Endocrine

The endocrine glands are groups of cells that produce specific chemicals, called hormones, **having well defined effects on body functions**. They are also called ***ductless glands*** since **their secretion is not conveyed along ducts but pass directly into blood and lymphatic vessels.**

- **General features of hormones:**

  - A specific chemical substance (with a specific composition),
  - Secreted by ductless gland,
  - **In a catalytic amount (very small amounts),**
  - Transported by the blood stream (direct or indirect through lymphatics),
  - To a specific target cells (which have a specific hormone receptors),
  - **Where it produces physiologic, morphologic and biochemical responses**

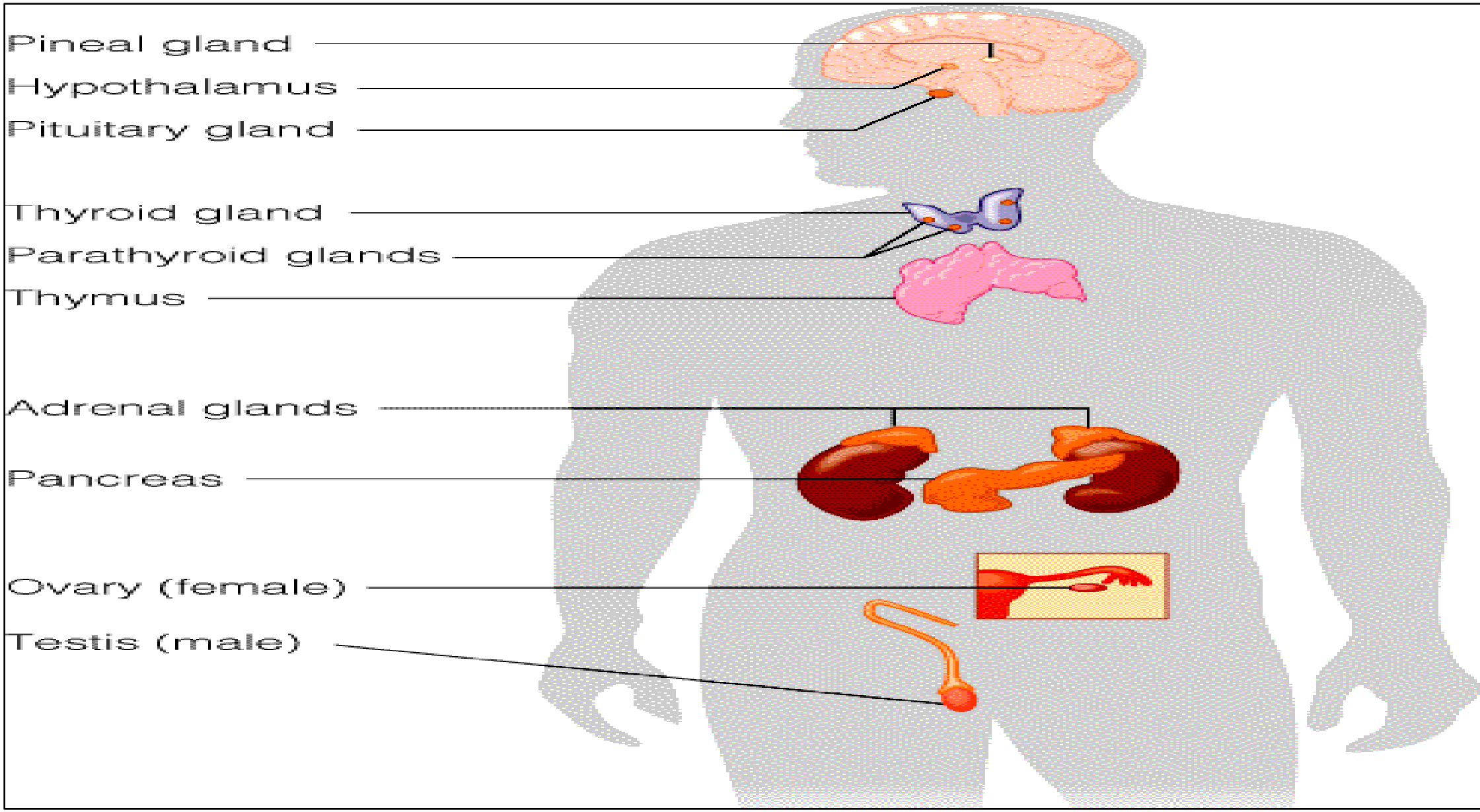


Fig. (1): Endocrine glands

Neuro-endocrine system:

