HORMONES

Hormones are chemical messengers produced by endocrine glands and released into the bloodstream. They regulate various physiological processes such as growth, metabolism, reproduction, stress response, and maintenance of homeostasis. Hormones act only on specific target cells that possess the appropriate receptors. The mechanism of hormone action depends on the chemical nature of the hormone and the location of its receptor.

CLASSIFICATION OF HORMONES

1. According to Chemical Nature:

Steroid Hormones:

These are made up of lipids, which basically derived from cholesterol, e.g. Testosterone, Estrogen, Progesterone etc.

Amine Hormones:

These hormones are made up of amines. Amine hormone is derivative of the amino acid tyrosine.

e.g. T_3, T_4, epinephrine, norepinephrine.

Peptide Hormones:

These hormones are made up of few amino acid residues only and present as simple linear chain.

e.g. Oxytocin and vasopressin both consist of only 9-amino acid residues only.

Protein Hormones:

These hormones are also made amino acid residues which are much more in numbers. They represent primary, secondary and tertiary configuration.

e.g. Insulin, glucagon, STH etc.

Glycoprotein Hormones:

These hormones are glycoprotein in nature. They are conjugated protein where carbohydrate groups are mannose, galactose, fucose etc.

e.g. LH, FSH, TSH etc.

Eicosanoids Hormones:

The eicosanoids are small fatty acid derivatives with a variety of arachidonic acid.

e.g. Prostaglandins.

2. On the Basis of Mechanism of Action:

Hormones binds on Intracellular receptor:

- These hormones bind to intracellular receptors to form **hormone-receptor complexes** (HRC), through which their biochemical functions are mediated.

- These hormones are lipophilic in nature and are derivatives of cholesterol (except T_3 and T_4).
- They are found in circulation in association with transport proteins and possess relatively longer half-lives (hours or day). e.g. Estrogen, Progesterone, Testosterone, T_3, T_4 etc.

Hormones binds on cell surface receptors

These hormones stimulate the release of certain molecules, namely the second messengers which in turn, perform the biochemical functions.

These hormones are subdivided into three categories on the basis of chemical nature of second messengers:

(i) The second messenger is cAMP. e.g. ACTH, FSH, LH etc.

(ii) The second messenger is phospholipid/inositol/Ca^{++}-> e.g. TRH, GnRH, Gastrin etc.

(iii) The second messenger is unknown -> e.g. STH, LTH, Insulin, Oxytocin etc.

3. According to Nature of Action:

(a) Local Hormones:

These hormones have got specific local effects by paracrine secretion. e.g. Testosterone.

(b) General Hormones:

These hormones are transported by circulation to the distal target organ/tissue.

e.g. Insulin, Thyroid hormone etc.

4. According to Effect:

(a) Kinetic Hormones:

These hormones may cause pigment migration, muscle contraction, glandular secretion etc.

e.g. Pinealin, MSH, Epinephrine etc.

(b) Metabolic Hormones:

These hormones mainly changes the rate of metabolism and balance the reaction.

e.g. Insulin, Glucagon, PTH etc.

(c) Morphogenetic Hormones:

These hormones are involved in growth and differentiation.

e.g. STH, LTH, FSH, Thyroid hormones etc.

5. On the Basis of Stimulation of Endocrine Glands:

(a) Tropic Hormones:

These hormones stimulate other endocrine glands for secretion.

e.g. TSH of pituitary stimulates secretion of thyroid gland.

(b) Non-tropic Hormones:

These hormones exert their effect on non-endocrine target tissues.

e.g. Thyroid hormone increases the O_2 consumption rate and metabolic activity of almost every cells.

MECHANISM OF HORMONE ACTION

Hormones are the chemical messenger secreted directly in the blood stream by endocrine gland. They are target specific and bind to the specific receptor. On the basis of binding of hormone on their specific receptor, the mechanism of hormonal action is categorized into two group. They are-

1. Water-Soluble Hormones

Examples

- Insulin
- Glucagon
- Adrenaline (Epinephrine)
- Growth Hormone

These hormones cannot cross the lipid cell membrane. Therefore, they bind to receptors on the cell surface and act through second messenger systems.

Mechanism

1. Hormone binds to a membrane receptor.
2. The receptor activates a G-protein or enzyme.
3. A second messenger (such as cAMP, IP_3, DAG, or Ca^{2+}) is produced.
4. The second messenger activates protein kinases.
5. Protein kinases phosphorylate target proteins.
6. Cellular activities such as enzyme activation, secretion, or muscle contraction occur.

Second Messenger Systems

A. cAMP (Cyclic AMP) Pathway

- Hormone binds to a G-protein-coupled receptor (GPCR).
- G-protein activates adenylate cyclase.
- Adenylate cyclase converts ATP into cAMP.
- cAMP activates Protein Kinase A (PKA).
- PKA phosphorylates proteins, producing the cellular response.

Examples: Glucagon, Adrenaline, ACTH, TSH.

B. IP_3–DAG Pathway

- Hormone activates phospholipase C.
- Membrane phospholipids are split into:

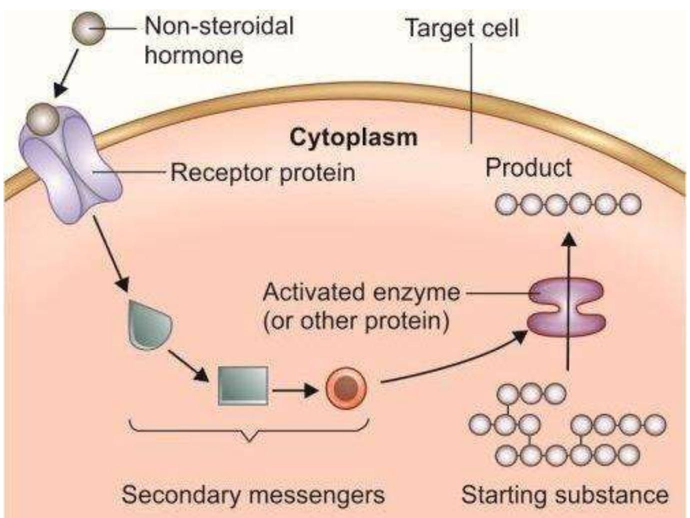
  a) Inositol triphosphate (IP_3)
  b) Diacylglycerol (DAG)

- IP_3 releases calcium ions from the endoplasmic reticulum.
- DAG and calcium activate Protein Kinase C (PKC).
- PKC produces the final cellular response.

