INTRODUCTION TO ENDOCRINOLOGY

By Dr. Dinesh Chouhan

INTRODUCTION

- All the physiological activities of the body are regulated by two major systems:

1. **NERVOUS SYSTEM**
2. **ENDOCRINE SYSTEM**

- These two systems interact with one another and regulate the body functions.
- Endocrine system functions by secreting some chemical substances called hormones.

CELL-TO-CELL SIGNALING

- Cell to cell signaling refers to the transfer of information from one cell to another.
- It is also called **cell signaling** or intercellular communication.
- The cells of the body communicate with each other through some chemical substances called chemical messengers.

CHEMICAL MESSENGERS

- Chemical messengers are the substances involved in cell signaling.
- These messengers are mainly secreted from endocrine glands.
- Some chemical messengers are secreted by nerve endings and the cells of several other tissues also.

- All these chemical messengers carry the message (signal) from the **signaling cells (controlling cells)** to the **target cells.**
- The messenger substances may be the hormones or hormone like substances.

CLASSIFICATION OF CHEMICAL MESSENGERS

- Generally the chemical messengers are classified into two types:

1. CLASSICAL HORMONES SECRETED BY ENDOCRINE GLANDS
2. LOCAL HORMONES SECRETED FROM OTHER TISSUES

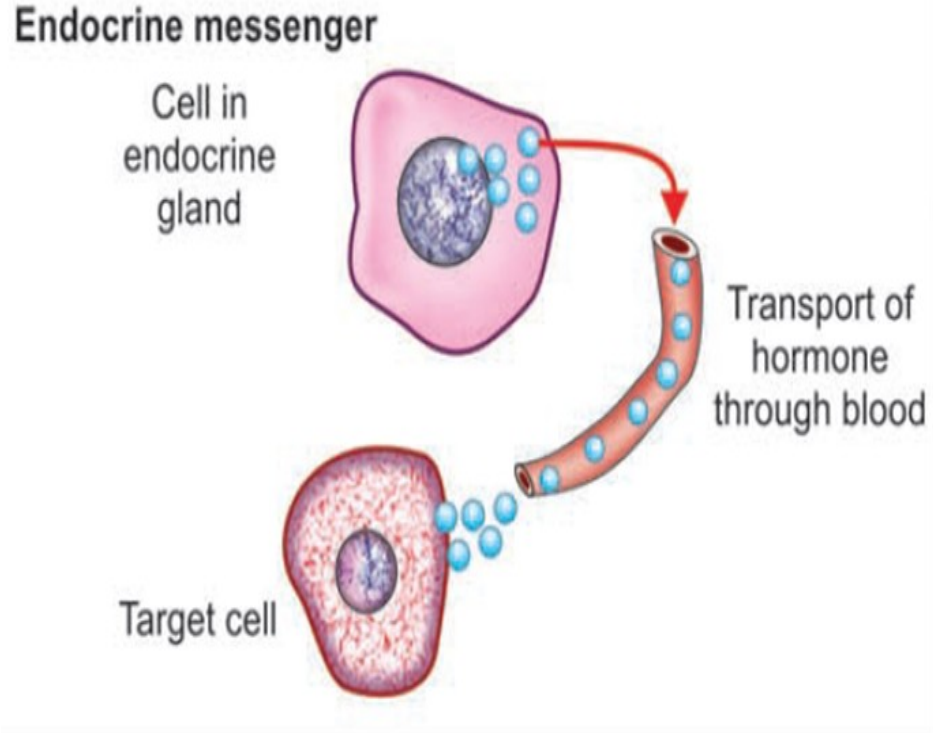
- However, recently chemical messengers are classified into four types:

1. Endocrine messengers
2. Paracrine messengers

3. Autocrine messengers
4. Neurocrine messengers.

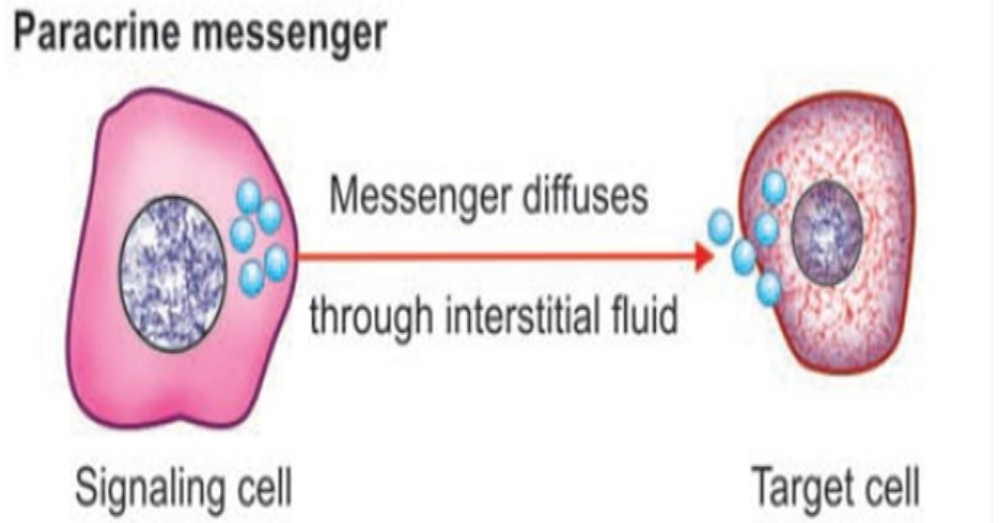
1. ENDOCRINE MESSENGERS

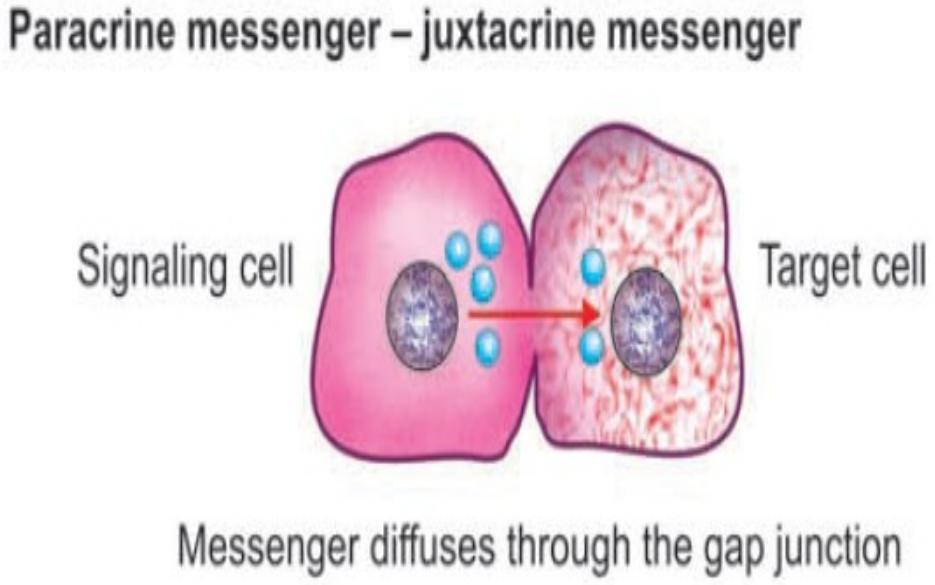
- Endocrine messengers are the classical hormones.
- A hormone is defined as a chemical messenger, synthesized by endocrine glands and transported by blood to the target organs or tissues (site of action).
- Examples are growth hormone and insulin.



2. PARACRINE MESSENGERS

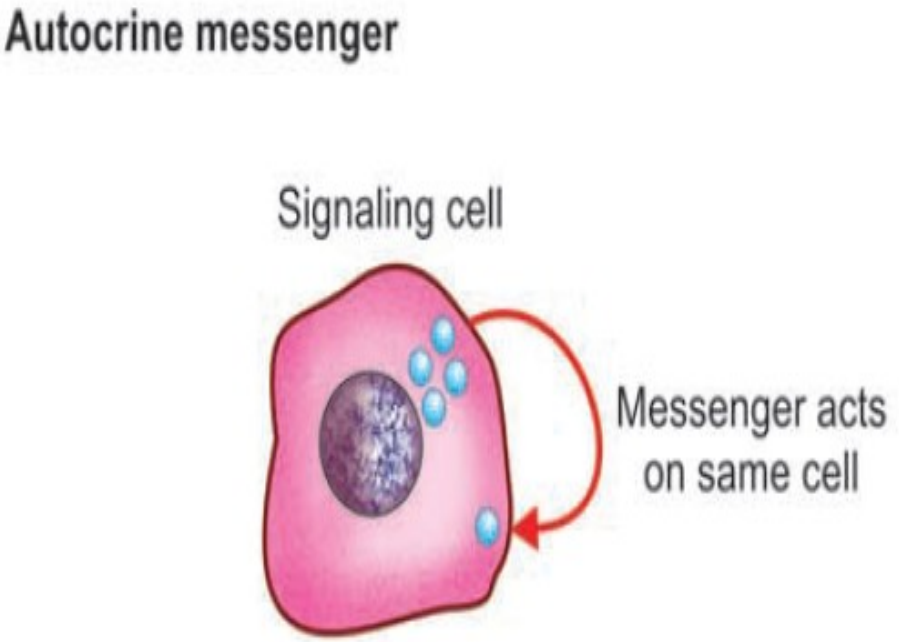
- Paracrine messengers are the chemical messengers, which diffuse from the control cells to the target cells through the interstitial fluid.
- Some of these substances directly enter the neighboring target cells through gap junctions.
- Such substances are also called **juxtacrine messengers** or **local hormones.**
- Examples are prostaglandins and histamine.