- **Both nervous and endocrine systems** form together a biological communication network for integration **of the body response to a changing environment.**

Examples of this link:

1- **Hypothalamic neurosecretory cells, which produce substances that are delivered into the hypothalamo-hypophyseal portal blood vessels** and transported to the anterior pituitary where they regulate the secretion of the **adenohypophyseal hormones**. Other hypothalamic neurons send their axons to the posterior pituitary, where they **release neurosecretory products directly into the blood stream.**

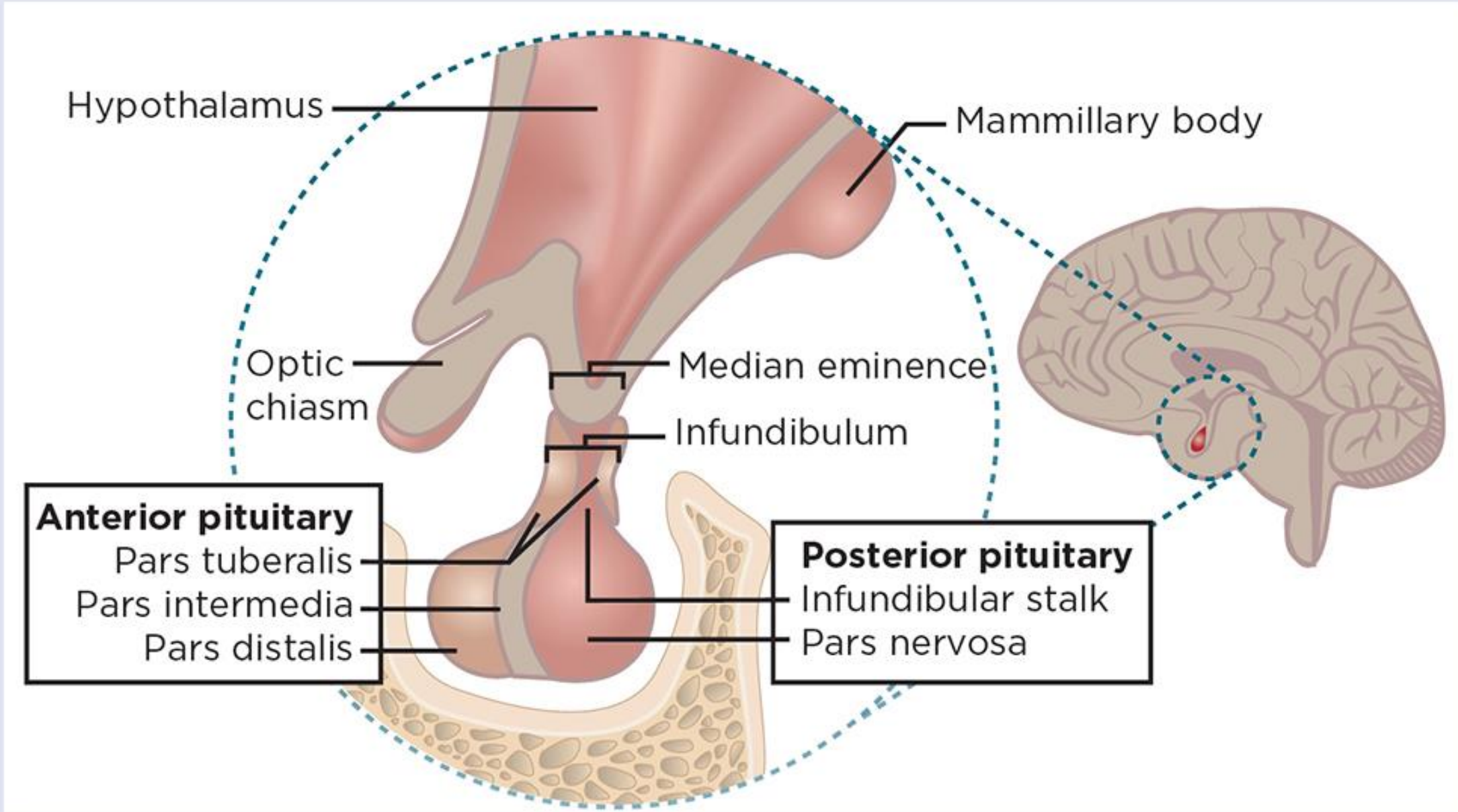
2- Innervation of the endocrine glands: Most, if not all, **endocrine glands, including the gonads, the thyroid and the adrenals receive** nerves that appear to control both their blood supply and their secretory activity.

