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Endocrine System

Anatomy & Physiology

Pituitary, thyroid, parathyroid, adrenal and other endocrine glands

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Endocrine System - Applied Anatomy Notes for B.Sc. Nursing

1. Introduction

The endocrine system is a network of ductless glands and hormone-producing tissues that release hormones directly into the bloodstream.

Hormones are chemical messengers that regulate growth, metabolism, reproduction, stress responses and the internal balance of the body.

Functions of the Endocrine System

- Regulates body growth and development.
- Controls metabolism and energy production.
- Maintains blood glucose levels.
- Regulates water and electrolyte balance.
- Controls reproductive functions.
- Helps the body respond to stress.
- Maintains calcium and phosphate balance.
- Supports maintenance of homeostasis.

2. Characteristics of Endocrine Glands

- They are ductless glands.
- They release hormones directly into the blood or surrounding tissue fluid.
- They are richly supplied with blood vessels.
- Their hormones act on specific target cells or organs.
- They regulate several body functions, often through feedback mechanisms.

3. Major Endocrine Glands

The major endocrine glands include:

1. Hypothalamus
2. Pituitary gland
3. Pineal gland
4. Thyroid gland
5. Parathyroid glands

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6. Thymus
7. Adrenal glands
8. Pancreas
9. Ovaries in females
10. Testes in males

Other organs, including the kidneys, heart, placenta and gastrointestinal tract, also produce hormones.

4. Hypothalamus

Location

The hypothalamus is located in the lower part of the diencephalon, below the thalamus and above the pituitary gland.

Structure

- It is a small region of the brain.
- It forms the floor and part of the lateral walls of the third ventricle.
- It is connected to the pituitary gland through the infundibulum (pituitary stalk).

Hormones and Functions

The hypothalamus produces releasing and inhibiting hormones that regulate the anterior pituitary.

Hormone

Main Function

TRH

Stimulates TSH release

CRH

Stimulates ACTH release

GnRH

Stimulates FSH and LH release

GHRH

Stimulates growth hormone release

Somatostatin

Inhibits growth hormone and TSH release

Dopamine

Inhibits prolactin release

The hypothalamus also synthesises:

- ADH (vasopressin): Helps regulate water balance.
- Oxytocin: Helps in uterine contractions and milk ejection.

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ADH and oxytocin are transported to and stored in the posterior pituitary for release.

Functions

- Controls pituitary gland activity.
- Regulates body temperature.
- Controls hunger and thirst.
- Helps regulate sleep and circadian rhythm.
- Maintains autonomic and endocrine functions.

5. Pituitary Gland

Definition

The pituitary gland, also called the hypophysis, is a small endocrine gland located at the base of the brain. It is often called the master gland because it regulates several other endocrine glands.

Location

- Situated in the sella turcica, a depression in the sphenoid bone.
- Connected to the hypothalamus through the infundibulum.
- Located below the optic chiasm.

Structure

The pituitary gland is divided into two main parts:

1. Anterior Pituitary (Adenohypophysis)
   - Larger part of the gland.
   - Produces and releases several hormones.
   - Regulated by hypothalamic hormones through the hypophyseal portal circulation.
2. Posterior Pituitary (Neurohypophysis)
   - Stores and releases ADH and oxytocin.
   - These hormones are synthesised in the hypothalamus.

Hormones of the Pituitary Gland

Hormone Main Function

Growth hormone (GH) Promotes body growth and protein synthesis

Thyroid-stimulating hormone (TSH) Stimulates thyroid hormone production

Adrenocorticotropic hormone (ACTH) Stimulates adrenal cortex

Follicle-stimulating hormone (FSH) Supports ovarian follicle development and sperm production

Luteinising hormone (LH) Triggers ovulation and stimulates testosterone production

Prolactin (PRL) Stimulates milk production

Antidiuretic hormone (ADH) Increases water reabsorption by kidneys

Oxytocin Causes uterine contractions and milk ejection

Functions

- Controls growth and development.
- Regulates thyroid activity.
- Regulates adrenal cortex activity.
- Controls reproductive functions.
- Supports lactation.
- Helps maintain water balance.