3. AUTOCRINE MESSENGERS

- Autocrine messengers are the chemical messengers that control the source cells which secrete them.
- So, these messengers are also called **intracellular chemical mediators.**
- Examples are leukotrienes.

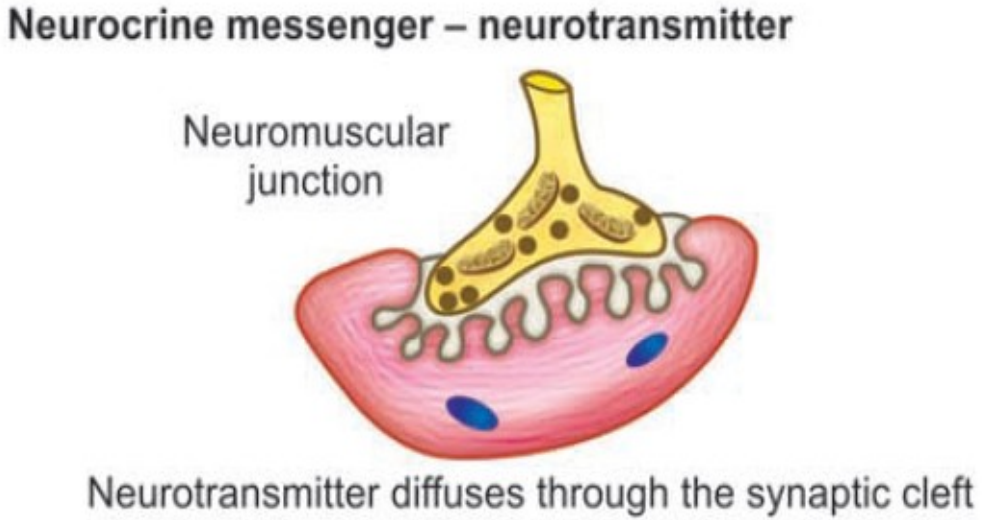


4. NEUROCRINE OR NEURAL MESSENGERS

- Neurocrine or neural messengers are neurotransmitters and neurohormones.

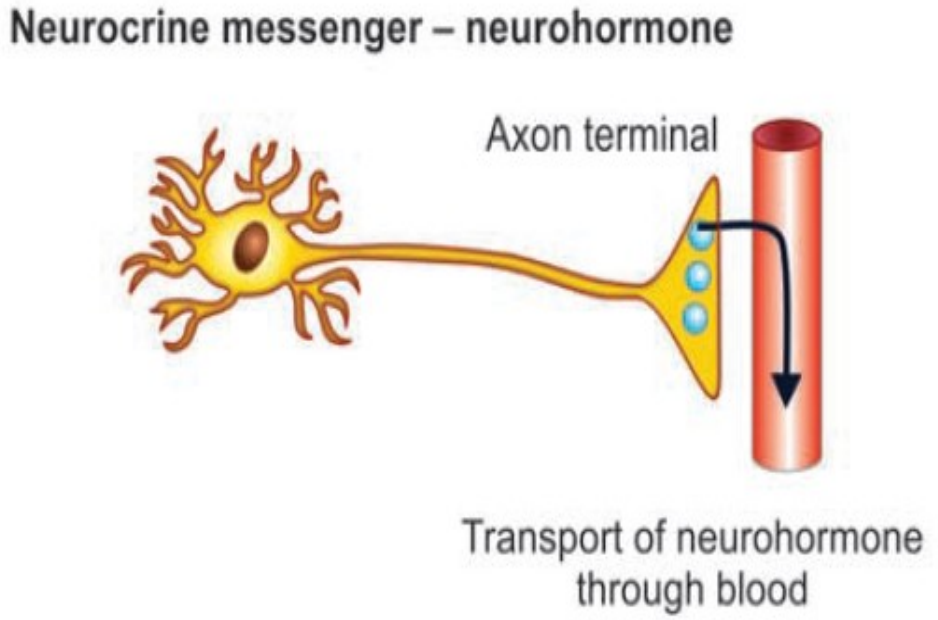
A. Neurotransmitter

- Neurotransmitter is an endogenous signaling molecule that carries information form one nerve cell to another nerve cell or muscle or another tissue.
- Examples are acetylcholine and dopamine.



