

CHEMICAL CONTROL & INTEGRATION

Endocrine System

Hormones

- In animals, control and coordination are carried out by the nervous system and endocrine system.
- Since nerve fibres do not reach every cell, hormones secreted by endocrine glands help regulate body functions.
- Hormones are recognised by their specific target receptors through a “lock and key” mechanism.
- Only cells having the specific receptor respond to a particular hormone.

Endocrine Glands

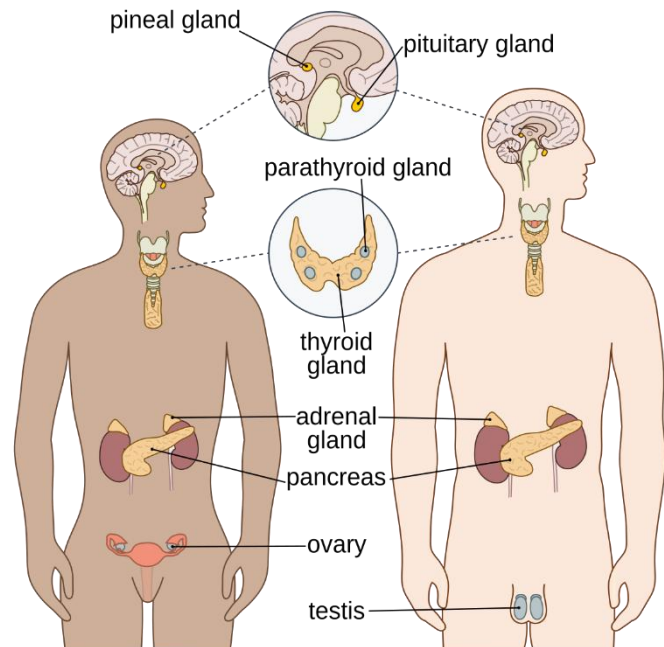
- Endocrine glands are ductless and release hormones directly into the blood.
- **Hormones** are non-nutrient chemical messengers, effective in trace amounts, and act on specific target organs to bring about metabolic changes.

Human Endocrine System

Endocrine glands and hormone-secreting tissues are spread throughout the body.

Properties of Hormones

- Secreted directly into the **bloodstream**.
- **Transient** in nature; non-antigenic.
- Regulate **body functions & metabolism** to maintain **homeostasis**.
- Required in **trace amounts**.
- Some act **very quickly**.
- Some secreted as **inactive prohormones** (e.g., proinsulin).
- Work on a “**lock and key**” mechanism → hormone (key) fits into specific receptor (lock).
- Each hormone acts on a **specific target organ**.



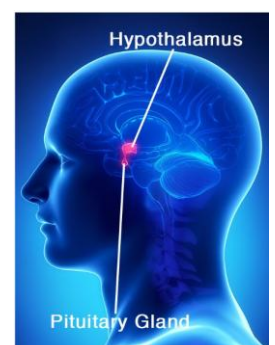
Classification of Hormones		
Based on Chemical Nature	Based on Solubility	Based on Mode of Action
Peptide/Protein hormones → e.g., Insulin, Glucagon, Growth Hormone	Water-soluble → Peptide & protein hormones, Catecholamines (act via membrane receptors)	Fast-acting hormones → Adrenaline, Noradrenaline
Steroid hormones → e.g., Cortisol, Testosterone, Estrogen		
Amino acid derivatives → e.g., Thyroxine, Adrenaline, Noradrenaline	Lipid-soluble → Steroid hormones, Thyroxine (act via intracellular receptors)	Slow-acting hormones → Steroids, Thyroxine

Functions of Hormones

- Regulate **growth, development, reproduction**
- Maintain **bone, muscle, heart, BP, metabolism**
- Control **mood, memory, sleep, stress, appetite, immunity**
- Imbalance → leads to **disorders/diseases**

Hypothalamus (Master of Master Gland)

- Located at the **base of the forebrain**.
- Contains neuro **secretory cells (nuclei)** that produce hormones.
- Regulates **pituitary hormone secretion**.



