

# Hormones

## Definition

- *Hormones are conventionally defined as organic substances produced in small amounts by specific tissues (endocrine glands), secreted into the blood stream to control the metabolic and biological activities in the target cells.*
- *They are regarded as the chemical messengers involved in the transmission of information from one tissue to another and from cell to cell*

## Sources or origin of hormones:

<i>Origin</i>	<i>Hormones</i>
<i>Adrenal cortex</i>	<i>Estrogen, androgen, glucocorticoids, mineralocorticoids</i>
<i>Adrenal medulla</i>	<i>Epinephrine, norepinephrine</i>
<i>Anterior pituitary gland</i>	<i>Adrenocorticotrophic hormone (ACTH), follicular stimulating hormone (FSH), luteinising hormone (LH), chorionic gonadotropic hormone (hCG), thyroid stimulating hormone (TSH), growth hormone (GH), prolactin (PRL)</i>
<i>Hypothalamus</i>	<i>Thyrotropin releasing hormone (TRH), gonadotropin releasing hormone (GnRH)</i>
<i>Intestine</i>	<i>Cholecystokinin (CCK)</i>
<i>Kidney</i>	<i>Calcitriol</i>
<i>Ovaries</i>	<i>Estrogen, progesterone</i>
<i>Pancreas</i>	<i>Insulin, glucagon,</i>
<i>Parathyroid gland</i>	<i>Parathyroid hormone</i>
<i>Placenta</i>	<i>Progestins</i>
<i>Posterior pituitary gland</i>	<i>Antidiuretic hormone (ADH), oxytocin</i>
<i>Stomach</i>	<i>Gastrin</i>
<i>Testes</i>	<i>Androgens</i>
<i>Thyroid gland</i>	<i>Thyroid hormones (triiodothyronine T3, thyroxine T4), calcitonin</i>

## Classification

- *Hormones may be classified in many ways based on their characteristics and functions*

*Two types of classification are discussed here:*

- 1. Based on chemical nature*
- 2. Based on the mechanism of action*

## **1. Based on chemical nature:**

- *The hormones can be categorised into three groups considering their chemical nature:*

- I. Amino acid derivatives*

- II. Protein & peptide hormones*

- III. Steroid hormones*

## ***Based on chemical nature:***

### *I. Amino acid derivative hormones:*

- *This category comprises of hormones that are derived from single amino acid*
- *For example:*
  - *norepinephrine, epinephrine, dopamine are derived from the amino acid tyrosine*
  - *Thyroid hormone*

## ***Based on chemical nature:***

### *II. Proteins and peptides hormones*

- *These hormones are protein in nature*
- *The individual hormone could be referred to as peptide, polypeptide or protein in nature, depending on their specific chain length*
- *For example:*
  - *thyrotropin releasing hormone (TRH) is composed of only 3 amino acids (small peptide), while pituitary gonadotropins possess as many as 180 amino acids (large peptides)*
  - *Insulin, glucagon*

## ***Based on chemical nature:***

### *III. Steroid hormones:*

- *These hormones are derivatives of cholesterol or fatty acids*
- *For example:*
  - *adrenal cortical hormone*
  - *Androgen*
  - *Estrogen*
  - *Calcitriol*
  - *prostaglandins*
  - *prostacyclin*

## ***2. Based on the mechanism of action:***

- Hormones are classified into two broad groups*
- Group I and group II based on the location of the receptors to which they bind and signals used to mediate their action*



## ***Based on the mechanism of action:***

### *I. Group I hormone:*

- These hormones bind to intracellular receptors to form receptor hormone complex (RHC) through which their biochemical functions are mediated*
- Group I hormones are lipophilic in nature and are mostly derivatives of cholesterol*
- Examples: estrogen, androgens, glucocorticoids, calcitriol, etc.*

## ***Based on the mechanism of action:***

### *II. Group II hormones:*

- *These hormones bind to cell surface (plasma membrane) receptors and stimulate the release of certain molecules, namely the second messengers which in turn perform the biochemical functions. Thus, hormones themselves are the first messengers.*