B. Neurohormone

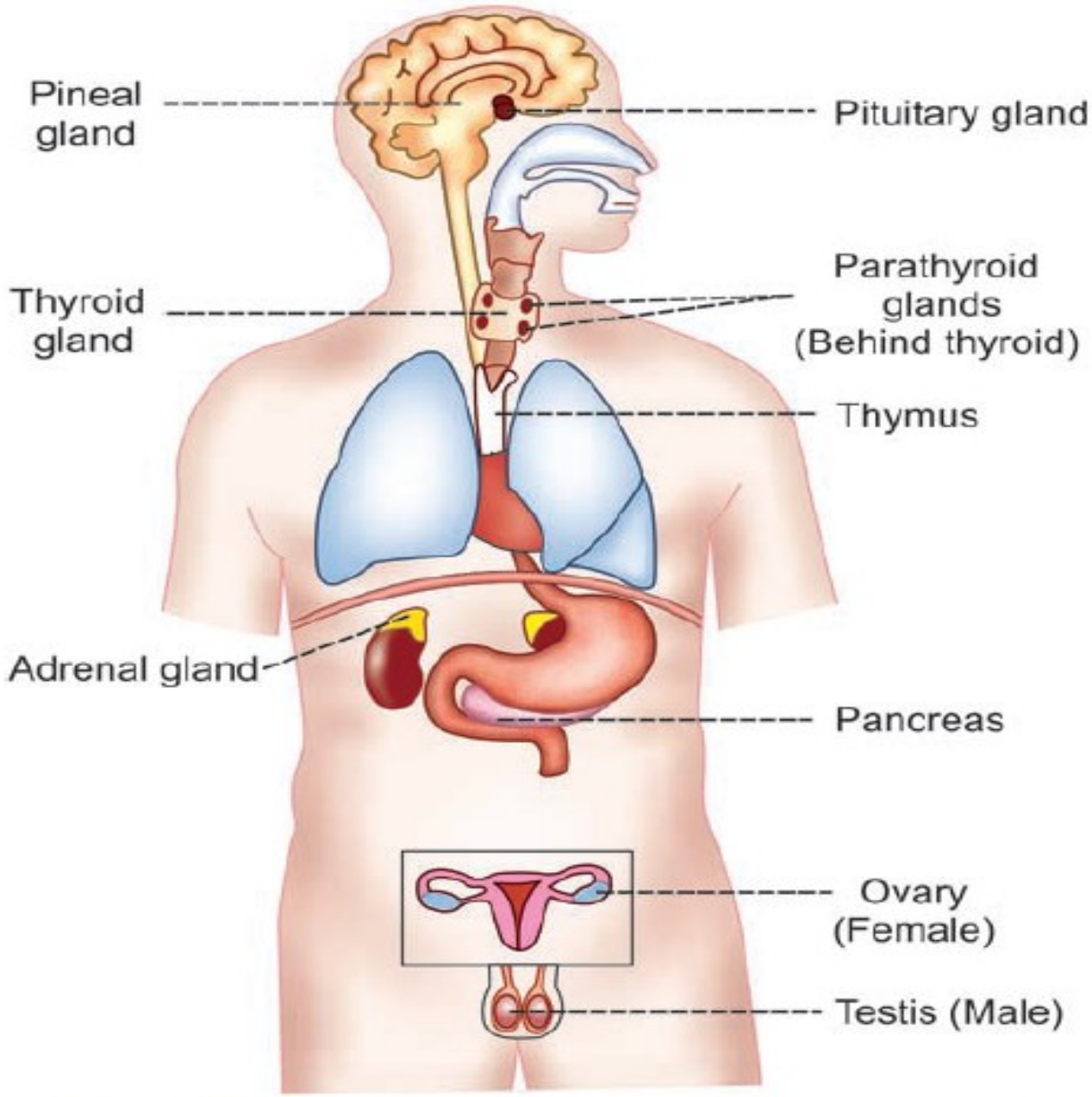
- Neurohormone is a chemical substance that is released by the nerve cell directly into the blood and transported to the distant target cells.
- Examples are oxytocin, antidiuretic hormone and hypothalamic releasing hormones.