Examples: Oxytocin, Vasopressin, Angiotensin II.

C. Calcium as a Second Messenger

Some hormones increase intracellular calcium concentration. Calcium binds to **calmodulin**, activating various enzymes responsible for cellular functions.



Action via Intracellular receptor (Mobile receptor)

- The lipid soluble hormones such as steroid hormones and Fatty acids hormones can easily passes through the plasma membrane.
- They have their receptor inside the cell, freely floating in the cytoplasm. Binding of hormone to the specific receptor activates the enzymatic activity of the cell for biochemical changes.
- These hormone have their receptor localized inside the nucleus, the hormone-receptor complex are carried inside the nucleus.

- The hormone-receptor complex initiate transcription of the DNA to form specific mRNA.
- mRNA initiate protein synthesis in the cytoplasm. The protein (enzyme) causes biochemical changes in the cell.

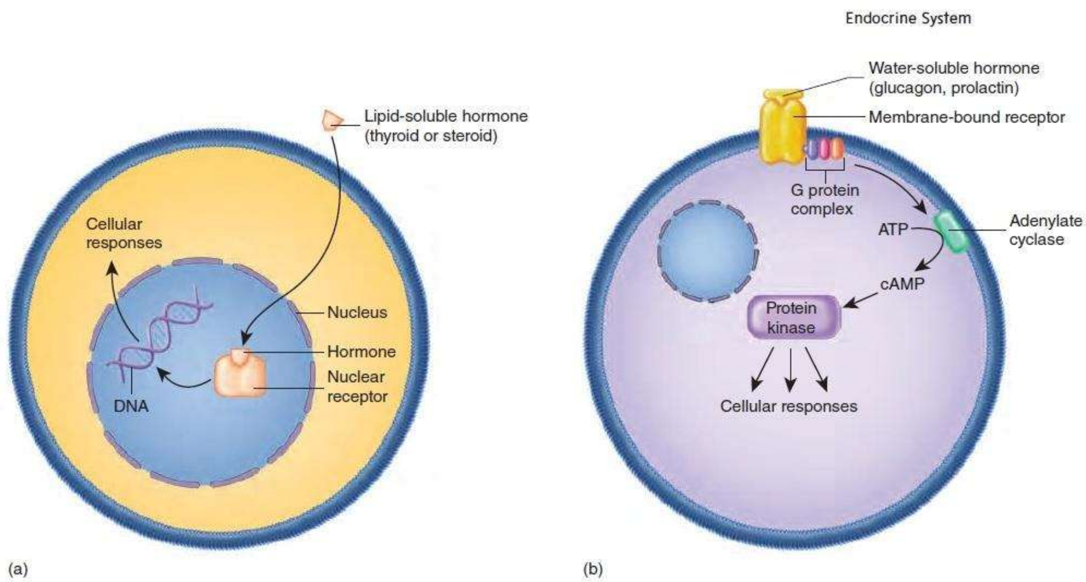


Figure 10.7 General Comparison of Nuclear and Membrane-Bound Receptors
(a) *Lipid-soluble* hormones diffuse through the plasma membrane of its target cell and bind to a cytoplasmic receptor or a nuclear receptor. In the nucleus, the combination of the hormone and the receptor initiates protein synthesis, described later in this chapter. (b) *Water-soluble* hormones bind to the external portion of membrane-bound receptors, which are integral membrane proteins on its target cell.

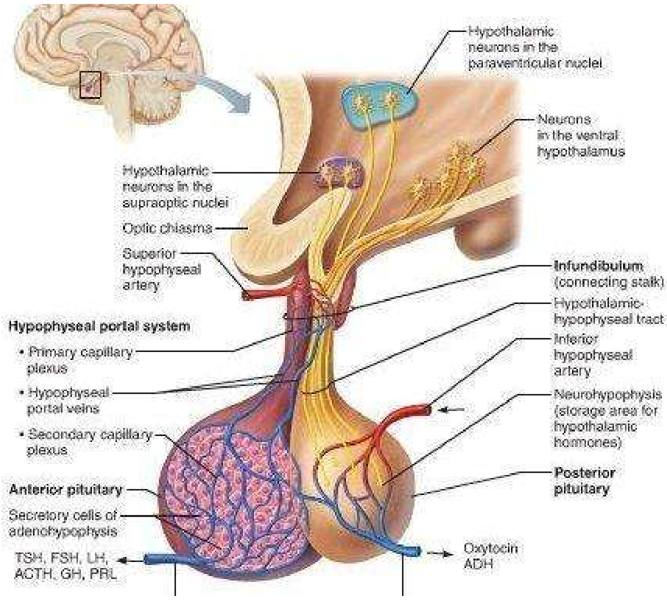
Ex: testosterone, progesterone, estrogen, cortisol, thyroxine

Steps in Hormone Action

The general mechanism of hormone action involves the following steps:

1. **Secretion of the hormone** by an endocrine gland.
2. **Transport** through the bloodstream to the target tissue.
3. **Binding** of the hormone to specific receptors on the target cell.
4. **Signal transduction** inside the cell.
5. **Cellular response**, such as enzyme activation, gene expression, or changes in metabolism.
6. **Termination** of hormone action by hormone degradation or removal.