*Group II hormones are subdivided into three categories based on the chemical nature of the second messengers.*

- i. The second messenger is cAMP. e.g. ACTH, FSH, LH, PTH, Glucagon, Calcitonin*
- ii. The second messenger is phosphatidyl inositol / calcium. E.g. TRH, GnRH, gastrin, CCK*
- iii. The second messenger is unknown. E.g. growth hormone, insulin, oxytocin, prolactin.*

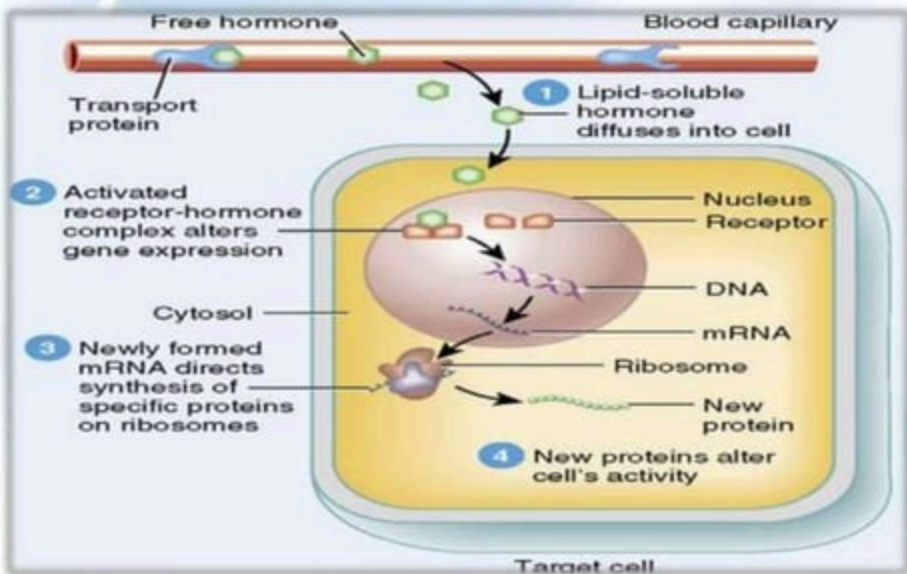
## Mode of action of hormones:

- *The first step of hormones action is to bind to specific receptors of the target cell*
- *Cells that lack receptors for the hormones do not respond to hormones*
- *Hormone receptor complex activates the receptor itself & the activated receptor initiates the hormonal effects*
- *Hormonal receptors are large proteins, which are highly specific for a single hormone. Due to this specificity a particular hormone will act on a particular tissue*
- *Hormone receptors are located in different parts of cell:*
  - *In or on the surface of the cell membrane- for protein, peptide hormones*
  - *In the cytoplasm- for steroid hormones*
  - *In the nucleus- for thyroid hormones*

### **Mode of action of group I hormones:**

- Several hormones, e.g.: sterol hormones (adrenal & gonadal), thyroid hormones, retinoid hormones, calcitriol bind with protein receptors inside the cell (in cytoplasm or nucleus). Because these hormones are lipid soluble and cross the cell membrane
- Inside cell they combine with receptors and form **hormone receptor complex (HRC)**
- The activated HRC undergoes conformational change & binds with a specific regulatory sequence of DNA called **hormone response element (HRE)**
- The HRE now activates the transcription of the gene and forms the m-RNA
- These m-RNA now translate into protein.
- Newly formed protein controls the cellular functions

# GROUP 1 HORMONE ACTION



### **Mode of action of group II hormones:**

*Group II hormones are water soluble in nature & hence can not pass the cell membrane*