ENDOCRINE GLANDS

- Endocrine glands are the glands which synthesize and release the classical hormones into the blood.
- Endocrine glands are also called **ductless glands** because the hormones secreted by them are released directly into blood without any duct.
- Hormones are transported by blood to target organs or tissues in different parts of the body, where the actions are executed.
- Endocrine glands play an important role in homeostasis and control of various other activities in the body through their hormones.

MAJOR ENDOCRINE GLANDS



HORMONES SECRETED BY ENDOCRINE GLANDS

Anterior pituitary	1. Growth hormone (GH) 2. Thyroid-stimulating hormone (TSH) 3. Adrenocorticotropic hormone (ACTH) 4. Follicle stimulating hormone (FSH) 5. Luteinizing hormone (LH) 6. Prolactin	Adrenal cortex	*Mineralocorticoids* 1. Aldosterone 2. 11-deoxycorticosterone
			Glucocorticoids 1. Cortisol 2. Corticosterone
Posterior pituitary	1. Antidiuretic hormone (ADH) 2. Oxytocin		*Sex hormones* 1. Androgens 2. Estrogen 3. Progesterone
Thyroid gland	1. Thyroxine (T_4) 2. Triiodothyronine (T_3) 3. Calcitonin		
Parathyroid gland	Parathormone	Adrenal medulla	1. Catecholamines 2. Adrenaline (Epinephrine) 3. Noradrenaline (Norepinephrine) 4. Dopamine
Pancreas – Islets of Langerhans	1. Insulin 2. Glucagon 3. Somatostatin 4. Pancreatic polypeptide		

HORMONES SECRETED BY GONADS

Testis	1. Testosterone 2. Dihydrotestosterone 3. Androstenedion
Ovary	1. Estrogen 2. Progesterone

HORMONES SECRETED BY OTHER ORGANS

Pineal gland	Melatonin
Thymus	1. Thymosin 2. Thymin
Kidney	1. Erythropoietin 2. Thrombopoietin 3. Renin 4. 1,25-dihydroxycholecalcifero (calcitriol) 5. Prostaglandins
Heart	1. Atrial natriuretic peptide 2. Brain natriuretic peptide 3. C-type natriuretic peptide
Placenta	1. Human chorionic gonadotropin (HCG) 2. Human chorionic somatomammotropin 3. Estrogen 4. Progesterone

HORMONES

- A hormone is defined as a chemical messenger, synthesized by endocrine glands and transported by blood to the target organs or tissues (site of action).
- Examples are growth hormone and insulin.

CLASSIFICATION OF HORMONES

- Hormones are **chemical messengers,** synthesized by endocrine glands.
- Based on chemical nature, hormones are classified into three types:

1. STEROID HORMONES
2. PROTEIN HORMONES
3. DERIVATIVES OF THE AMINO ACID CALLED TYROSINE.

1. STEROID HORMONES

- Steroid hormones are the hormones synthesized from cholesterol or its derivatives.
- Steroid hormones are secreted by adrenal cortex, gonads and placenta.

2. PROTEIN HORMONES

- Protein hormones are large or small peptides.
- Protein hormones are secreted by pituitary gland, parathyroid glands, pancreas and placenta ('P's).

3. TYROSINE DERIVATIVES

- Two types of hormones, namely thyroid hormones and adrenal medullary hormones are derived from the amino acid tyrosine.

HORMONAL ACTION

- Hormone does not act directly on target cells.
- First it combines with receptor present on the target cells and forms a **hormone-receptor complex.**
- This hormonereceptor complex induces various changes or reactions in the target cells.

HORMONE RECEPTORS

- Hormone receptors are the large proteins present in the target cells.
- Each cell has thousands of receptors.
- Important characteristic feature of the receptors is that, each receptor is specific for one single hormone, i.e. each receptor can combine with only one hormone.

