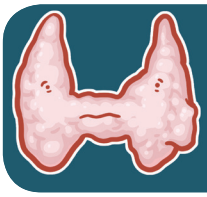

NOTES
ANATOMY & PHYSIOLOGY

ENDOCRINE ANATOMY & PHYSIOLOGY

osms.it/endocrine-anatomy-and-physiology

ENDOCRINE GLANDS

- Secrete hormones directly into bloodstream (exocrine glands use ducts)
- Maintain homeostasis by controlling variables such as body temperature, fluid balance
  - Especially with negative feedback mechanisms

HORMONES

- Can be classified as steroids/non-steroids

Steroid hormones

- Derived from cholesterol; produced in adrenal glands, gonads (testes/ovaries)
- Hydrophobic/non-polar → travel through bloodstream with transport proteins, diffuse across target cell phospholipid membrane

Non-steroid hormones

- Derived from peptides/proteins or single amino acids
- Peptidic hormones are hydrophilic → bind surface receptor proteins instead of passing through target cell membrane
- Amino acid hormones derived from tyrosine; generally hydrophilic (e.g. adrenaline/epinephrine and noradrenaline/norepinephrine), apart from thyroid hormones

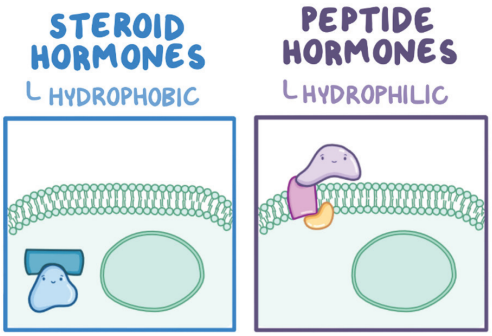

Figure 31.1 Steroid hormones diffuse across the target cell membrane and bind to an intracellular receptor. Peptide hormones bind to a cell surface receptor. Both methods result in changes in gene expression.

HORMONE SECRETION & REGULATION

Paracrine signaling

- Effects of hormones released by nearby cells; e.g. glucagon → activates alpha cells, inhibits beta cells

Sympathetic nervous system

- Epinephrine/norepinephrine alter secretion depending on adrenergic receptor type;
- e.g. β2: activates beta cells

Parasympathetic nervous system

- Acetylcholine activates alpha cells and beta cells via M3 receptors

GLAND LOCATIONS & FUNCTIONS

- Endocrine glands scattered throughout body

Hypothalamus

- Located at base of brain
- Hypothalamus, brain work closely to make hormones that control other endocrine glands
- Made up of several nuclei (neuron clusters) which secrete hormones

Pituitary gland

- Located just below brain; physically connected to hypothalamus by pituitary stalk (infundibulum)
- Made up of anterior, posterior lobe
- *Anterior pituitary:* AKA adenohypophysis
  - Made of glandular tissue
  - Receives stimulatory, inhibitory hormones from hypothalamus via hypothalamo-hypophyseal-portal system
- *Posterior pituitary:* AKA neurohypophysis
  - Made of axons from hypothalamic supraoptic, paraventricular nuclei
  - Receives hormones directly from hypothalamus
  - Instead of producing own hormones, posterior pituitary stores hormones for later release
  - *Herring bodies:* axon dilations which store hormones
  - Hormones include antidiuretic hormone (ADH/vasopressin), oxytocin
  - *ADH signals:* ↑ blood osmolarity, ↓ blood volume (ADH retains water from urine, constricts blood vessels → negative feedback)
  - *Oxytocin signals:* childbirth (dilates cervix, stimulates uterine contractions), breastfeeding (contracts breast cells), social interaction, orgasm
- Stimulatory pituitary hormones
  - *Thyrotropin releasing hormone (TRH):* pituitary secretes thyroid-stimulating hormone (TSH) → thyroid produces thyroid hormones
  - *Corticotropin releasing hormone (CRH):* pituitary secretes adrenocorticotropic hormone (ACTH) → adrenal glands produce cortisol
  - *Gonadotropin releasing hormone (GnRH):* pituitary secretes gonadotropins, e.g. follicle-stimulating hormone (FSH), luteinizing hormone (LH) → gonads produce gametes (sperm for testes, oocytes for ovaries), sex hormones (testosterone, estrogen, progesterone)
  - *Growth hormone releasing hormone (GHRH):* pituitary secretes growth hormone → growth of long bones, tissues in body
- Inhibitory pituitary hormones
  - *Growth hormone inhibiting hormone (GHIH/somatostatin):* pituitary secretes less/no growth hormone