*They have the receptors present on the cell membrane*

*They attach to the membrane receptors*

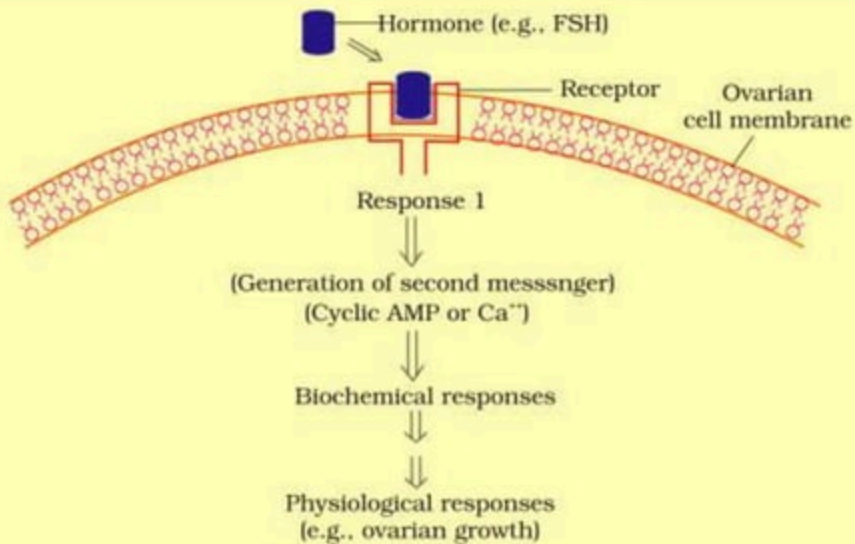
*These membrane receptors become activated & in turn they activate the secondary messengers inside the cell*

*The activated secondary messengers now activate or deactivate the enzymes inside cell as per the message from the hormones*

*(Secondary messengers: cyclic adenosine monophosphate, (cAMP), cyclic guanosine monophosphate (cGMP), inositol trisphosphate, diacylglycerol, and calcium)*

## GROUP 2 HORMONE ACTION

*For example: Follicular Stimulating Hormone (FSH)*





## Clinical significance of thyroid hormones

*Thyroid: The thyroid gland, or simply the thyroid, is an endocrine gland in the neck, consisting of two lobes connected by an isthmus. It is found at the front of the neck, below the Adam's apple. The thyroid gland secretes thyroid hormones, which primarily influence the metabolic rate and protein synthesis. Thyroid gland also secretes calcitonin, a hormone concerned with calcium homeostasis.*

*Hormones of thyroid gland: triiodothyronine (T3), thyroxine (T4) & calcitonin*

### *Functions of thyroid hormones:*

- ✓ Thyroid hormones stimulate protein synthesis*
- ✓ Promote intestinal absorption of glucose*
- ✓ Have tendency to lower the serum cholesterol level*
- ✓ Increase the metabolic activity*
- ✓ In males, lack of thyroid hormone is likely to cause complete loss of libido (sexual desire), whereas on the other hand much more excess of thyroid hormones cause impotence*
- ✓ In female, excess of thyroid hormones causes menorrhoea (i.e. excessive & frequent menstrual bleeding). Lack of thyroid hormones may cause irregular period or even total amenorrhoea (abnormal absence of period)*

*Clinical significances / Abnormalities of thyroid function:*

*Among the endocrine glands, thyroid is the most susceptible for hypo or hyperfunction*

*Following three abnormalities associated with thyroid function are known-*

- 1. Goitre*
- 2. Hyperthyroidism*
- 3. Hypothyroidism*

## *Goitre:*

*abnormal increase in the size of the thyroid gland is known as goitre. Enlargement of thyroid gland is mostly to compensate the decreased synthesis of thyroid hormones and is associated with elevated TSH. Goitre may occur due to goitrogenic substances or due to deficiency of iodine in body.*

### *Symptoms of goitre:*

- A visible swelling at the base of neck that may be particularly obvious during shave or put on makeup*
- A tight feeling in throat*
- Coughing*
- Hoarseness*
- Difficulty swallowing*
- Difficulty breathing*

## *Hyperthyroidism:*

➤ *Also known as thyrotoxicosis*

➤ *Is associated with overproduction of thyroid hormone*

### *Symptoms:*

- *Sudden weight loss*
- *Rapid heartbeat (tachycardia)*
- *Increased appetite*
- *Nervousness, anxiety and irritability*
- *Tremor, fatigue, weakness*
- *Sweating, changes in menstrual patterns, skin thinning*
- *Increased sensitivity to heat*
- *Changes in bowel patterns, especially more frequent bowel movements*
- *Difficulty sleeping*
- *Fine, brittle hair*

## **Reasons for hyperthyroidism:**

- **Graves' disease.** Graves' disease, an autoimmune disorder in which antibodies produced by immune system stimulate thyroid to produce too much thyroid hormone, is the most common cause of hyperthyroidism.