SITUATION OF THE HORMONE RECEPTORS

- Hormone receptors are situated either in cell membrane or cytoplasm or nucleus of the target cells as follows:

1. CELL MEMBRANE

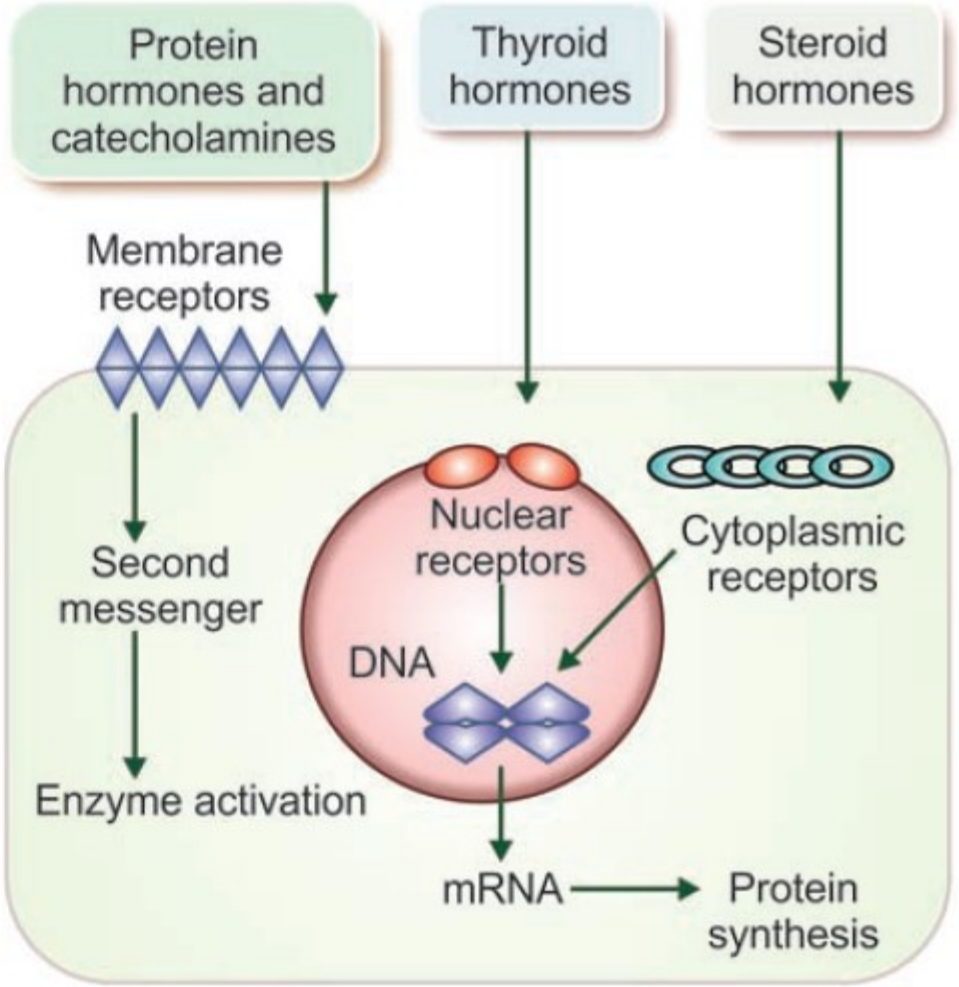
- Receptors of protein hormones and adrenal medullary hormones (catecholamines) are situated in the cell membrane.

2. CYTOPLASM

- Receptors of steroid hormones are situated in the cytoplasm of target cells.

3. NUCLEUS

- Receptors of thyroid hormones are in the nucleus of the cell.



REGULATION OF HORMONE RECEPTORS

- Receptor proteins are not static components of the cell.
- Their number increases or decreases in various conditions.
- Generally, when a hormone is secreted in excess, the number of receptors of that hormone decreases due to binding of hormone with receptors. This process is called **down regulation.**
- During the deficiency of the hormone, the number of receptor increases, which is called **upregulation.**
- Hormone in the form of hormone-receptor complex enters the target cell by means of endocytosis and executes the actions. The whole process is called **internalization.**

- After internalization, some receptors are recycled, whereas many of them are degraded and new receptors are formed.
- Formation of new receptors takes a long time.
- So, the number of receptors decreases when hormone level increases.

MECHANISM OF HORMONAL ACTION

- Hormone does not act on the target cell directly.
- It combines with receptor to form hormone-receptor complex.
- This complex executes the hormonal action by any one of the following mechanisms:

1. BY ALTERING PERMEABILITY OF CELL MEMBRANE

2. BY ACTIVATING INTRACELLULAR ENZYME
3. BY ACTING ON GENES

BY ALTERING PERMEABILITY OF CELL MEMBRANE

- Neurotransmitters in synapse or neuromuscular junction act by changing the permeability of post synaptic membrane.
- For example, in a neuromuscular junction, when an impulse (action potential) reaches the axon terminal of the motor nerve, acetylcholine is released from the vesicles.
- Acetylcholine increases the permeability of the postsynaptic membrane for sodium ions.
- So sodium ions enter the neuromuscular junction from ECF through the channels and cause the development of endplate potential.