Clinical Importance

- Gigantism: Excess growth hormone before closure of growth plates.
- Acromegaly: Excess growth hormone in adults.
- Pituitary dwarfism: Growth hormone deficiency during childhood.
- Diabetes insipidus: May occur due to inadequate ADH production or release, or renal resistance to ADH.

6. Pineal Gland

Location

The pineal gland is a small, cone-shaped gland located near the centre of the brain, attached to the roof of the third ventricle.

Hormone

Melatonin

Functions

- Regulates the sleep-wake cycle.
- Helps maintain the body's circadian rhythm.
- Its secretion increases in darkness and decreases with light exposure.

7. Thyroid Gland

Definition

The thyroid is a butterfly-shaped endocrine gland that produces hormones responsible for regulating metabolism, growth and development.

Location

- Situated in the anterior part of the neck.
- Located below the larynx and in front of the upper trachea.
- Consists of right and left lobes connected by an isthmus.

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Structure

The thyroid gland consists of:

1. Right lobe
2. Left lobe
3. Isthmus

Microscopically, it contains numerous follicles filled with colloid. Follicular cells produce thyroid hormones, while parafollicular (C) cells produce calcitonin.

Hormones of the Thyroid Gland

Hormone Function

Thyroxine (T4) Regulates metabolism and supports growth and development

Triiodothyronine (T3) Active thyroid hormone; increases metabolic activity

Calcitonin Helps lower blood calcium by inhibiting bone resorption

Functions

- Regulates basal metabolic rate.
- Supports normal growth and development.
- Helps regulate body temperature.
- Influences heart rate and energy use.
- Supports normal nervous system development.

Blood Supply

- Superior thyroid artery.
- Inferior thyroid artery.
- A thyroid ima artery may be present as an anatomical variation.

Clinical Importance

- Goitre: Enlargement of the thyroid gland.
- Hypothyroidism: Reduced thyroid hormone production.
- Hyperthyroidism: Excess thyroid hormone production.
- Thyroid nodules: Abnormal lumps within the thyroid gland.
- Thyroid cancer: Malignant growth in thyroid tissue.

8. Parathyroid Glands

Location

Usually four small glands situated on the posterior surface of the thyroid gland:

- Two superior parathyroid glands.

- Two inferior parathyroid glands.

Their exact position can vary.

Structure

- Small, oval-shaped glands.
- Usually yellowish-brown in appearance.
- Composed mainly of chief cells and oxyphil cells.

Hormone

Parathyroid hormone (PTH)

Functions of PTH

- Increases blood calcium levels.
- Stimulates calcium release from bone through its effects on bone cells.
- Increases calcium reabsorption by the kidneys.
- Decreases phosphate reabsorption by the kidneys.
- Stimulates activation of vitamin D in the kidneys, increasing intestinal calcium absorption.

Clinical Importance

- Hypoparathyroidism: Low PTH levels may cause hypocalcaemia and muscle spasms or tetany.
- Hyperparathyroidism: Excess PTH may cause hypercalcaemia and bone demineralisation.

9. Adrenal Glands

Definition

The adrenal glands, also called suprarenal glands, are paired endocrine glands located above the upper poles of both kidneys.

Location

- Right adrenal gland: Usually pyramidal in shape.
- Left adrenal gland: Usually crescent-shaped.
- Both lie in the retroperitoneal space.

Structure

Each adrenal gland has two main regions:

1. Adrenal Cortex

The outer part of the gland. It has three zones:

Zone Hormone Main Function

Zona glomerulosa Aldosterone Regulates sodium and potassium balance and blood volume

Zona fasciculata Cortisol Helps regulate metabolism and stress responses

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Zona reticularis Adrenal androgens Contributes to sex hormone activity

2. Adrenal Medulla

The inner part of the gland.

It produces:

- Adrenaline (epinephrine)
- Noradrenaline (norepinephrine)

These hormones prepare the body for the fight-or-flight response.

Functions

- Regulates blood pressure and fluid balance.
- Helps the body respond to physical and emotional stress.
- Influences glucose and protein metabolism.
- Supports the fight-or-flight response.
- Produces adrenal sex hormones.

Clinical Importance

- Addison's disease: Primary adrenal insufficiency.
- Cushing's syndrome: Prolonged exposure to excessive glucocorticoids.
- Pheochromocytoma: A tumour of adrenal medullary chromaffin cells that may produce excess catecholamines.