PITUITARY GLAND (THE MASTER GLAND)



Pituitary gland:

- It is located directly just below the hypothalamus of brain and is held by an infundibular stalk.
- It is about 1 cm long, 1 to 1.5 cm wide and 0.5 cm thick (about the size and shape of a pea).
- It is also known as the master gland because the hormones released by this gland regulates and controls the secretions of other endocrine glands in our body.
- Pituitary gland itself is under the control of hypothalamus, hence also called the **hypophyseal gland**.
- The pituitary gland has two distinct lobes:
    - The anterior lobe (Adenohypophysis)
    - The posterior lobe (Neurohypophysis)
- Between these two lobes is a small zone called the pars intermedia.
- The anterior lobe is larger with more than 75% of the total weight of the gland and abundance of functional secretory cells.
- The posterior lobe has a greater supply of large nerve endings.

Hormones of the Neurohypophysis:

- It doesn't secrete hormone but stores hormones secreted by the hypothalamus which is brought to it by nerve fibers (hypothalamus-hypophyseal tract).
- It has spindle shaped cells called pituicytes. The hormones are:

1. Antidiuretic hormone (ADH):

- It is a polypeptide and is also known as vasopressin.
- It causes the **contraction** of arterial walls increasing blood pressure.
- It also promotes the reabsorption of water from the distal convoluted tubules of nephrons in kidneys.
- Its deficiency (hyposecretion) causes **diabetes insipidus**, i.e. micturition increases (frequent urination).

2. Oxytocin:

- It is a polypeotide.
- It stimulates parturition (the contraction of pregnant uterus), so called a **birth hormone**.
- It also induces lactation (milk ejection from breasts after childbirth), so called milk ejection hormone.

Hormones of the Adenohypophysis:

- It synthesizes 5 tropic or stimulating hormones (whose primary target is another endocrine gland).
- The 2 non tropic hormones are growth hormone and prolactin, which are involved with growth and milk production respectively.

1. Growth hormone (Somatotropin):

- It is a polypeptide (protein).
- It stimulates the growth rate of body by increasing the tissue mass (protein synthesis), maintaining epiphyseal growth of bones and stimulating cell division.
- Hyposecretion in young person causes dwarfism (marked closure of epiphyseal disks of bones and no growth of body).
- Hypersecretion in young person causes gigantism (the person continues to grow to 7 to 8 feet, looking like a giant).
- After normal growth has stopped, overproduction of growth hormone causes acromegaly (bones in head, hands, and feet start thickening rather than lengthening).

2. Prolactin:

- It is a polypeptide.
- It promotes breast development during pregnancy.
- It stimulates milk production from the mammary glands of mother after childbirth.

***milk ejection** (not milk production) is stimulated by oxytocin.

3. Thyroid stimulating hormone (TSH):

- It is glycoprotein in nature and stimulates the production and secretion of thyroid hormones (Thyroxine).

4. Adrenocorticotropic hormone (ACTH)

- It is also called corticotropin.
- It stimulates the secretion of adrenal cortex steroids (glucocorticoids).

5. Luteinizing hormone (LH)

- It is glycoprotein in nature and is also called a gonadotropin.
- In females, it stimulates the development of corpus luteum, release of oocyte (ovum) and the production of progesterone and estrogen.
- In males, it stimulates the secretion of testosterone and the development of interstitial tissue of testes.

6. Follicle stimulating hormone (FSH)

- It is glycoprotein in nature.
- In females, it stimulates the growth of ovarian follicles and ovulation.
- In males, it stimulates the production of sperm.

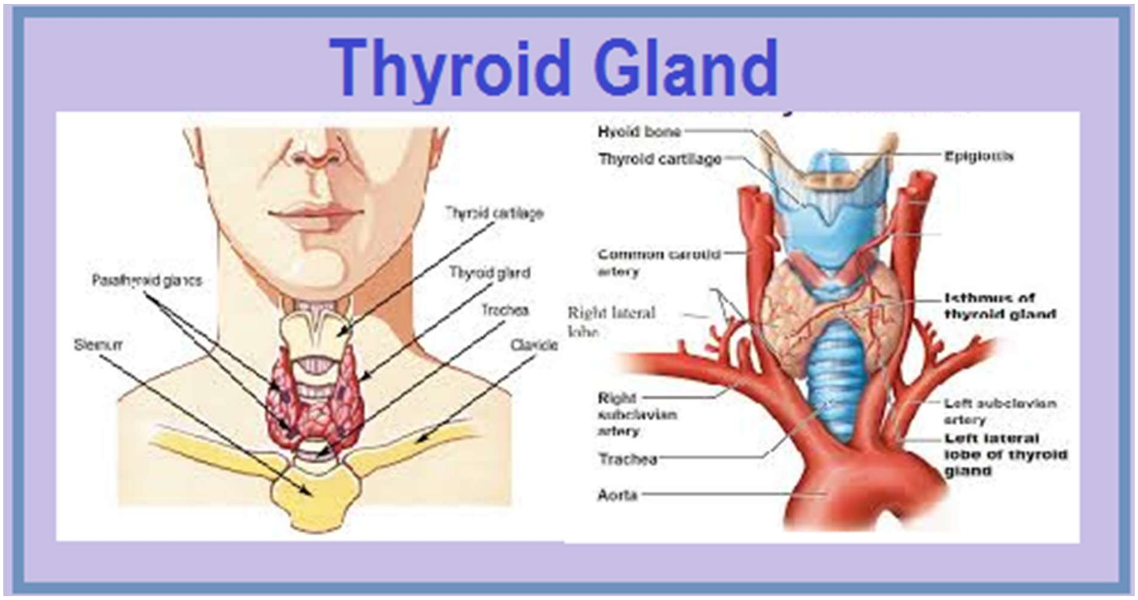
7. Melanocyte stimulating hormone (MSH)

- It is also known as intermidin.
- It is apparently involved with the distribution of melanin (skin pigment produced by melanocytes) in combination with the ACTH.