- Produces two types of hormones:
 1. **Releasing hormones** (stimulate pituitary)
 2. **Inhibiting hormones** (suppress pituitary)

Hormone	Function	Hyposecretion Effects	Hypersecretion Effects	Cells Formed By
Releasing hormones (stimulate pituitary)				
Thyrotropin-Releasing Hormone (TRH)	Stimulates the release of TSH (Thyroid Stimulating Hormone) and prolactin from the anterior pituitary.	Decreased TSH and thyroid hormones → hypothyroidism symptoms like fatigue, weight gain.	Excess thyroid hormone release → hyperthyroidism (anxiety, weight loss, increased metabolism).	Hypothalamic neurosecretory cells
Prolactin-Releasing Hormone (PRH)	Stimulates the release of prolactin from the anterior pituitary for milk production.	Low prolactin → failure in milk production (agalactia) in lactating mothers.	High prolactin → galactorrhoea (abnormal milk production), temporary infertility, menstrual irregularities.	Hypothalamic neurosecretory cells
Gonadotropin-Releasing Hormone (GnRH)	Stimulates release of LH (Luteinizing Hormone) and FSH (Follicle-Stimulating Hormone).	Delayed puberty, infertility, irregular menstrual cycle in females.	Early puberty, hormonal imbalances.	Hypothalamic neurosecretory cells
Adreno-Corticotropin-Releasing Hormone (CRH)	Stimulates release of ACTH (Adrenocorticotrophic Hormone) from anterior pituitary.	Reduced ACTH → adrenal insufficiency, fatigue, low stress response.	Increased ACTH → excessive cortisol (Cushing's syndrome).	Hypothalamic neurosecretory cells
Growth Hormone-Releasing Hormone (GHRH)	Stimulates release of Growth Hormone (GH) from anterior pituitary.	Growth hormone deficiency → dwarfism in children.	Increased GH → gigantism (children) or acromegaly (adults).	Hypothalamic neurosecretory cells

Hormone	Function	Hyposecretion Effects	Hypersecretion Effects	Cells Formed By
Inhibiting hormones (suppress pituitary)				
Somatostatin (Growth Hormone Inhibiting Hormone, GHIH)	Inhibits the release of GH and TSH. Also reduces insulin and glucagon secretion.	Excess GH → gigantism or acromegaly as GH is unchecked.	GH suppression → growth failure.	Hypothalamic neurosecretory cells
Dopamine (Prolactin Inhibiting Hormone, PIH)	Inhibits prolactin secretion from anterior pituitary.	Increased prolactin → galactorrhoea (milk production), infertility.	Suppressed prolactin → failure of lactation.	Hypothalamic dopaminergic neurons
Melanocyte-stimulating Hormone Releasing Hormone (MRH)	Stimulates release of MSH from anterior pituitary; affects pigmentation, appetite.	Reduced MSH secretion → hypopigmentation, altered appetite.	Increased MSH → hyperpigmentation.	Hypothalamus
Melanocyte-stimulating Hormone Inhibiting Hormone (MIH)	Inhibits release of MSH from anterior pituitary.	Excessive MSH → hyperpigmentation.	Reduced MSH → hypopigmentation, mood changes.	Hypothalamus

Pituitary Gland (Master Gland)

Tiny, pea-sized gland located at the base of the [brain](#), attached to Hypothalamus by stalk called – infundibulum. Located in bony cavity- **Sella turcica**. It controls functions as growth, metabolism, and reproduction. It has two main parts:

1. Anterior pituitary (Adenohypophysis)

Made of glandular epithelial tissue.