10. Pancreas

Location

The pancreas is an elongated gland situated in the upper abdomen, behind the stomach.

Structure

It has four main parts:

1. Head
2. Neck
3. Body
4. Tail

The pancreas is both an exocrine and endocrine gland.

Endocrine Part

The endocrine portion consists of clusters of cells called the islets of Langerhans.

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Hormones of the Pancreas

Cell Type

Hormone

Function

Alpha cells

Glucagon

Increases blood glucose

Beta cells

Insulin

Decreases blood glucose

Delta cells

Somatostatin

Inhibits the release of several hormones, including insulin and glucagon

PP cells

Pancreatic polypeptide

Helps regulate pancreatic secretion and gastrointestinal activity

Functions

- Insulin helps cells take up and store glucose.
- Glucagon stimulates the liver to release glucose.
- Somatostatin regulates the secretion of other hormones.
- Pancreatic polypeptide helps regulate digestive activity.

Clinical Importance

- Diabetes mellitus: A disorder characterised by chronic hyperglycaemia due to problems with insulin secretion, insulin action or both.
- Hypoglycaemia: Abnormally low blood glucose.
- Insulinoma: A usually pancreatic beta-cell tumour that may cause excessive insulin secretion.

11. Thymus Gland

Location

The thymus is located in the anterior and superior mediastinum, behind the sternum.

Structure

- Bilobed gland.
- Relatively large and active during childhood.
- Gradually undergoes involution after puberty, with increasing replacement by fatty tissue.

Hormones and Functions

The thymus produces several thymic factors, including thymosin-like peptides.

Its major role is to support the maturation and selection of T lymphocytes.

Functions

- Supports T-cell development.
- Helps establish immune tolerance.
- Plays an important role in childhood immunity.

12. Gonads as Endocrine Glands

The gonads are reproductive organs that also produce sex hormones.

A. Ovaries

Location: Female reproductive organs situated on either side of the uterus in the pelvic cavity.

Hormones:

Hormone

Function

Oestrogen

Supports female secondary sexual characteristics and reproductive tissue development

Progesterone

Prepares and maintains the uterine lining for pregnancy

Inhibin

Inhibits FSH secretion

Functions:

- Regulate the menstrual cycle.
- Support female reproductive development.
- Help maintain pregnancy through hormonal effects.

B. Testes

Location: Paired male reproductive glands located in the scrotum.

Hormones:

Hormone

Function

Testosterone

Supports male reproductive development and secondary sexual characteristics

Inhibin B

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Helps regulate FSH secretion and sperm production

Functions:

- Support sperm production.
- Develop and maintain male reproductive organs.
- Promote male secondary sexual characteristics.

13. Other Hormone-Producing Organs

Several organs outside the major endocrine glands also produce hormones.

Organ

Hormone

Main Function

Kidneys

Erythropoietin

Stimulates red blood cell production

Kidneys

Renin

Helps regulate blood pressure

Kidneys

Calcitriol

Active vitamin D; increases calcium absorption

Heart

Atrial natriuretic peptide (ANP)

Promotes sodium and water excretion

Placenta

hCG, oestrogen and progesterone

Supports pregnancy

Gastrointestinal tract

Gastrin, secretin and CCK

Regulate digestive activity

14. Feedback Mechanism in the Endocrine System

Hormone secretion is regulated mainly through feedback mechanisms.

Negative Feedback

Negative feedback is the main regulatory mechanism. When the level or effect of a hormone becomes sufficient, it reduces further hormone secretion.

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Example: Thyroid Regulation

1. Hypothalamus releases TRH.
2. Anterior pituitary releases TSH.
3. Thyroid gland produces T3 and T4.
4. Increased T3 and T4 levels inhibit TRH and TSH release.

This helps maintain normal thyroid hormone levels.

Positive Feedback

Positive feedback increases a response until a specific event is completed.

Example: Childbirth

1. Uterine contractions stimulate oxytocin release.
2. Oxytocin increases uterine contractions.
3. Stronger contractions stimulate further oxytocin release.
4. This continues until delivery.