Thyroid Gland

The thyroid gland is a ductless endocrine gland situated in the anterior/front portion of the neck. It roughly resembles the shape of a butterfly. It is also one of the largest endocrine glands, weighing an average of 25 – 30 g. This gland has two lobes on either side of the trachea, with each lobe measuring 4 – 6 cm in length and 1.3 – 1.8 cm in width.

The primary function of the thyroid gland is to secrete two hormones namely, Triiodothyronine (T3) hormone and the Thyroxine hormone (T4). Both T3 and T4 hormones play a very important role and affect almost every tissue in the body.



Location

The thyroid gland is located in the anterior neck between C5 and T1 vertebrae. It consists of two lobes embedded within the parathyroid gland on their posterior surfaces.

Thyroid Hormones

There are two thyroid hormones:

- **T4: Thyroxine (Tetraiodothyronine)**
- **T3: Triiodothyronine**

T4

Thyroxine is a hormone secreted by the thyroid gland in the bloodstream. It then travels to the organs such as kidneys and liver where it gets converted into and gets converted into its active form triiodothyronine.

T3

It is a thyroid hormone that affects physiological processes such as growth, development, metabolism, etc.

Thyroid Symptoms

Sometimes, symptoms of a thyroid disorder are not very obvious. This is because there are various other factors that can induce similar symptoms and usually, the treatment is given according to the symptoms. For instance, excessive tiredness may be associated with sleep apnea, narcolepsy etc, but the underlying symptoms may actually be thyroid related. Some of the common symptoms of the thyroid are:

- Nervousness
- Poor concentration and knowledge retention

- Change in the menstrual cycle
- Increased heart rate
- Muscle aches
- Weight gain
- High level of cholesterol

Thyroid Gland Disorders

The thyroid gland is susceptible to many disorders and diseases. These problems might be due to the excess secretion of hormones, unusual growth of the gland, malignant lumps etc. Also, scientists have theorized a relationship between stress and thyroid health. I.e., stress may actually aggravate the underlying thyroid condition. Some of the common thyroid problems are:

Goitre

It is an excessive enlargement of the thyroid gland often obstructing the oesophagus or other organs in the neck and chest by causing difficulty to eat and breathe.

Thyroid cancer

It is a very common form of cancer. However, the chances of survival for a thyroid cancer patient is quite high compared to other forms of cancer. There are four types of thyroid cancer, namely:

1. Papillary thyroid cancer
2. Follicular thyroid cancer
3. Medullary cancer
4. Anaplastic thyroid cancer

Hyperthyroidism

This condition is caused when thyroid glands excessively produce a hormone called thyroxine. The symptoms include a change in appetite, unexpected weight loss, insomnia, fatigue, irritability, frequent urination, increased sweating and heat intolerance. But this condition usually resolves within a few months of relevant treatments and proper medication.

Hypothyroidism

This condition is caused by the under-secretion of the thyroid hormones. It is a very common problem and often stays undetected for years. One of the main reasons that trigger hypothyroidism is an autoimmune disorder called Hashimoto's disease. In this condition, the antibodies produced by the body attack the thyroid gland and this results in the glands producing fewer hormones.

Thyroid Treatment

The most common treatment available for thyroid problems like hyperthyroidism is to replace thyroxine with another synthetic man-made hormone called levothyroxine (or L-thyroxine). It is an injectable and an oral medication that can return the balance in the thyroid glands. Patients will experience a reduction in the symptoms of hyperthyroidism in a few weeks post medication.

Cancer in the thyroid gland could be treated quite successfully with radiation. Thyroid cancer would be difficult to diagnose sometimes as it shows no signs or symptoms. A periodic checkup is essential for preventing such diseases from taking root.