BY ACTIVATING INTRACELLULAR ENZYME

- Protein hormones and the catecholamines act by activating the intracellular enzymes.

FIRST MESSENGER

- The hormone which acts on a target cell, is called first messenger or **chemical mediator.**
- It combines with the receptor and forms hormone-receptor complex.

SECOND MESSENGER

- Hormone-receptor complex activates the enzymes of the cell and causes the formation of another substance called the second messenger or **intracellular hormonal mediator.**

- Second messenger produces the effects of the hormone inside the cells.
- Protein hormones and the catecholamines act through second messenger.
- Most common second messenger is cyclic AMP.
- In addition to cAMP, some other substances also act as second messengers like Calcium ions and calmodulin, Inositol triphosphate, Diacylglycerol etc.

Cyclic AMP

- Cyclic AMP, cAMP or cyclic adenosine 3′5′- monophosphate acts as a second messenger for protein hormones and catecholamines.

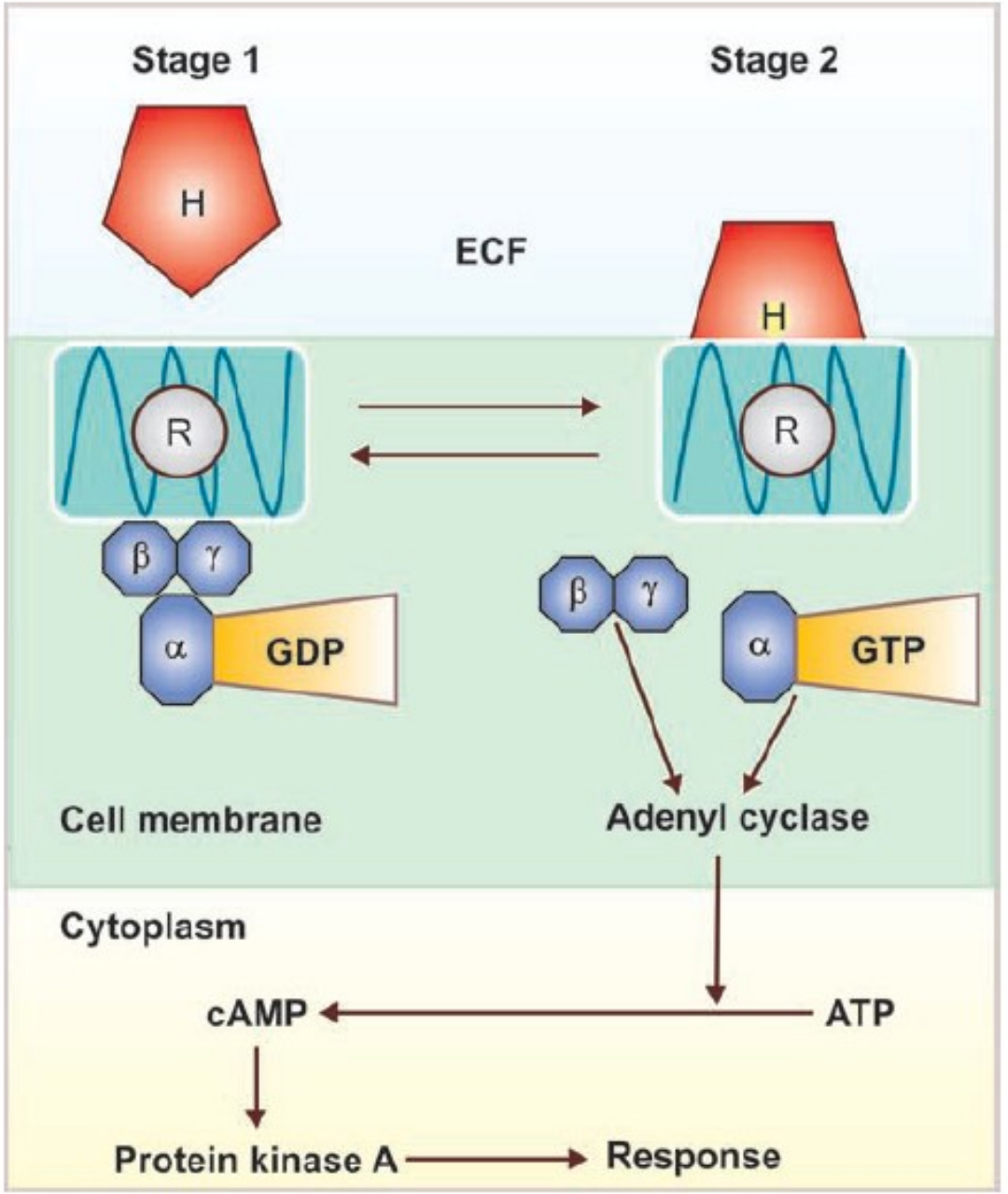
Actions of cAMP

- Cyclic AMP executes the actions of hormone inside the cell by stimulating the enzymes like protein kinase A.