3-In turn, hormones of the thyroid as well as**, gonadal and adrenocortical steroids act directly on the CNS** and either inhibit or stimulate the secretory activity of the hypothalamic neurons.

Hormone secreting tissues:

Virtually all organs of the body exhibit endocrine function.

Fig 1. **Anatomy of the hypothalamus and pituitary gland**



I-Endocrine glands:

1- The hypothalamus which has 2 endocrinal functions:

a) Controls the secretion of the anterior pituitary gland, by:

ii- Releasing hormones for: thyrotropin, corticotropin and gonadotropin.

b) Releases the posterior pituitary hormones: antidiuretic hormone and oxytocin.

2- The pituitary gland, which is formed mainly of 2 lobes:

a) The anterior lobe which releases:

i- **Its own primary hormones**: growth hormone and prolactin hormone as well as **melanocyte stimulating hormone, β-lipoproteins, and β-endorphin**.

Ii- **Trophic hormones** which regulate the functions of all the other endocrine glands **except the parathyroid glands, the pancreas and the adrenal medulla.**

b) The posterior lobe which releases antidiuretic and oxytocin hormones.

3- The thyroid gland which releases: **thyroxin, tri-iodothyronine and calcitonin hormones.**

4- The parathyroid glands which **release parathormone hormone.**

5- The suprarenal glands. Each is formed of cortex and medulla:

a) **Cortex, which** is the outer part of the gland and releases:

- **Mineralocorticoid hormones e.g. aldosterone hormone.**
- **Glucocorticoid hormones e.g. cortisol.**
- **Androgenic corticoids** e.g. dehydro-epiandrosterone.

b) **Medulla, the** inner part of the gland, which releases the catecholamines **epinephrine and norepinephrine**, together with some dopamine.

6- The endocrine portion of the pancreas (islets of Langerhans):

a) Alpha cells **release glucagons hormone.**

b) Beta cells release insulin hormone.

c) Delta cells **which secrete somatostatine hormone.**

d) F cells which release pancreatic polypeptide.

7- The primary sex organs:

a) **The testes** (male gonads) **which release the male sex hormone, testosterone**. They also release small amounts of androstenedione, dihydrotestosterone, **estradiol, inhibin, and mullerian-inhibiting substance**.

b) **The ovaries** (female gonads) which release oestrogen and progesterone hormones, as well as some testosterone, **androstenedione, inhibin, activin, FSH-releasing peptide and relaxin.**

8- The thymus gland **which releases thymosin hormone**.

9- The pineal gland **which releases melatonin hormone**.

II- Other organs with endocrine functions:

- The production of hormones is not confined only to the above endocrine glands, for example:

a) **Heart: atrial natriuretic factor (ANF).**

b) **Kidney:** erythropoietic factor, renin and active vitamin D_3.

c) **Liver: somatomedins, 25-hydroxycholecalciferol.**

d) **Skin: calciferol (from 7-dehydrocholesterol).**

e) **Gastrointestinal tract: gastrin, pancreozymine, secretin, vasoactive intestinal peptide (VIP).**

f) **Placenta:** estrogen, progesterone, human chorionic gonadotropin (HCG), human ***chorionic somatomammotropin (HCS), luteinizing hormone releasing hormone (LHRH), and relaxin hormone***.

Local hormones: Some hormones act only locally, e.g.:

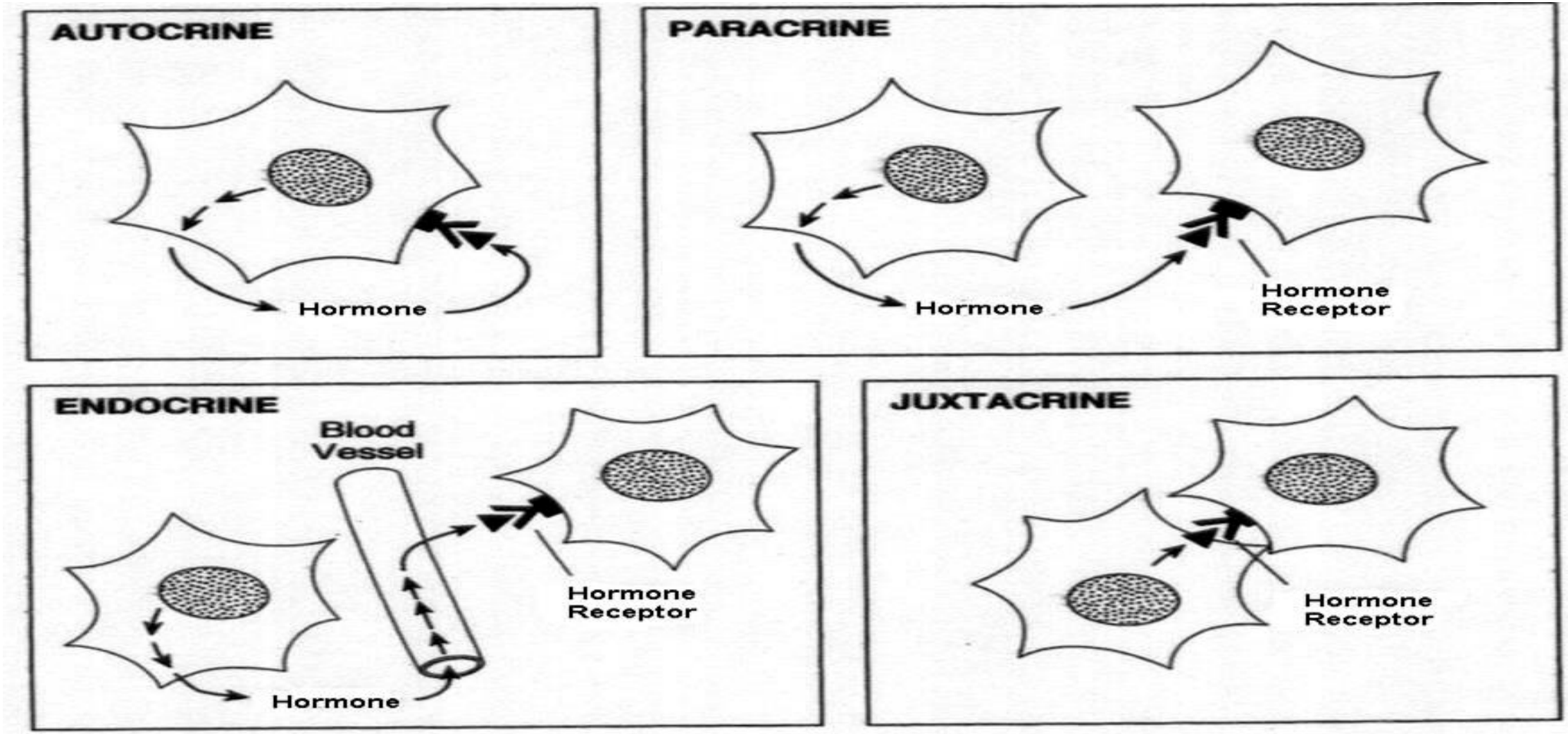
1- **Paracrine hormones,** which diffuse for a short distance through the interstitial space to affect neighbouring cells.

2- **Autocrine hormones**, which act on the same cells that produce them.

3- **Juxtacrine, whereby one cell interact with specific receptor on juxta-posed cells**

4- Of these local hormones are: Prostaglandins, histamine,

5-hydroxytryptamine (serotonin), bradykinin, epinephrine, norepinephrine, acetylcholine, endorphins, encephalins, GIT hormones, and many others.



Various mechanisms of hormone action. ***Autocrine, paracrine*** **and** ***juxtacrine*****,** refer to a local hormone action (see text), **while *endocrine* refers to a mechanism by which the hormone enters the blood and reaches a target cell via circulation.**

Chemical nature of hormones:

Mammalian hormones fall into two main general classes:

1. **Protein hormones:** which can be further subdivided into:

   a) ***Small molecular weight (a.a.) hormones:*** Thyroid hormones from tyrosine, **catecholamines from phenylalanine, and melatonin from tryptophan**.

   b) ***Polypeptides*** e.g. anterior and posterior pituitary gland hormones, calcitonin, **parathyroid hormone, pancreatic hormones, erythropoietin, renin, GIT hormones and relaxin**.

2. Steroid hormones: These are derived from cholesterol and include:

a) Adrenal cortical hormones.

b) Sex hormones.

c) Active metabolites of vitamin D.