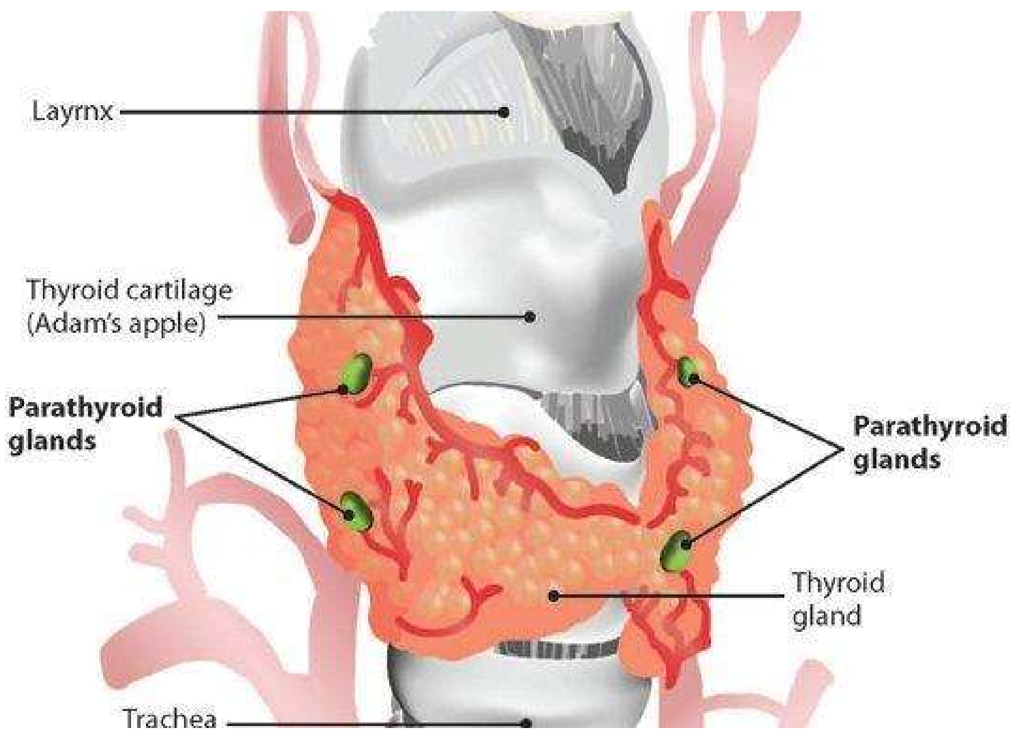
PARATHYROID GLAND

The parathyroid glands are four small endocrine glands located on the posterior surface of the thyroid gland. These glands secrete parathyroid hormone (PTH), which plays a vital role in maintaining the normal concentration of calcium and phosphorus in the blood. PTH increases blood calcium levels by stimulating calcium release from bones, increasing calcium reabsorption in the kidneys, and promoting the activation of vitamin D, which enhances calcium absorption from the intestine.

Structural anatomy of Parathyroid gland

- Parathyroid glands are tiny, lentil sized gland embeded in posterior of thyroid gland.
- two pairs of parathyroid glands are found.
- each thyroid lobe contains two parathyroid gland.
- The gland is composed of principal cells (secrete parathormone) and Oxyphilic cells (store parathormone)

Location: embedded on posterior of thyroid gland



Hormones of Parathyroid gland

1. **Parathormone**

- Regulate the concentration of calcium and phosphate level in blood
- Increase level of Ca++ in blood by reabsorption from intestine and kidney, Osteolysis
- Low Ca++ concentration in blood stimulate parathormone synthesis.
- Promote decalcification and demineralization of bone.
- stimulates Osteoclast to break (Osteolysis) to release Calcium from bone to blood.

* Improper balance of calcium and phosphate in blood causes faulty nerve impulse transmission, destruction of bone tissue, hamper bone growth and muscle tetany.

** when calcium level increases in blood, parathormone stimulates inhibition of reabasorption of calcium in kidney and inhibit osteolysis of bone.

Disorder of Parathyroid gland

Hyperparathyroidism

It is a disorder characterized by excessive secretion of parathyroid hormone, leading to increased blood calcium levels (**hypercalcemia**) and decreased phosphate levels. It is classified into primary, secondary, and tertiary hyperparathyroidism.

Causes

Primary hyperparathyroidism is most commonly caused by a benign tumor (adenoma) of one of the parathyroid glands. Less commonly, it may result from hyperplasia of all four glands or, rarely, parathyroid cancer.

Secondary hyperparathyroidism develops as a compensatory response to chronic low calcium levels. Common causes include chronic kidney disease, vitamin D deficiency, and disorders that reduce calcium absorption from the intestine.

Tertiary hyperparathyroidism occurs when prolonged secondary hyperparathyroidism causes the glands to become enlarged and secrete PTH independently, even after calcium levels return to normal.

Signs and Symptoms

Excess PTH causes calcium to be removed from bones, making them weak and fragile. Patients commonly experience bone pain, frequent fractures, muscle weakness, fatigue, and joint pain. High calcium levels may also cause kidney stones, excessive thirst, frequent urination, constipation, nausea, abdominal pain, loss of appetite, depression, confusion, and memory problems. In severe cases, cardiac rhythm disturbances may occur.

Diagnosis

Diagnosis is based on laboratory investigations showing elevated blood calcium, increased parathyroid hormone levels, decreased serum phosphate, and elevated alkaline phosphatase in some cases. Imaging studies such as ultrasound or nuclear scans may be used to identify enlarged parathyroid glands or adenomas. Bone density testing helps evaluate bone loss.

Treatment

Treatment depends on the severity and cause of the disease. Mild cases may require regular monitoring, adequate hydration, and medications to reduce calcium levels. Patients are advised to avoid dehydration and maintain appropriate vitamin D intake. In symptomatic cases or when complications such as kidney stones or osteoporosis occur, surgical removal of the affected parathyroid gland (parathyroidectomy) is the treatment of choice.

Hypoparathyroidism

It is a condition in which the parathyroid glands produce insufficient amounts of parathyroid hormone. As a result, blood calcium levels decrease (**hypocalcemia**) while phosphate levels increase.

Causes

The most common cause is accidental damage or removal of the parathyroid glands during thyroid or neck surgery. Other causes include autoimmune destruction of the glands, congenital absence or underdevelopment of the glands, genetic disorders, severe magnesium deficiency, or radiation therapy to the neck.

Signs and Symptoms

Low calcium levels increase the excitability of nerves and muscles. Common symptoms include tingling or numbness around the mouth, fingers, and toes; muscle cramps; painful muscle spasms (tetany); twitching of facial muscles; fatigue; anxiety; and seizures in severe cases. Long-term hypocalcemia may lead to dry skin, brittle nails, hair loss, cataracts, and dental abnormalities.

Diagnosis

Diagnosis includes blood tests showing low calcium levels, elevated phosphate levels, and reduced parathyroid hormone levels. Magnesium and vitamin D levels may also be assessed to determine contributing factors. Electrocardiography (ECG) may reveal changes caused by hypocalcemia.