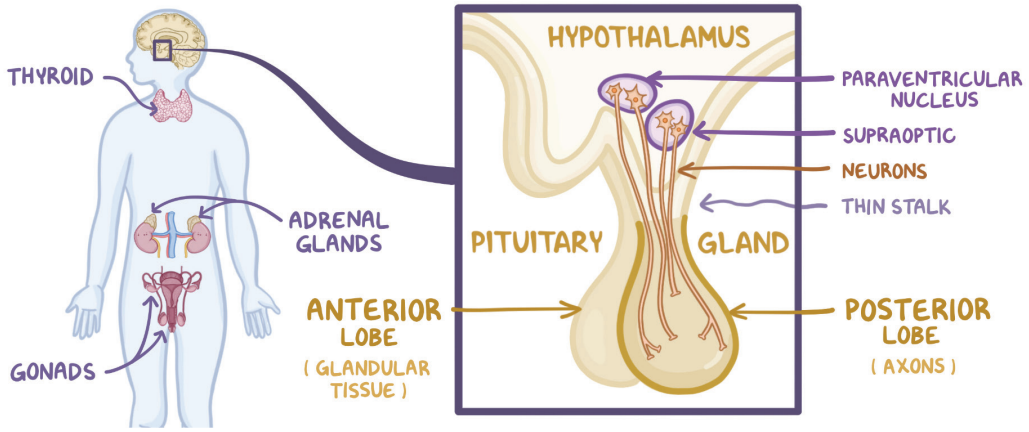

Figure 31.2 Endocrine glands' location and the relationship between the hypothalamus and the the pituitary gland's two lobes.

- *Prolactin inhibiting hormone (dopamine):* pituitary secretes less/no prolactin (no milk is produced whenever not breastfeeding)

Pineal gland

- Located behind hypothalamus, pituitary gland
- Contains pinealocytes which synthesize melatonin
  - Melatonin mostly secreted during night, regulates body's circadian rhythm (body clock)

Thyroid gland

- Located at front of neck
- Left, right lobe
- Made of thousands of follicles which synthesize triiodothyronine (T_3), thyroxine (T_4)
  - In the cell $T_4 \rightarrow T_3$
  - $T_3 \rightarrow \uparrow$ basal metabolic rate
- Parafollicular cells (C-cells) between follicles secrete calcitonin
- Two parathyroid glands on back of each thyroid lobe (four in total) secrete parathyroid hormone
- Calcitonin, parathyroid hormone work similarly
  - Control calcium, phosphate, bone metabolism
- Regulated by blood calcium levels

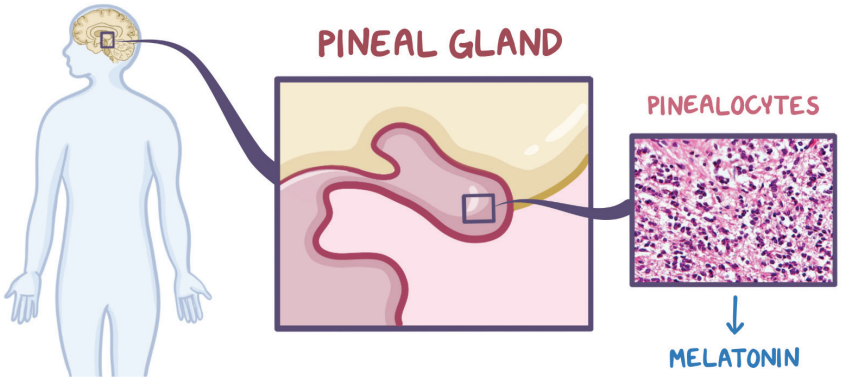

Figure 31.3 Pineal gland location and histological appearance of pinealocytes.

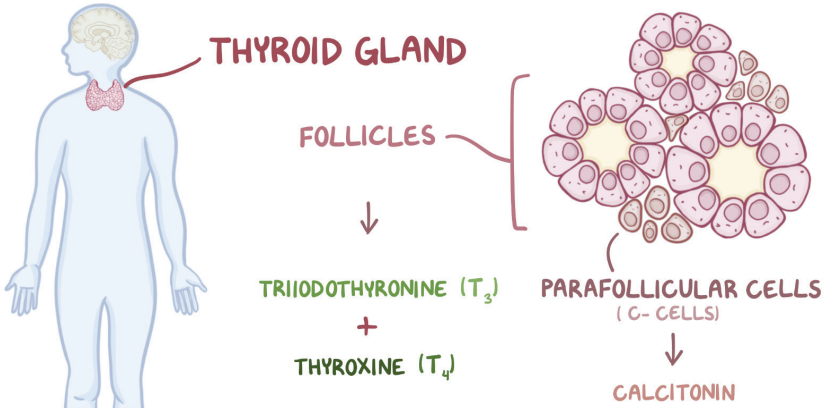

Figure 31.4 Follicular cells of the thyroid gland synthesize T_3, T_4; parafollicular cells secrete calcitonin.