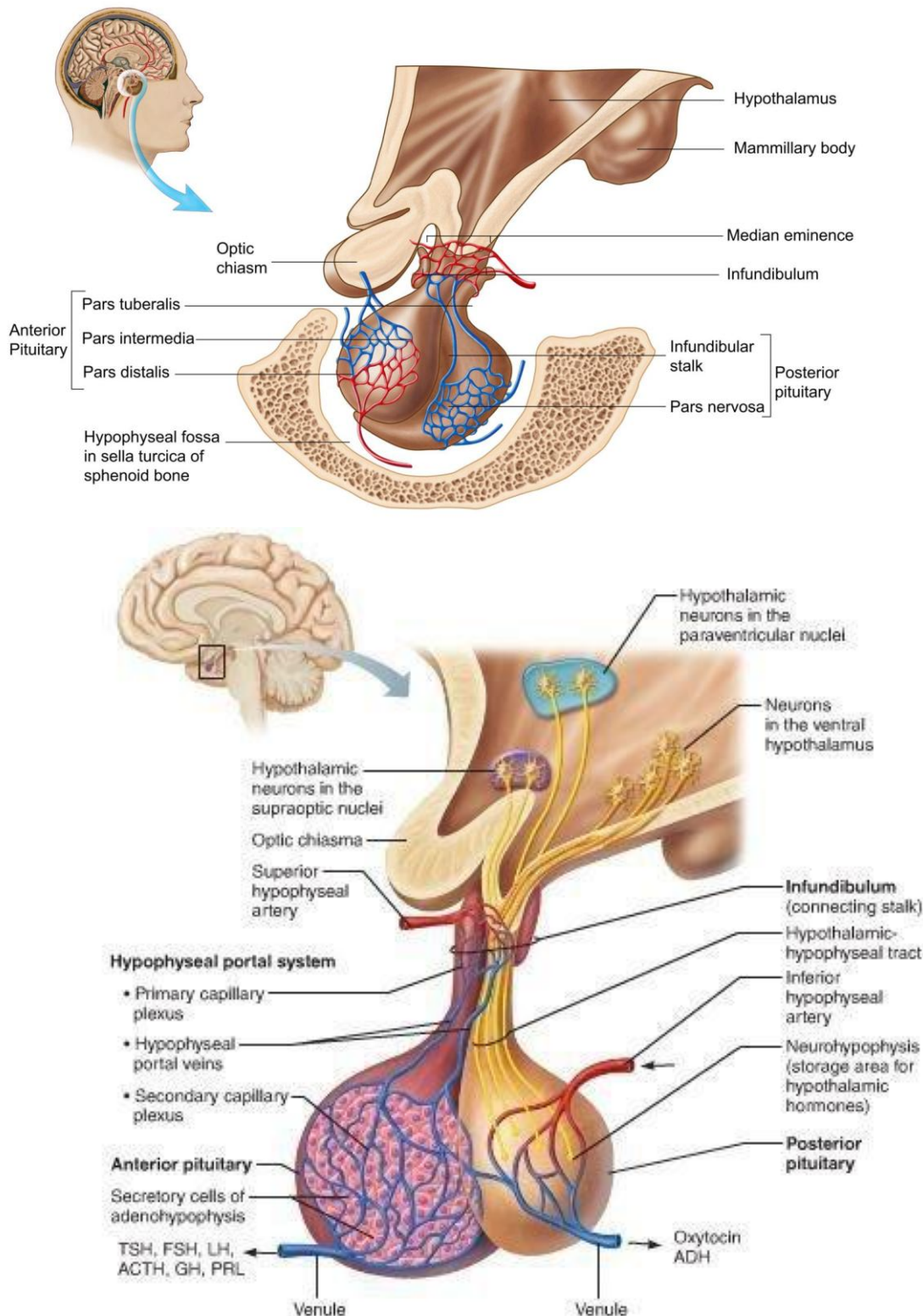
Has rich blood supply via **hypophyseal portal system**, which carries releasing/inhibiting hormones from the hypothalamus.

2. Posterior pituitary (Neurohypophysis)

Develops from **neural ectoderm** (down-growth of hypothalamus).

Made of **nervous tissue** (pituicytes + axon terminals of hypothalamic neurons).

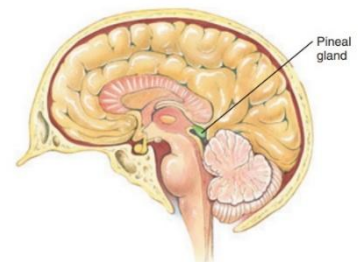
Contains **Herring bodies** (swellings of axons storing oxytocin & ADH).



Hormone	Function	Hyposecretion	Hypersecretion
Anterior Pituitary			
Pars Distalis - largest part			
Somatotrophin or Growth Hormone (GH)	Stimulates growth of bones, tissues, and muscles.	Dwarfism (children)	Gigantism (children), Acromegaly (adults)
Thyroid Stimulating Hormone (TSH)	Stimulates the thyroid gland to release T3 & T4 hormones.	Hypothyroidism (low T3/T4 production)	Hyperthyroidism (Graves' disease)
Adrenocorticotrophic Hormone (ACTH)	Stimulates adrenal cortex to secrete cortisol.	Addison's disease (low cortisol)	Cushing's syndrome (high cortisol levels)
Luteinizing Hormone (LH)	Stimulates ovulation and hormone production (estrogen/testosterone).	Infertility, Irregular menstrual cycles	Excessive sex hormones → hormone imbalance
Follicle-Stimulating Hormone (FSH)	Stimulates gamete production (sperm in males, eggs in females).	Infertility, reduced gamete production	Rare; excessive gamete production
Prolactin (PRL)	Stimulates milk production in lactating females.	Agalactia (failure in milk production)	Galactorrhoea (excessive milk secretion)
Pars Intermedia			
Melanocyte Stimulating Hormone (MSH)	Stimulates melanin production in the skin BY Melanocytes (present in basal layer of the epidermis).	Loss of skin pigmentation	Hyperpigmentation
Pars Tuberalis			
Melatonin-dependent gonadotropin-regulating hormones	Regulates FSH/LH secretion & seasonal breeding	Excess FSH/LH-Early puberty Over active reproductive cycles	Low FSH/LH-Delayed puberty Infertility / irregular reproductive cycles
Neurohypophysis (Posterior Pituitary)			
Pars- Nervosa			
Oxytocin (Released by Pituitary formed in Hypothalamus- paraventricular nuclei.)	Contract smooth muscles, Stimulates uterine contractions and milk ejection.	Weak uterine contractions, poor lactation	Strong uterine contractions, overstimulation
Antidiuretic Hormone (ADH)- (Released by Pituitary formed in Hypothalamus- supraoptic nuclei)	Regulates water balance by reabsorption of water & electrolyte by DCT of Kidney- reduce diuresis	Diabetes insipidus (excessive urination)	Syndrome of Inappropriate ADH → fluid retention, low sodium levels