15. Difference Between Endocrine and Exocrine Glands

Feature

Endocrine Glands

Exocrine Glands

Ducts

Ductless

Have ducts

Secretion

Hormones

Enzymes, mucus, sweat and other substances

Route

Into blood or surrounding tissue fluid

Through ducts to a surface or cavity

Action

Often acts on distant target organs

Usually acts locally

Examples

Pituitary, thyroid, adrenal

Sweat, salivary and sebaceous glands

Note: Some organs, such as the pancreas, have both endocrine and exocrine functions.

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16. Nursing Importance of the Endocrine System

Knowledge of endocrine anatomy is essential for nurses to:

- Understand hormone-related disorders.
- Monitor blood glucose levels.
- Recognise signs of hypo- and hyperglycaemia.
- Monitor patients with thyroid disorders.
- Observe for signs of adrenal insufficiency.
- Monitor fluid balance and electrolyte levels.
- Administer insulin and other prescribed hormonal medications safely.
- Educate patients about medication adherence and lifestyle management.
- Recognise symptoms of hormonal imbalance.
- Monitor growth and development in children.

17. Important Examination Questions

Long Answer Questions

1. Describe the structure and functions of the pituitary gland.
2. Explain the anatomy and hormones of the thyroid gland.
3. Describe the structure and functions of the adrenal glands.
4. Explain the endocrine functions of the pancreas.
5. Describe the major endocrine glands and their hormones.

Short Answer Questions

1. Write the functions of the hypothalamus.
2. Differentiate between anterior and posterior pituitary.
3. Describe the location and structure of the thyroid gland.
4. Write the functions of parathyroid hormone.
5. Explain the three zones of the adrenal cortex.
6. What are the islets of Langerhans?
7. Write the functions of the pineal gland.
8. Explain the role of the thymus.
9. Differentiate between endocrine and exocrine glands.
10. Explain negative feedback with an example.

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Very Short Answer Questions

1. Which gland is called the master gland? - Pituitary gland.
2. Which hormone regulates blood glucose by lowering it? - Insulin.
3. Which gland produces thyroxine? - Thyroid gland.
4. Which hormone increases blood calcium? - Parathyroid hormone.
5. Which gland produces melatonin? - Pineal gland.
6. Which gland produces adrenaline? - Adrenal medulla.
7. Where are the adrenal glands located? - Above the kidneys.
8. Which cells produce insulin? - Beta cells.
9. Where do T lymphocytes mature? - Thymus.
10. Which hormone stimulates milk production? - Prolactin.
11. Which hormone causes milk ejection? - Oxytocin.
12. Which hormone stimulates uterine contractions during childbirth? - Oxytocin.

