learning objectives

After studying this chapter you will be able to: (1) define pathophysiology; (2) explain what goes wrong in type 1 and type 2 diabetes; (3) describe hypothyroidism and hyperthyroidism simply; (4) explain goitre; (5) describe polycystic ovary syndrome (PCOS) in sensitive, factual terms.

20.2 Definitions

Pathophysiology. The study of what goes wrong in the body during disease — "patho" (disease) + "physiology" (normal working). For each disease we ask: what breaks, and what signs follow?

Diabetes mellitus. A disorder where blood sugar stays too high because insulin is lacking or not working properly. ("Mellitus" = sweet — old doctors noted sweet urine.)

Goitre. Visible enlargement of the thyroid gland in the neck — a sign, not a disease by itself; many thyroid problems can cause it.

> **KEY TAKEAWAY:** Pathophysiology = the story of the breakdown. Learn each disease as: cause → what breaks → signs.

20.3 Diabetes mellitus — two main types

Type 1 diabetes: the body's immune system destroys the beta cells of the pancreas, so little or no insulin is made. Usually starts in childhood or youth. Needs lifelong insulin injections — the body cannot make its own.

Type 2 diabetes: the pancreas still makes insulin, but body cells resist it (**insulin resistance**), and over time insulin production also falls. Linked with excess weight and low physical activity. Managed with lifestyle, oral medicines, and sometimes insulin.

Feature	Type 1	Type 2
Cause	Beta cells destroyed (autoimmune)	Insulin resistance + falling insulin
Usual onset	Childhood/youth	Adults (increasingly younger)
Body weight	Often normal/thin	Often overweight
Insulin needed	Always, from the start	Sometimes, later
Prevention	Not preventable	Lifestyle can delay/prevent

Common warning signs (both types): passing urine often, feeling very thirsty, feeling tired, weight loss without trying, wounds healing slowly, blurred vision.

> **Flowchart — why sugar stays high in type 2:** Cells resist insulin → glucose cannot enter cells easily → blood sugar stays high → pancreas works harder → over years beta cells tire → sugar rises further

> **Example:** Think of insulin as a key and the cell's insulin receptor as a lock. In type 1, there are no keys (no insulin). In type 2, the locks are rusty (resistance) — keys exist but don't turn well.

Complications (general, long-term): if blood sugar stays high for years, it can damage eyes, kidneys, nerves and blood vessels — which is why control matters. Pharmacists reinforce adherence and foot care.

> **KEY TAKEAWAY:** Type 1 = no insulin (autoimmune, needs injections); Type 2 = insulin doesn't work well (resistance, lifestyle + medicines).

20.4 Hypothyroidism — too little thyroid hormone

- **What breaks:** thyroid makes too little T3/T4 (common causes: autoimmune attack on the thyroid — Hashimoto's thyroiditis — or iodine deficiency).
- **Signs (body slows down):** tiredness, feeling cold, weight gain, dry skin, hair loss, constipation, slow heart rate, low mood. In babies, untreated severe deficiency harms brain development.
- **Management (general):** daily thyroid hormone replacement tablets (levothyroxine), taken lifelong in most cases; regular blood tests to adjust.

20.5 Hyperthyroidism — too much thyroid hormone

- **What breaks:** thyroid makes too much T3/T4 (common cause: Graves' disease — antibodies stimulate the thyroid).
- **Signs (body speeds up):** weight loss despite good appetite, feeling hot and sweaty, fast/pounding heart, nervousness, trembling hands, bulging eyes (in Graves' disease).
- **Management (general):** medicines that reduce hormone production, radioactive iodine treatment, or surgery — decided by the doctor.

Feature	Hypothyroidism (too little)	Hyperthyroidism (too much)
Energy	Tired, slow	Nervous, restless
Weight	Gain	Loss
Temperature	Feels cold	Feels hot
Heart	Slow	Fast
Bowels	Constipation	Frequent motions

Mnemonic: HYPO = LOW and SLOW (low hormone, slow body); **HYPER = HIGH and HURRIED** (high hormone, hurried body).

20.6 Goitre

- **What it is:** an enlarged thyroid gland visible as a swelling in the front of the neck.
- **Why it happens:** the commonest worldwide cause is **iodine deficiency** — without iodine the thyroid cannot make hormone, the pituitary sends more TSH, and the gland enlarges trying harder. It can also occur in hyperthyroidism or thyroid inflammation.
- **Signs:** neck swelling; if very large, difficulty swallowing or breathing.
- **Prevention (public health):** iodised salt. Pharmacists can reassure: most simple goitres are not cancer, but any neck swelling should be examined by a doctor.

> **KEY TAKEAWAY:** Goitre = enlarged thyroid; think iodine deficiency first, but always refer for examination.