Pineal Gland (Smallest)

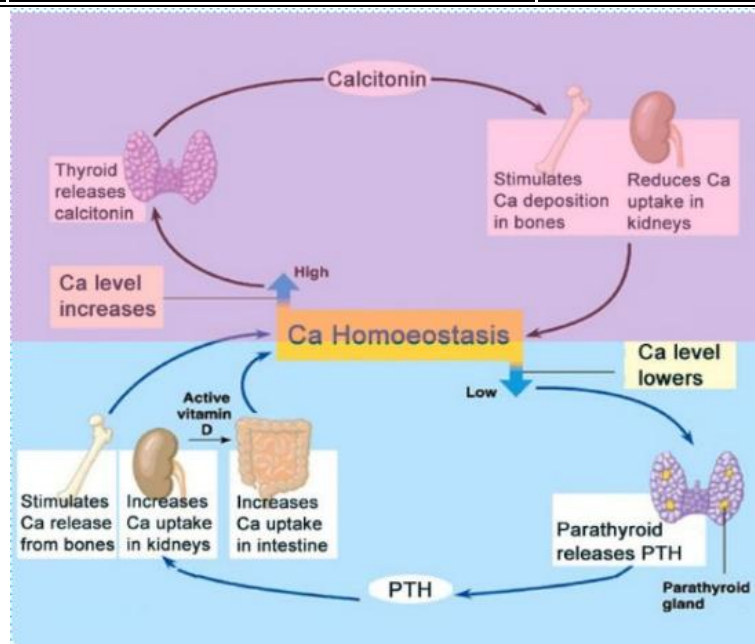
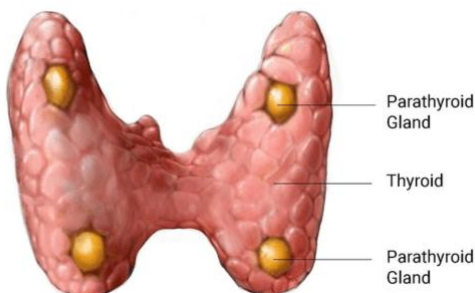
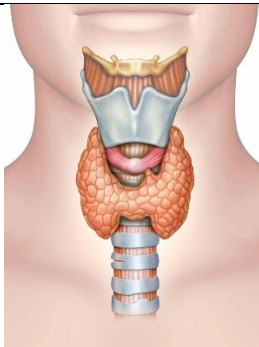
- Smallest gland located on dorsal side of forebrain
- Made of pinealocytes (secrete melatonin) & glial cells (support).
- Regulates diurnal/circadian rhythm (**24-hour biological clock**) & sleep-wake cycle, temperature etc.



Hormone	Function	Hyposecretion Effects	Hypersecretion Effects
Melatonin	Regulates sleep-wake cycle, temperature, puberty timing, pigmentation & menstrual cycle	Insomnia, early puberty	Delayed puberty, excessive sleepiness