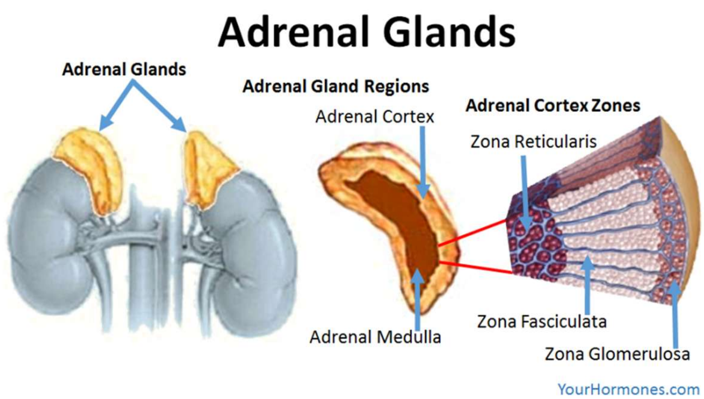
Treatment

Patients are treated with oral calcium supplements and active forms of vitamin D, such as calcitriol, to improve calcium absorption. Magnesium deficiency should be corrected if present. Severe hypocalcemia with tetany or seizures requires intravenous calcium administration under medical supervision. Regular monitoring of blood calcium is essential to prevent complications.

ADRENAL GLAND: STRUCTURE, LOCATION AND HORMONES

- The adrenal gland occurs in pair. each adrenal gland is made up of two separate endocrine gland. the inner portion of each gland is called Medulla and outer portion is called Cortex.
- **Location:** each adrenal gland is located on top of kidney as kidney cap
- **Size**: 4-6 cm long and 2-3 cm wide

Structure of Adrenal gland



1. Adrenal cortex:

- It accounts for about 90% of weight of adrenal gland which weight for 5-7 gram.
- the cortex has three distinct zone

i. Zona glomerulosa

- It lies directly beneath the capsule.
- It supplies cells for all other three zone. it is actually germinal layer.
- It produce mineralocorticoid.

ii. Zona faciculata

- It lies beneath zona glomerulosa.
- It make up bulk of adrenal cortex.
- It secretes glucocorticoids and small amount of gonadocorticoids.

iii. Zona reticularis

- It is the deepest layer.
- It consists of similar cell as zona faciculata but cells are arranged irregularily.
- It produce Dehydroepiandrosterone (an intermediate hormone needed for production of sex hormone Androstenedione).

Hormones secreted by Adrenal cortex

1. Glucocorticoid

- Regulate blood glucose level
- Stimulate gluconeogenesis
- Enhance synthesis of aminoacids which are substrate for gluconeogenesis
- Promote protein and nucleic acid metabolism
- Regulated by ACTH
- Acts as anti-inflammatory agents

2. Mineralocorticoid

- It is group of Steroid hormone (eg. Aldosterone), regulate concentration of mineral
- Help in maintaining blood pressure
- Help in Na^+ reabsorption and cause excretion of K^+, H^+ and NH_4^+

3. Gonadocorticoid

- Sex hormone, stimulate gonads
- Regulated by ACTH

2. Adrenal medulla

- It is the inner portion of adrenal gland.
- Medulla acts as a separate endocrine gland. It secretes separate hormones than cortex. However hormones produced by medulla are not as essential as cortical hormones.
- The secretory cells of adrenal medulla is called as Chromaffin cell because of their tendency to stain dark color.
- chromaffin cell synthesize, store and secrete epinephrine and nor-epinephrine which prepare body for fright, flight and fight.

Hormones secreted by Adrenal Medulla

1. Epinephrine (adrenaline)

- commonly known as Adrenaline
- Increase rate of metabolism, heart rate and blood pressure
- Increase glycogenolysis, respiration rate, O_2 consumption

2. Nor-epinephrine (Nor-Adrenaline)

- Increase heart rate, cardiac output, blood pressure
- Enhance lipid metabolism

- Relaxes smooth muscles of GI tract.
- Release free fatty acid from adipose tissue.

Disorder/disease of adrenal gland

1. addition's disease

- bronze color pigmentation of skin
- low Na+ and high K+ level in blood plasma
- decrease resistance to infection

2. Cushing syndrome

- abnormal obesity
- high Na+ and Low K+ level in blood

3. Aldosteronism

- High Na+ level and Low K+ level in blood
- high blood pressure and increase blood volume

4. Adrenal virilism

- male type external character such as beard, moustaches and voice develops in female

PANCREAS

Mixed gland (both endocrine and exocrine function)

Structure

- Pancreas is elongated 12-15 cm long organ consisting of head, body and tail. It is located posterior to stomach with its head in the curve of duodenum. The body and tail extends laterally. The tail touches the spleen.
- pancreas is considered as mixed gland as it acts as exocrine and endocrine gland.
- As exocrine gland, pancreas secretes digestive enzymes into pancreatic duct.
- As endocrine gland,it secretes hormones into blood.
- Only about 1% of total weight of gland acts as endocrine gland. This portion of pancreas is known as Islet of Langerhans.
- Adult pancreas contsins 200,000-20,00,000 islet of Langerhans.

Endocrine portion of pancreas is called Islet of Langerhans, which is a group of cells.

- **Alpha cell**= produce glucagon. Glucagon plays an important role in blood glucose regulation; low blood glucose levels stimulate its release.

- **Beta cell**= produce Insulin. Elevated blood glucose levels stimulate the release of insulin.
- **Delta cell=** produce peptide hormone Somatostatin. Pancreatic somatostatin inhibits the release of both glucagon and insulin.
- * somatostatin is also released by the hypothalamus (as GHIH), and the stomach and intestines
- **F cell (PP cell)=** produce pancreatic polypeptide hormone.

Hormones of pancreas

1. Glucagon

- Alpha cells produce, stores and secretes glucagon.
- Glucagon stimulate glycogenolysis and gluconeogenesis; increase blood glucose level

2. Insulin

- Beta cell produce, store and secretes insulin.
- Insulin stimulate glycogenesis; decrease blood glucose level and Store glucose in the form of glycogen in liver and muscles
- Insulin function opposite to glucagon and work to maintain normal glucose level in blood.