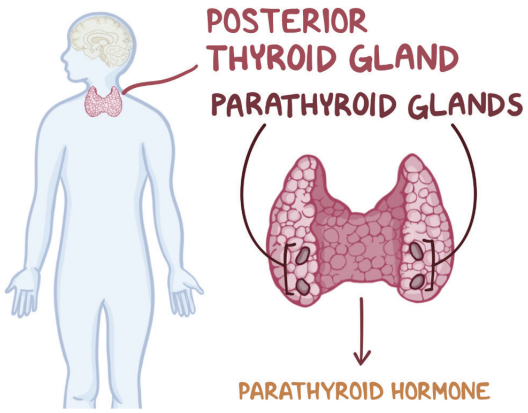

Figure 31.5 The parathyroid glands are found on the back of the thyroid. They secrete parathyroid hormone.

Adrenal glands

- Two glands situated retroperitoneally inside renal fascia, each surrounded by fibrous capsule; sit on top of kidneys
  - Connective tissue separates them from kidney, renal fascia from diaphragm
  - One of the most vascularized tissues
  - Differ in shape (right shaped as pyramid, left shaped as crescent moon)
- Outer layer (cortex) surrounding a core (medulla)
- *Medulla:* neuroectodermal origin; secretes catecholamines (e.g. adrenaline, noradrenaline) during "fight or flight" situations
  - ↑ blood pressure, ↑ cardiac output, ↑ bronchial dilation, ↑ glycogenolysis
- *Cortex:* makes up 80% of gland, mesodermal origin, secretes adrenocortical steroid hormones
  - *Three zones:* zona glomerulosa (makes mineralocorticoids—e.g. aldosterone), zona fasciculata (makes glucocorticoids), zona reticularis (makes sex hormone precursors)
  - *Aldosterone:* regulates extracellular fluid volume, potassium homeostasis; involved in renin-angiotensin-aldosterone system (RAAS); ↑ renal water and sodium reabsorption, ↑ renal potassium excretion → ↑ blood pressure
  - *Cortisol:* integral to stress response; also has metabolic, anti-inflammatory, immunosuppressive, vascular effects; regulated via hypothalamic-pituitary-adrenal (HPA) axis
  - *Androgens:* adrenals only source of androgens in biologically-female individuals; effects include ↑ libido, pubic hair development, sebaceous gland hypertrophy; minor role in biologically-male adults

ENDOCRINE PANCREAS

- Located behind stomach
- Three sections
  - Head, body, tail
- Has both endocrine, exocrine functions
- Contains hormone-producing cell clusters
  - Islets of Langerhans (1–2% of pancreas)
- Produce hormones secreted directly into bloodstream that regulate blood glucose

Cell types

- Alpha (α) cells
  - 15–20% of total islet cells
  - Produce glucagon
  - ↓ blood glucose → glucagon secreted → hepatic glycogenolysis and gluconeogenesis → glucose released into bloodstream
- Beta (β) cells
  - 65–80% of total islet cells
  - Produce insulin, amylin
  - ↑ blood sugar → insulin secreted → anabolic functions: promotes glucose entry into cells, ↑ glycogen synthesis, ↓ lipolysis
- Gamma (ɣ) cells/PP cells
  - 3–5% of total islet cells
  - Produce pancreatic polypeptide
  - Secretion stimulated by meals high in protein, hypoglycemia, physical activity, fasting; inhibits pancreatic exocrine (enzymes) and endocrine (insulin) activity
- Delta (δ) cells
  - 3–10% of total islet cells
  - Produce somatostatin
  - Paracrine function of suppressing both insulin and glucagon
- Epsilon (ε) cells
  - < 1% of total islet cells
  - Produce ghrelin
  - Functions in appetite stimulation