Thyroid Gland Hormones

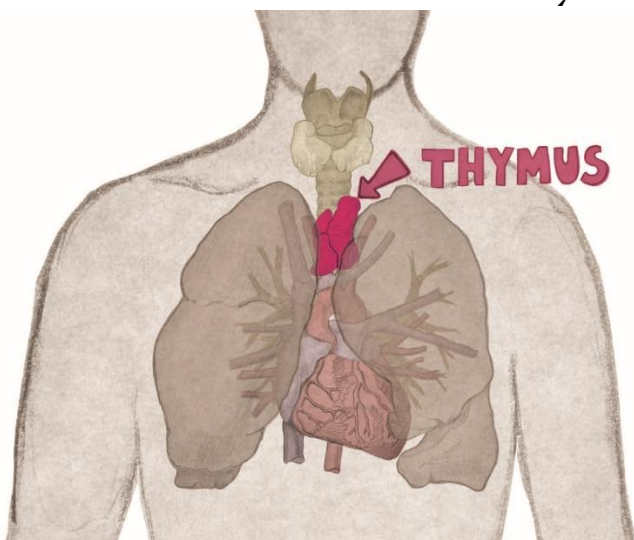
Hormone	Function	Hyposecretion Effects	Hypersecretion Effects
Thyroxine (T4) & Triiodothyronine (T3)	Regulate metabolism, energy production, and growth. Iodine is essential for normal hormone synthesis	Iodine deficiency Could lead to Hypothyroidism → Goitre , fatigue, weight gain. Iodine deficiency (hypothyroidism) during pregnancy affects the baby causing cretinism (Stunted growth, mental retardation, low intelligence quotient, abnormal skin, deaf-mutism.	Hyperthyroidism → Graves' disease, weight loss
Calcitonin	Lowers blood calcium levels by inhibiting osteoclasts. Store Calcium to Bones.	Rare	Hypocalcemia (low calcium levels in blood)



Parathyroid Gland

Hormone	Function	Hyposecretion Effects	Hypersecretion Effects
Parathyroid Hormone (PTH)	Increases blood calcium levels by breaking down bone (activates osteoclasts), reabsorbing calcium in kidneys, and activating vitamin D.	Hypocalcemia → muscle cramps, tetany	Hypercalcemia → kidney stones, weak bones

Thymus Gland



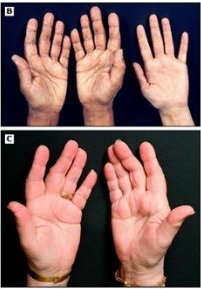
Hormone	Function	Hyposecretion Effects	Hypersecretion Effects
Thymosin	Promotes T-lymphocyte differentiation and maturation , thereby helping in the development of cell-mediated immunity .	Reduced T-cell maturation → weakened cell-mediated immunity and increased susceptibility to infections	May cause excessive T-cell activity/immune responses ; clinically significant hypersecretion is not well established

Pancreatic (Islets of Langerhans) Gland

Hormone	Secreted by	Function	Hyposecretion Effects	Hypersecretion Effects
Insulin	β (Beta) cells	Decreases blood glucose by promoting glucose uptake by cells and conversion of glucose into glycogen .	Diabetes mellitus → hyperglycaemia, glucose in urine, excessive thirst and frequent urination	Hypoglycaemia → sweating, weakness, dizziness, confusion and, in severe cases, unconsciousness
Glucagon	α (Alpha) cells	Increases blood glucose by promoting glycogenolysis and gluconeogenesis , mainly in the liver.	Hypoglycaemia due to reduced ability to increase blood glucose	Hyperglycaemia → abnormally high blood glucose
Somatostatin	δ (Delta) cells	Inhibits the secretion of insulin and glucagon and helps regulate digestive activity.	Disturbance in regulation of insulin and glucagon secretion	Excessive inhibition of insulin and glucagon → abnormal blood glucose regulation
Pancreatic polypeptide (PP)	PP/F cells (γ/Gamma cells)	Helps regulate pancreatic secretion, gastrointestinal activity and appetite .	Not clearly established in humans	Not clearly established; excess may alter gastrointestinal and pancreatic functions

DISEASES

Disease	Cause	Hormone Involved	Key Symptoms
Acromegaly 	Hypersecretion of GH in adults	Growth Hormone (GH)	Enlarged hands, feet, and facial features
Goiter	Iodine deficiency or thyroid imbalance	T ₃ , T ₄	Neck swelling, difficulty swallowing/breathing

				
Addison's Disease				
 		Hyposecretion of cortisol and aldosterone	Cortisol, Aldosterone	Fatigue, hyperpigmentation, low BP, salt cravings
Cushing's Syndrome				
		Hypersecretion of cortisol	Cortisol	Moon face, buffalo hump, weight gain
Exophthalmic Goiter				
		Hyperthyroidism (autoimmune Graves' disease)	T₃, T₄	Bulging eyes, goiter, weight loss, heat intolerance
Hyperpigmentation				
		Excessive ACTH stimulating melanin production	ACTH	Darkened skin in creases, joints, and scars
		Loss of melanocytes (autoimmune)	Melanin	White patches on skin, loss of skin pigment
Vitiligo				
SYNDROME OF INAPPROPRIATE ADH		Hypersecretion of ADH	Antidiuretic Hormone (ADH)	Fluid retention, low sodium, confusion, seizures