20.7 Polycystic ovary syndrome (PCOS)

Note: this topic is taught factually and sensitively. PCOS is a common hormonal condition, not anyone's fault, and it is manageable.

- **What breaks:** in PCOS the ovaries produce slightly higher levels of androgens (male-type hormones) than usual, and ovulation (egg release) becomes irregular. The name comes from ultrasound images showing many small follicles ("cysts") on the ovaries — these are not dangerous tumours, just immature follicles.
- **Signs (vary between women):** irregular or missed periods, difficulty conceiving, acne, excess facial/body hair growth, weight gain, thinning scalp hair. Insulin resistance is also common.
- **Management (general):** lifestyle (healthy weight, regular exercise) helps greatly; doctors may prescribe medicines to regulate periods, manage insulin resistance, or help with fertility. Emotional support matters — symptoms can affect confidence.
- **Pharmacist's role:** counsel sensitively, reinforce that it is a manageable hormonal condition, encourage adherence and follow-up, never make insensitive remarks about weight or appearance.

> **KEY TAKEAWAY:** PCOS = irregular ovulation + higher androgens + many small ovarian follicles; manageable with lifestyle and medical care; handle with sensitivity.

20.8 PHARMACY RELEVANCE

- Diabetes: pharmacists are central — dispensing insulin/oral agents, teaching injection technique, spotting hypoglycaemia, reinforcing foot care and adherence.
- Thyroid: counsel on levothyroxine timing (empty stomach, away from calcium/iron), lifelong adherence, and never stopping abruptly.
- Goitre: promote iodised salt; refer neck swellings.
- PCOS: dispense with sensitivity; counsel on adherence and lifestyle; watch for medicines that worsen insulin resistance.

20.9 India context

- India has a large diabetic population; community pharmacists often do the first blood-sugar screening and referral.
- Iodised salt programmes reduced goitre nationally, but pharmacists in formerly endemic hilly areas still see cases.
- PCOS is increasingly recognised in young Indian women; pharmacists can be a trusted, non-judgmental source of information.

20.10 COMMON CONFUSIONS

- **Type 1 vs type 2 diabetes:** type 1 = no insulin made (needs injections always); type 2 = insulin resisted (lifestyle + tablets first).
- **Hypo vs hyperthyroidism:** hypo = slow everything; hyper = fast everything.
- **Goitre vs thyroid cancer:** goitre is enlargement (usually benign cause); cancer is a separate, much less common condition — don't panic patients, refer them.
- **PCOS "cysts" vs tumours:** the "cysts" are small immature follicles, not cancerous growths.

20.11 COMMON MISTAKES

- Saying type 2 diabetics "never need insulin" — many eventually do.
- Saying goitre is always due to iodine deficiency — it has several causes.
- Describing PCOS insensitively or blaming the patient — it is a hormonal disorder, not a lifestyle failure.

20.12 ONE-MINUTE REVISION

Diabetes = high blood sugar: type 1 (beta cells destroyed, always needs insulin) vs type 2 (insulin resistance, lifestyle + medicines, insulin later). Hypothyroidism = too little thyroid hormone (tired, cold, weight gain, slow); hyperthyroidism = too much (nervous, hot, weight loss, fast heart) — HYPO = low and slow, HYPER = high and hurried. Goitre = enlarged thyroid, classically iodine deficiency — refer any neck swelling. PCOS = irregular ovulation with higher androgens and many small follicles; manageable; counsel with sensitivity.

20.13 Practice questions

MCQs

1. Type 1 diabetes is caused by: (a) insulin resistance (b) destruction of beta cells (c) eating sugar (d) thyroid failure
2. Which is a sign of hypothyroidism? (a) Weight loss (b) Feeling cold and tired (c) Fast heartbeat (d) Trembling hands
3. The commonest worldwide cause of goitre is: (a) calcium deficiency (b) iodine deficiency (c) iron deficiency (d) vitamin D deficiency
4. PCOS is characterised by: (a) regular ovulation (b) irregular ovulation with higher androgen levels (c) excess insulin production only (d) thyroid enlargement

Short answers

1. Differentiate between type 1 and type 2 diabetes.
2. List the signs of hypothyroidism and hyperthyroidism.
3. What is goitre? What causes it?
4. Describe PCOS briefly.

Long answer

1. Explain the pathophysiology of diabetes mellitus (both types) with flowcharts. Add the pharmacist's role in diabetes care.

Application-based

1. A young woman newly told she has PCOS is upset and asks the pharmacist, "Did I cause this? Will I ever be normal?" Draft a short, sensitive, factual response.

Viva

1. Why does iodine deficiency cause the thyroid to enlarge?

UNIT IV — Combined references

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