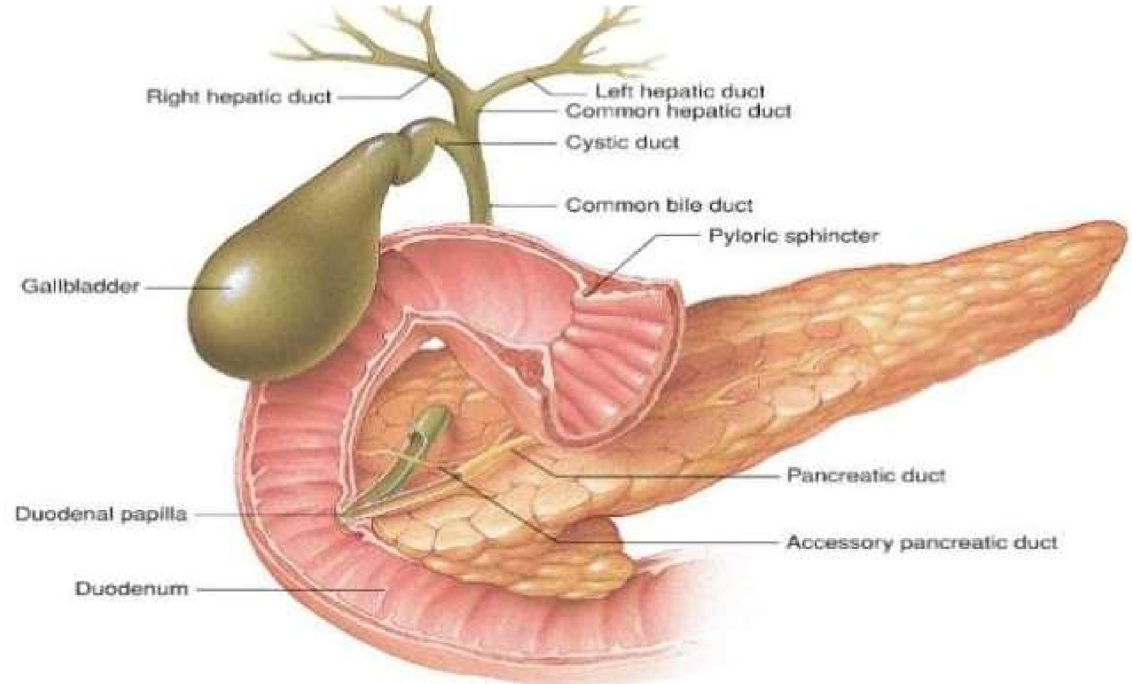
3. Somatostatin

inhibit release of both glucagon and insulin

Disorders

Diabetes mellitus: condition caused by destruction or dysfunction of the beta cells of the pancreas or cellular resistance to insulin that results in abnormally high blood glucose levels.

- hyperglycemia: abnormally high blood glucose levels
- hypoglycemia; abnormally low blood glucose levels.



Pineal Gland

Introduction

The pineal gland is a small, cone-shaped endocrine gland located near the center of the brain, between the two cerebral hemispheres. It is attached to the roof of the third ventricle and is a part of the epithalamus. Although it is very small, measuring about **5–8 mm in length**, the pineal gland plays an important role in regulating the body's biological clock and sleep–wake cycle. It is often referred to as the **"biological clock"** or the **"third eye"** because of its sensitivity to light and its influence on circadian rhythms.

The principal hormone secreted by the pineal gland is **melatonin**, which regulates the body's daily (circadian) rhythm and seasonal biological activities. The secretion of melatonin is influenced by the amount of light entering the eyes. Darkness stimulates melatonin production, whereas exposure to bright light suppresses its secretion.

Structure of the Pineal Gland

The pineal gland is a reddish-grey, pinecone-shaped structure located in the posterior part of the brain. It lies above the superior colliculi and behind the third ventricle. The gland is richly supplied with blood vessels and is composed mainly of specialized cells called **pinealocytes**, which are responsible for producing melatonin. It also contains supporting glial cells that provide structural and functional support.

Unlike many other parts of the brain, the pineal gland is not completely protected by the blood-brain barrier. This allows it to receive signals from the bloodstream and regulate hormone secretion effectively.

Hormones Secreted by the Pineal Gland

The major hormone secreted by the pineal gland is **melatonin**. Melatonin is synthesized from the amino acid **tryptophan** through the intermediate compound **serotonin**. Its secretion follows a daily rhythm, with maximum levels produced during the night and minimum levels during the day.

Melatonin production is controlled by the **suprachiasmatic nucleus (SCN)** of the hypothalamus, which acts as the body's master biological clock. Information about environmental light reaches the SCN through the retina of the eye. During darkness, the SCN stimulates the pineal gland to release melatonin, while exposure to light inhibits its secretion.

Functions of the Pineal Gland

The pineal gland performs several important physiological functions:

1. Regulation of Circadian Rhythm

The primary function of the pineal gland is to regulate the body's **circadian rhythm**, which is the natural 24-hour cycle controlling sleep, wakefulness, body temperature, and hormone secretion. Melatonin helps synchronize these rhythms with the external light-dark cycle.

2. Regulation of Sleep

Melatonin promotes sleep by signaling the body that it is nighttime. Increased melatonin secretion during darkness induces drowsiness, reduces alertness, and helps maintain normal sleep patterns. This hormone is essential for maintaining healthy sleep quality.

3. Regulation of Reproductive Functions

Melatonin influences the secretion of reproductive hormones by affecting the hypothalamus and pituitary gland. In children, higher melatonin levels may delay sexual maturation, while a decline in melatonin contributes to the onset of puberty.