(Normally, immune system uses antibodies to help protect against viruses, bacteria and other foreign substances that invade body. In Graves' disease, antibodies mistakenly attack thyroid. Scientists aren't sure exactly what causes Graves' disease, although several factors — including a genetic predisposition are likely involved.)

- **Hyperfunctioning thyroid nodules (toxic adenoma, toxic multinodular goiter, Plummer's disease)**

- **Thyroiditis**

## *Hypothyroidism:*

*Hypothyroidism (underactive thyroid) is a condition in which thyroid gland doesn't produce enough thyroid hormones*

### *Symptoms:*

- Fatigue, Increased sensitivity to cold*
- Constipation, Weight gain*
- Dry skin, Puffy face*
- Hoarseness*
- Muscle weakness, Muscle aches, tenderness and stiffness*
- Elevated blood cholesterol level*
- Pain, stiffness or swelling in your joints*
- Heavier than normal or irregular menstrual periods*
- Thinning hair*
- Slowed heart rate*
- Depression*
- Impaired memory*

**Cretinism:** Hypothyroidism in children is associated with physical & mental retardation

**Myxoedema:** hypothyroidism in adult & is characterised by bagginess under the eyes, puffiness of face, slow physical & mental activity

**Reasons for hyperthyroidism:**

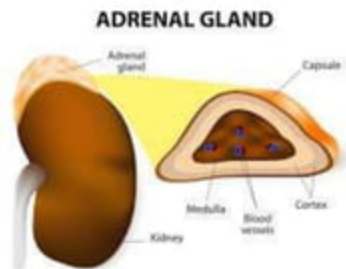
- Autoimmune disease- **Hashimoto's thyroiditis**
- Treatment for hyperthyroidism
- Thyroid surgery
- Radiation therapy
- Medications

## Hormones of adrenal cortex:

Adrenal glands are two small organs located above the kidneys. Each adrenal consist of two distinct tissues- an outer cortex & inner medulla.

As many as 50 steroid hormones, with the name adrenocorticosteroid hormones are produced by adrenal cortex. However, there only a few of them possess biological activity.

1. Glucocorticoid
2. Mineralocorticoid
3. Androgens & estrogens





*Glucocorticoid hormone:*

*The important glucocorticoids are: cortisol, cortisone & corticosterone*

*Functions:*

- 1. Effects on carbohydrate metabolism: promotes synthesis of glucose, increases the blood glucose concentration. The biological action of glucocorticoid is generally opposite of that of insulin*
- 2. Effect on lipid metabolism: it increases the circulating free fatty acids by –  
i) breaking the triacylglycerol & ii) reducing the utilization of plasma free fatty acid*
- 3. Effect on protein & nucleic acid metabolism: they exhibit both anabolic & catabolic effects on protein and nucleic acid*
- 4. Increased glucocorticoid suppresses immune system*
- 5. This hormone increases production of gastric acid & some enzymes*

*Mineralocorticoid hormone:*

*The most important mineralocorticoid is the aldosterone*

*Function of mineralocorticoid is to regulate the water & electrolyte balance. It promotes sodium reabsorption in kidneys*

*Androgens & estrogens:*

*They participate in the sexual development and act through the gonads*

*Abnormalities of adrenocorticosteroid hormones:*

- 1. Addison's disease- because of insufficient adrenal hormone & is characterised by; hypoglycaemia, weight loss, loss of appetite (anorexia), muscle weakness, impaired cardiac function, low BP, decreases Na.*
- 2. Cushing's syndrome- due to hyperfunction of adrenal cortex. Characterised by; hyperglycaemia, fatigue, muscle wasting, oedema, osteoporosis, hypertension.*