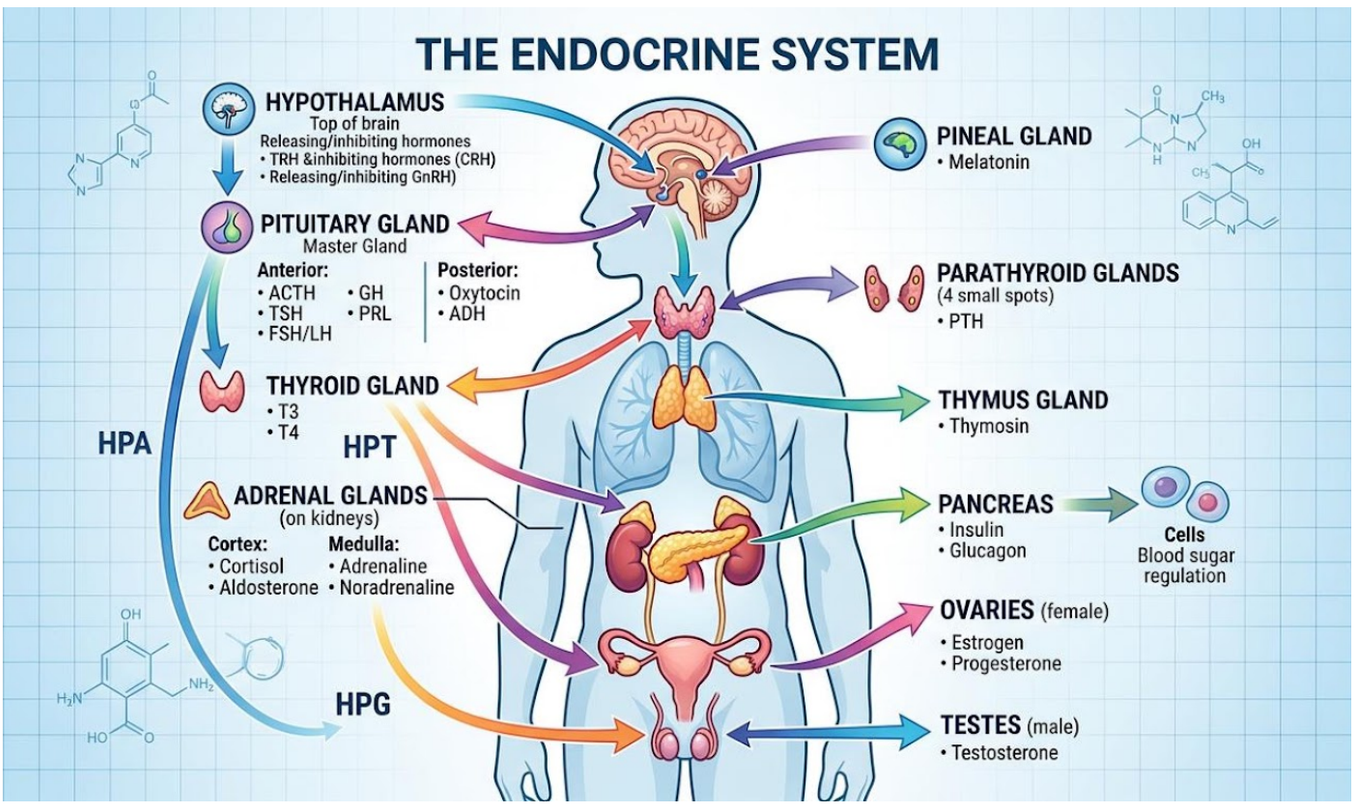
18. Quick Revision

- Endocrine glands are ductless glands.
- Hormones are chemical messengers.
- Hypothalamus controls pituitary activity.
- Pituitary gland is located in the sella turcica.
- The anterior pituitary produces several hormones.
- The posterior pituitary releases ADH and oxytocin.
- Pineal gland produces melatonin.
- Thyroid gland produces T3, T4 and calcitonin.
- Parathyroid glands produce PTH.
- Adrenal cortex has three zones.
- Adrenal medulla produces adrenaline and noradrenaline.
- Pancreatic beta cells produce insulin.
- Pancreatic alpha cells produce glucagon.
- Thymus supports T-cell maturation.
- Ovaries produce oestrogen and progesterone.
- Testes produce testosterone.
- Negative feedback is the main mechanism regulating hormone secretion.