4. Antioxidant Activity

Melatonin acts as a powerful antioxidant. It protects body cells from damage caused by harmful free radicals and reduces oxidative stress. This protective effect supports healthy brain function and may reduce cellular aging.

5. Immune System Regulation

Melatonin helps regulate immune function by influencing the activity of immune cells. It enhances the body's defense mechanisms and may contribute to resistance against infections and inflammation.

6. Seasonal Biological Rhythm

In many animals, melatonin regulates seasonal breeding, migration, and hibernation according to changes in day length. Although this role is less prominent in humans, melatonin still contributes to seasonal changes in biological activity.

Disorders of the Pineal Gland

Abnormal function of the pineal gland or altered melatonin secretion can lead to several health problems.

Insomnia

Reduced melatonin secretion or disruption of the normal sleep cycle can cause difficulty in falling asleep or maintaining sleep. Exposure to bright light at night, shift work, and excessive use of electronic devices may decrease melatonin production and contribute to insomnia.

Circadian Rhythm Sleep Disorders

Disturbances in the body's internal clock can result in disorders such as jet lag, delayed sleep phase syndrome, and shift work sleep disorder. These conditions affect sleep quality and daytime alertness.

Seasonal Affective Disorder (SAD)

Seasonal Affective Disorder is a form of depression that commonly occurs during the winter months when daylight hours are shorter. Altered melatonin secretion and reduced exposure to sunlight are believed to contribute to this condition.

Pineal Tumors

Although rare, tumors of the pineal gland can interfere with melatonin secretion and compress nearby brain structures. Symptoms may include headaches, nausea, vomiting, vision problems, and disturbances in eye movements due to increased pressure within the brain.

THYMUS GLAND

Introduction

The thymus gland is a specialized lymphoid and endocrine organ located in the upper part of the chest (thorax), behind the sternum (breastbone) and in front of the heart. It is an important component of both the endocrine system and the immune system. The thymus is most active during infancy and childhood, when it plays a crucial role in the development and maturation of the body's immune defenses. As a person grows older, especially after puberty, the thymus gradually decreases in size and is replaced largely by fatty tissue, a process known as thymic involution.

The thymus secretes several hormones that promote the development and maturation of **T-lymphocytes (T-cells)**, which are essential for protecting the body against infections, viruses, and abnormal cells.

Location and Structure

The thymus gland is situated in the **anterior mediastinum**, just behind the sternum and above the heart. It consists of **two lobes**, each enclosed by a connective tissue capsule. The gland is divided into numerous smaller lobules.

Each lobule contains two distinct regions:

- **Outer cortex:** Rich in immature T-lymphocytes (thymocytes), where these cells undergo early stages of development.
- **Inner medulla:** Contains mature T-lymphocytes, epithelial cells, and characteristic structures known as **Hassall's corpuscles**, which are involved in the maturation and regulation of immune cells.

The thymus is supplied with a rich network of blood vessels and lymphatic vessels, allowing immune cells to circulate between the thymus and other lymphoid organs.

Hormones Secreted by the Thymus

The thymus produces several hormones that regulate the growth, maturation, and function of T-lymphocytes. The major thymic hormones include:

1. Thymosin

Thymosin is the principal hormone secreted by the thymus. It stimulates the differentiation and maturation of T-lymphocytes, enabling them to recognize and destroy foreign microorganisms while protecting normal body tissues.

2. Thymopoietin

Thymopoietin promotes the development and specialization of T-cells and contributes to the proper functioning of the immune system.

3. Thymulin

Thymulin enhances the activity of mature T-cells and supports communication between different immune cells. Its activity depends on the presence of adequate zinc levels in the body.

Functions of the Thymus Gland

1. Maturation of T-Lymphocytes

The primary function of the thymus is the maturation of T-lymphocytes. Immature lymphocytes produced in the bone marrow migrate to the thymus, where they undergo growth, differentiation, and selection. Only properly functioning T-cells are released into the bloodstream to participate in immune responses.

2. Development of Cell-Mediated Immunity

The thymus is responsible for the development of **cell-mediated immunity**, which protects the body against viruses, intracellular bacteria, fungi, parasites, and cancer cells. T-cells directly destroy infected or abnormal cells and coordinate immune responses.

3. Prevention of Autoimmune Diseases

During their development in the thymus, T-cells undergo a selection process that removes cells capable of attacking the body's own tissues. This process helps maintain **immune tolerance** and reduces the risk of autoimmune diseases.

4. Production of Thymic Hormones

The thymus secretes hormones such as thymosin, thymopoietin, and thymulin, which regulate T-cell development, maturation, and immune function throughout childhood.

5. Support of the Immune System

A healthy thymus ensures the production of effective T-cells, enabling the body to recognize and eliminate harmful microorganisms while coordinating the activity of other immune cells.

Disorders of the Thymus Gland

Abnormalities of the thymus can affect immune function and lead to various disorders.

Thymic Hypoplasia or Aplasia

In some congenital disorders, such as **DiGeorge syndrome**, the thymus is absent or poorly developed. As a result, T-cell production is severely reduced, making affected individuals highly susceptible to recurrent infections.

Thymoma

A **thymoma** is a tumor arising from the epithelial cells of the thymus. Most thymomas are slow-growing and benign, but some may become malignant. Symptoms may include chest pain, cough, difficulty breathing, or may be absent until the tumor becomes large.

Myasthenia Gravis

The thymus is closely associated with **myasthenia gravis**, an autoimmune disorder in which antibodies attack receptors at the neuromuscular junction. This results in muscle weakness, drooping eyelids, difficulty swallowing, and fatigue. Many patients with myasthenia gravis have an enlarged thymus or a thymoma, and surgical removal of the thymus (**thymectomy**) may improve symptoms.