### Hormones of reproductive system:

- *reproductive hormones are important for both sexes throughout life, starting with early fetal development where hormones have a key role in sexual differentiation. For teenagers, hormonal changes give rise to puberty*
- *the gonads (testes in males & ovaries in females) produce these hormones*
- *These are steroid in nature and are responsible for growth, development, maintenance & regulation of reproductive system.*

*Following are the hormones of the reproductive system*

***Androgens:***

- In males*
- Steroid hormone*
- Produced by testes in men and adrenal gland & ovaries of females also produce in small amount*
- Cholesterol is the precursor for synthesis of androgens*
- Active form of androgen is testosterone*

### *Functions of androgens (testosterone):*

- 1. Growth, development & maintenance of male reproductive organs*
- 2. Sexual differentiation & secondary sexual characteristics (maturation of testes & penis)*
- 3. Spermatogenesis (the making of sperms)*
- 4. Promote the development of facial & body hair, the growth of larynx & strengthening of muscles*
- 5. Androgen promote RNA & protein synthesis*
- 6. Increase glycolysis, citric acid cycle*
- 7. Promote mineral deposition & bone growth*

## **Estrogen:**

- *In females*
- *Steroid hormone*
- *Estrogens are predominantly ovarian hormones, synthesized by the ovaries*
- *Precursor is cholesterol*

### *Functions of estrogens*

- 1. Growth, development & maintenance of female reproductive organs*
- 2. Development of female sexual characters (breast development, maturation of vagina, uterus, fallopian tubes during puberty)*
- 3. Maintenance of menstrual cycles*
- 4. Increases lipogenesis ( & hence women have relatively more fat than men)*
- 5. Lowers plasma cholesterol (& hence low incidence of CHD in women during reproductive age)*
- 6. Helps in bone growth*

## **Progesterone:**

- *Steroid hormone*
- *Synthesized by corpus luteum of ovary & placenta*
- *Cholesterol is the precursor*

### *Functions:*

- 1. Helps to prepare the endometrium (womb lining) for the implementation of an fertilized egg & maintenance of pregnancy*
- 2. Prepares mammary glands for milk production*



***Follicle stimulating hormone (FSH) & luteinising hormone (LH) are the gonadotrophic hormones. Both are released by the pituitary gland into the bloodstream***

- Follicle stimulating hormone is one of the hormones essential to pubertal development and the function of women's ovaries and men's testes. In women, this hormone stimulates the growth of ovarian follicles in the ovary before the release of an egg from one follicle at ovulation*
- In men, follicle stimulating hormone acts on the cells of the testes to stimulate sperm production (spermatogenesis)*
- LH stimulates synthesis of estrogens & progesterone*
- LH also promotes androgens synthesis by testes*

## Hormones involved in calcium phosphate homeostasis

The hormones – calcitriol, parathyroid hormone and calcitonin regulate the level of calcium phosphate in blood

### **Calcitriol:**

- this is the physiological active form of vitamin D
- calcitriol induces the synthesis of a specific calcium binding protein in the intestinal cells
- This protein increases the intestinal absorption of calcium and phosphate
- Calcitriol also stimulates calcium uptake by osteoblasts of bone.

**Parathyroid hormone:** the prime function of PTH is to elevate serum calcium level

- *Action on bone: PTH causes decalcification or demineralization of bone. Demineralization ultimately leads to an increase in the blood calcium level*
- *Action on the kidney: PTH increases the Ca reabsorption by kidney tubules. This is the most rapid action of PTH to elevate blood calcium level.*
- *Action on intestine: increases the intestinal absorption of Ca by promoting the synthesis of calcitriol*

## **Calcitonin:**

- *synthesized by thyroid gland*
- *Calcitonin promotes calcification of bones*
- *Decreases bone resorption, increases excretion of Ca into urine, thus has a decreasing influence on blood calcium level & hence is regarded as antagonistic to PTH*

***Thank you***