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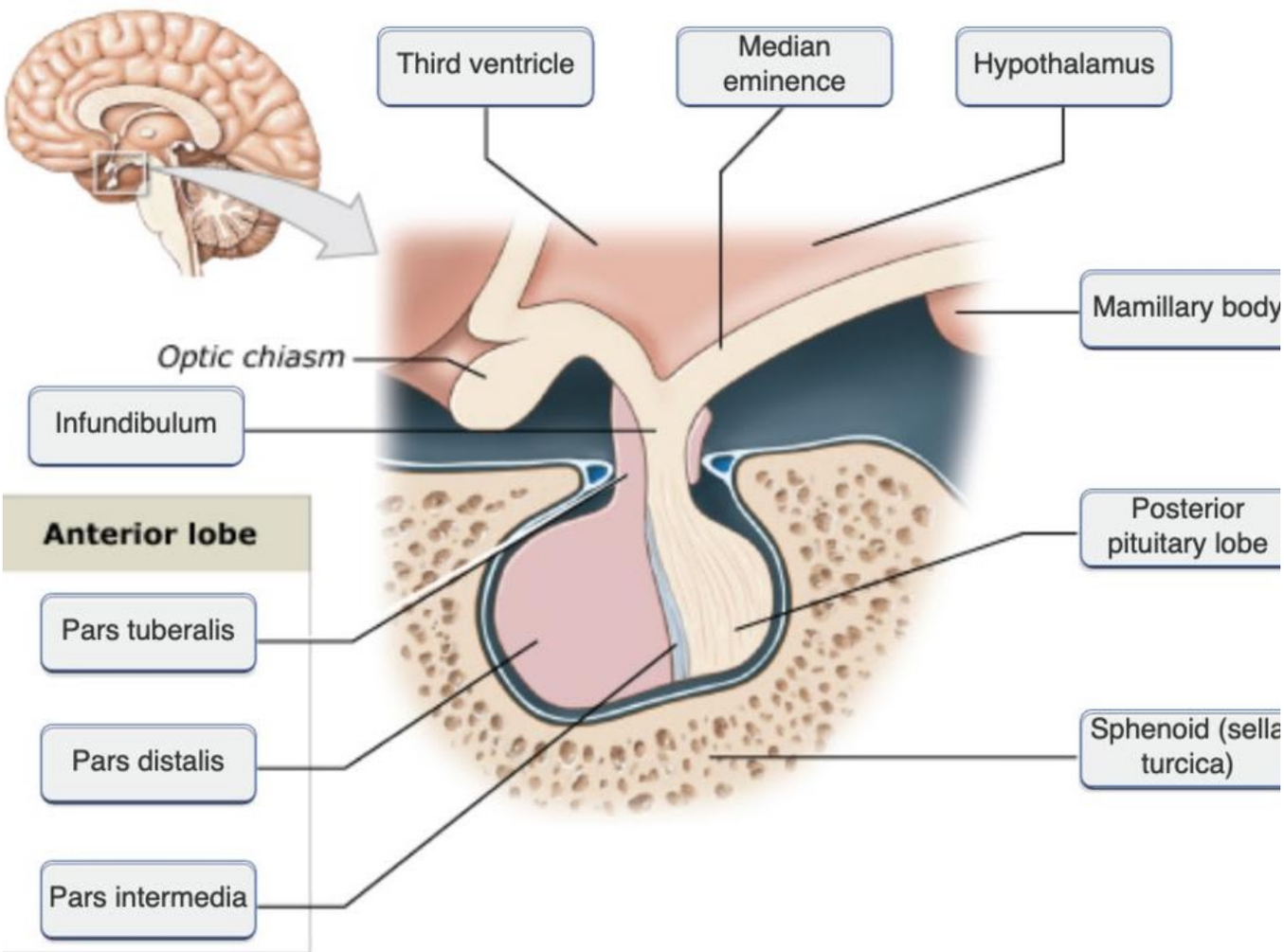
Conclusion

The endocrine system regulates important body functions through hormones. The pituitary, thyroid, parathyroid, adrenal glands, pancreas, pineal gland, thymus and gonads work together to maintain growth, metabolism, reproduction, fluid balance and homeostasis. Knowledge of these glands is essential for nursing students to understand endocrine disorders and provide safe patient care.