Response produced by cAMP

- Cyclic AMP produces one or more of the following responses:

i. Contraction and relaxation of muscle fibers
ii. Alteration in the permeability of cell membrane
iii. Synthesis of substances inside the cell
iv. Secretion or release of substances by target cell
v. Other physiological activities of the target cell.



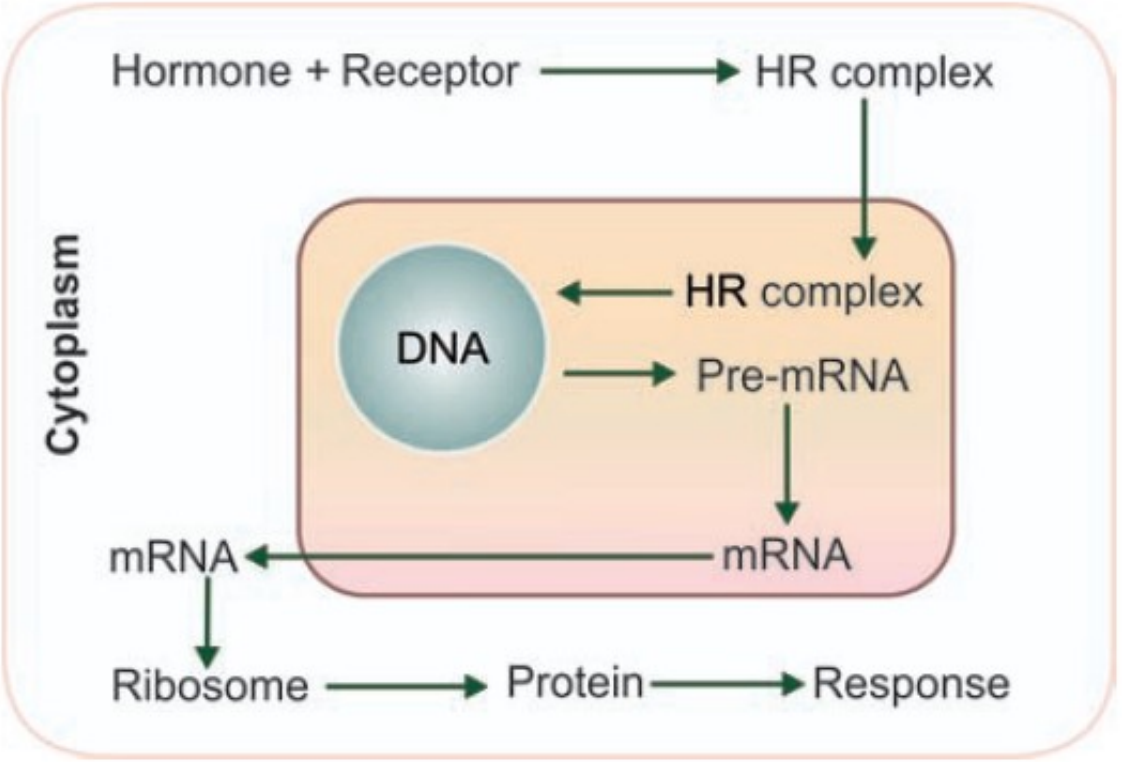
BY ACTING ON GENES

- Thyroid and steroid hormones execute their function by acting on genes in the target cells.

Sequence of Events during Activation of Genes

i. Hormone enters the interior of cell and binds with receptor in cytoplasm (steroid hormone) or in nucleus (thyroid hormone) and forms hormonereceptor complex.
ii. Hormone-receptor complex moves towards the DNA and binds with DNA.
iii. This increases transcription of mRNA.
iv. The mRNA moves out of nucleus and reaches ribosomes and activates them.

v. Activated ribosomes produce large quantities of proteins
vi. These proteins produce physiological responses in the target cells.



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