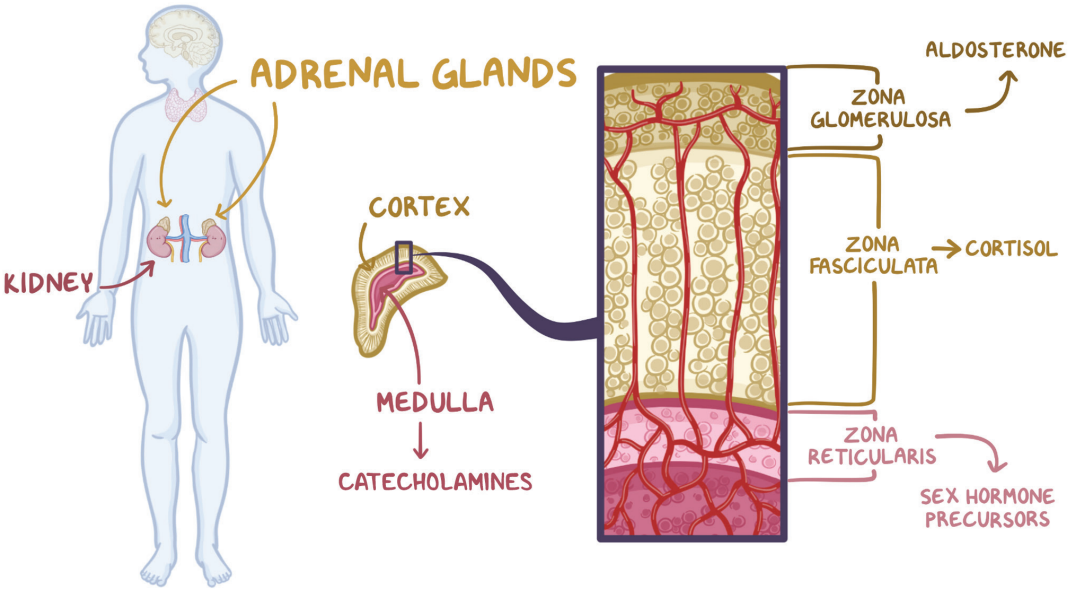

Figure 31.6 Location of the adrenal glands and the hormones secreted by the cortex, medulla.

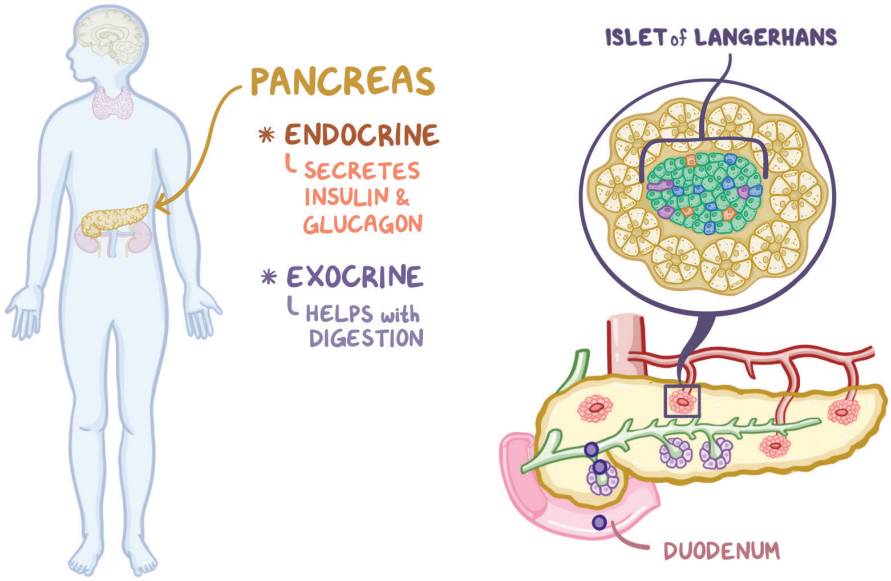

Figure 31.7 The pancreas has both endocrine and exocrine functions. It has hormone-producing clusters of cells called Islets of Langerhans.

MAJOR HORMONES AND THEIR FUNCTIONS

GLAND	HORMONE	TYPE	REGULATED BY	TARGET	FUNCTION
HYPOTHALAMUS	Oxytocin	Peptide	Bonding, motherhood	Uterus, mammaries	Uterine contractions, milk ejection
	ADH	Peptide	Blood osm., volume	Kidneys	↑ water reabsorption
ANTERIOR PITUITARY	Growth hormone	Peptide	GHRH, GHIH	Muscles, liver	Muscle growth, bone growth (by IGF-1)
THYROID	T_3, T_4	Amine	TSH	Cells	↑ metabolism
	Calcitonin	Peptide	Calcium in blood	Bones, kidneys, etc.	↓ blood calcium levels
PARATHYROID	Parathyroid	Peptide	Calcium in blood	Bones, kidneys, etc.	↑ blood calcium levels
ADRENAL CORTEX	Cortisol	Steroid	ACTH	All tissues	↑ blood glucose, inflammatory response
	Aldosterone	Steroid	↓ blood pressure, ↑ blood potassium	Kidneys	↓ urine sodium, ↑ urine potassium
	Sex hormones	Steroid	Puberty, ongoing	Gonads	Sex characteristics
ADRENAL MEDULLA	Epinephrine, norepinephrine	Modified amino acid	"Fight or flight" situations	All tissues	"Fight or flight" response
PANCREAS	Insulin	Protein	↑ blood sugar	Liver, muscle, fat	↓ blood sugar
	Glucagon	Protein	↓ blood sugar	Liver, muscle, fat	↑ blood sugar
TESTES	Testosterone	Steroid	FSH, LH	Gonads	Male sex characteristics and function
OVARIES	High	High	FSH, LH	Gonads	Female sex characteristics and function