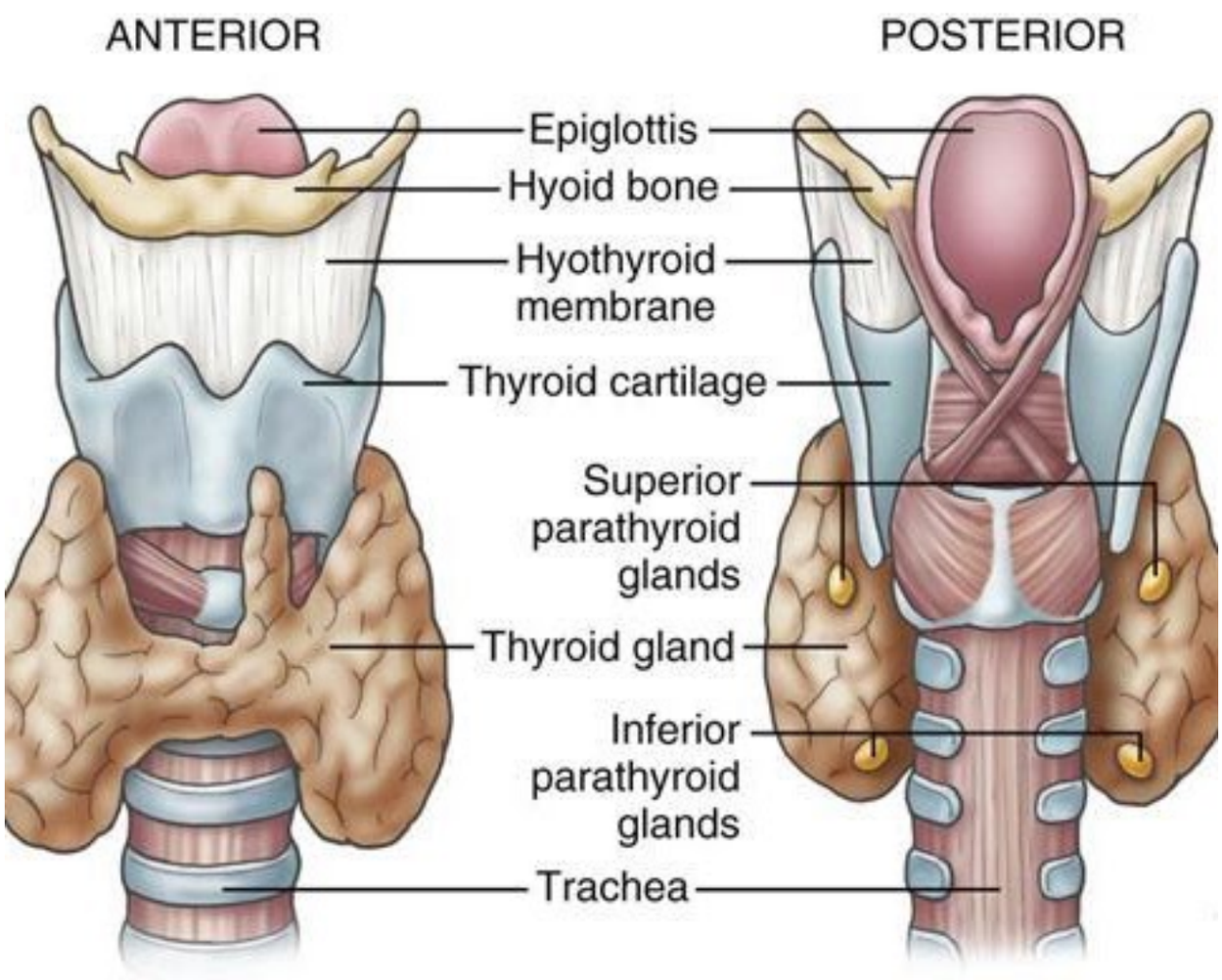
Endocrine System - illustration 1

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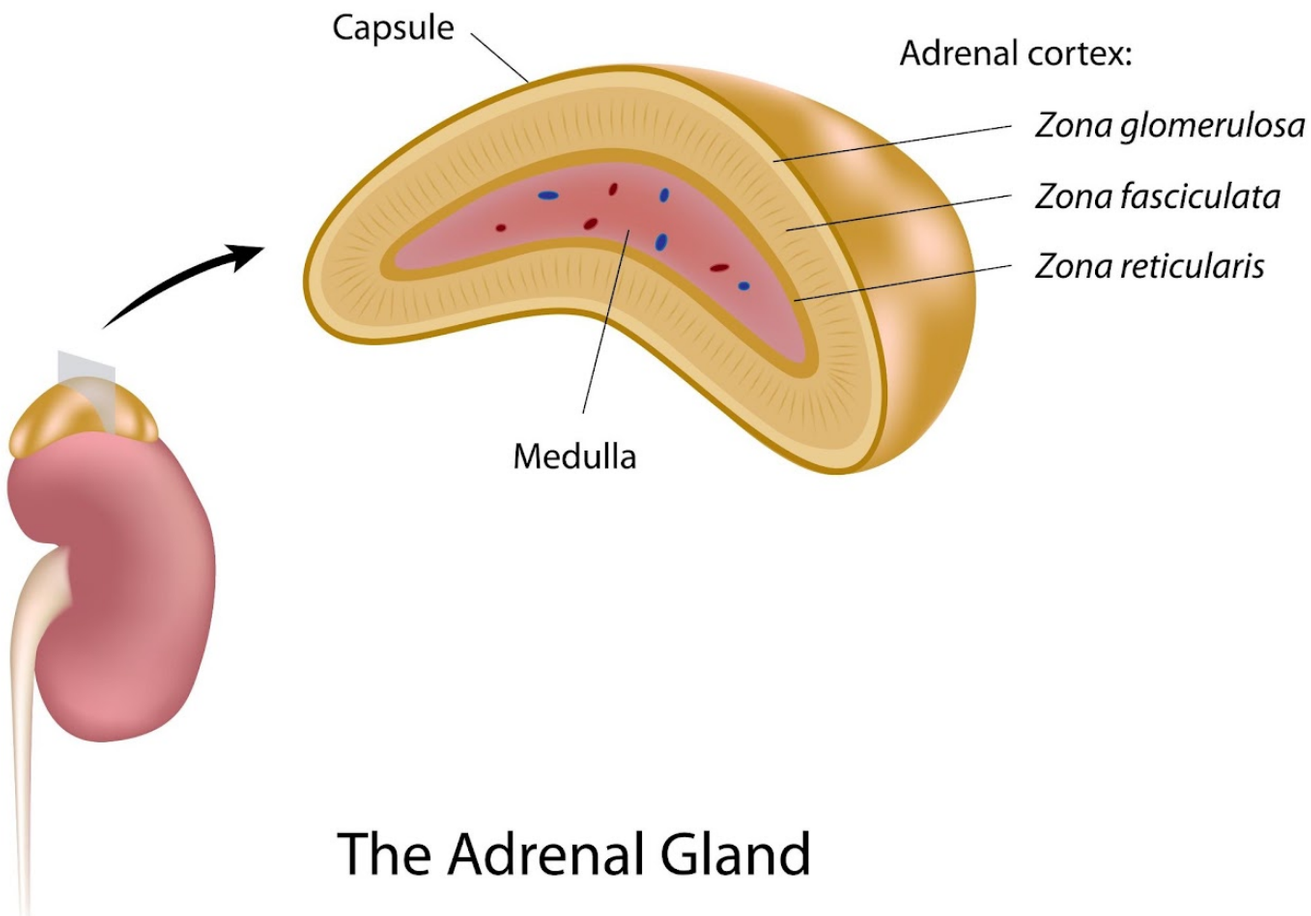
Endocrine System - illustration 2

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Endocrine System - illustration 3

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Endocrine System - illustration 4

Quick Revision

- Pituitary & hypothalamus: The pituitary lies in the sella turcica of the sphenoid and connects to the hypothalamus by the infundibulum. The adenohypophysis is glandular; the neurohypophysis is neural. The posterior pituitary stores and releases ADH and oxytocin synthesized in the hypothalamus.

- Thyroid & parathyroid: Two thyroid lobes flank the upper trachea and are connected by an isthmus. Follicles contain colloid and are lined by follicular cells; parafollicular C cells lie between follicles. Usually four parathyroid glands lie on the posterior thyroid surface; their chief cells secrete PTH.

- Adrenal glands: Adrenal glands lie superior to the kidneys. Cortex and medulla are distinct tissues with different functions.

- Other endocrine structures:

Examination questions

1. Compare anterior and posterior pituitary.

2. Describe thyroid follicles.

3. List adrenal cortical zones from outer to inner.

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Practice questions

Choose one best answer. The answer key and explanations follow the questions.

1. Which part of the pituitary is neural tissue?

A. Adenohypophysis
B. Neurohypophysis
C. Thyroid follicle
D. Adrenal cortex

2. Parathyroid glands usually lie:

A. Behind the thyroid
B. In the sella turcica
C. Within the pancreas
D. Below the bladder

3. The outermost adrenal cortical zone is:

A. Reticularis
B. Fasciculata
C. Glomerulosa
D. Medulla

4. After thyroid surgery, a patient develops tingling around the mouth and muscle spasms. Injury to which nearby glands would explain reduced calcium regulation?

A. Parathyroid glands
B. Thyroid follicular cells through excess thyroxine release
C. Adrenal cortex through reduced cortisol production
D. Posterior pituitary through reduced antidiuretic hormone release

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Answer key and explanations

1. B - Neurohypophysis

The neurohypophysis is the posterior neural portion.

2. A - Behind the thyroid

They usually occupy the posterior thyroid surface.

3. C - Glomerulosa

The order is glomerulosa, fasciculata, reticularis, then medulla.

4. A - Parathyroid glands

The parathyroid glands regulate calcium through parathyroid hormone. Their impairment can cause hypocalcaemia and neuromuscular irritability.

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