- The **synthesis** of both amine and steroid hormones takes place through series of enzymatic reactions **whereas peptide hormones are synthesized as proteins in the ribosomes.**

- Catecholamines and polypeptide hormones are stored in secretory granules but other **amine and steroid hormones** are accommodated in discrete compartments within the cytoplasm.

- **Most endocrine glands produce their hormones continually at levels determined by:**

a) Requirements.

b) Rate of hormone inactivation.

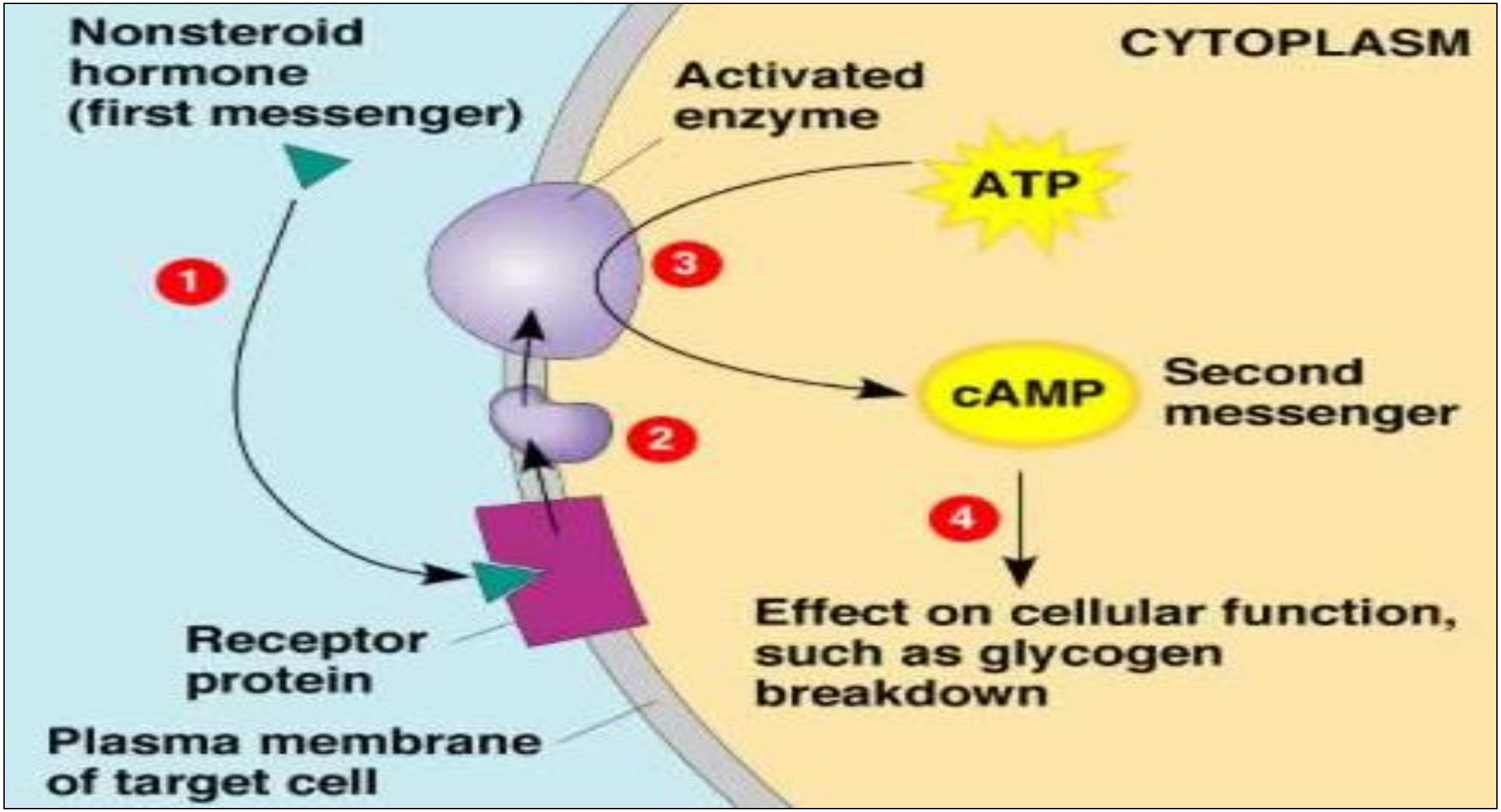
c) Rate of hormone clearance from the body.

Mechanism of hormone action:

- To exert its action, the hormone **must first bind to specific, high affinity cellular receptors.**

- **These receptors may be located at:**

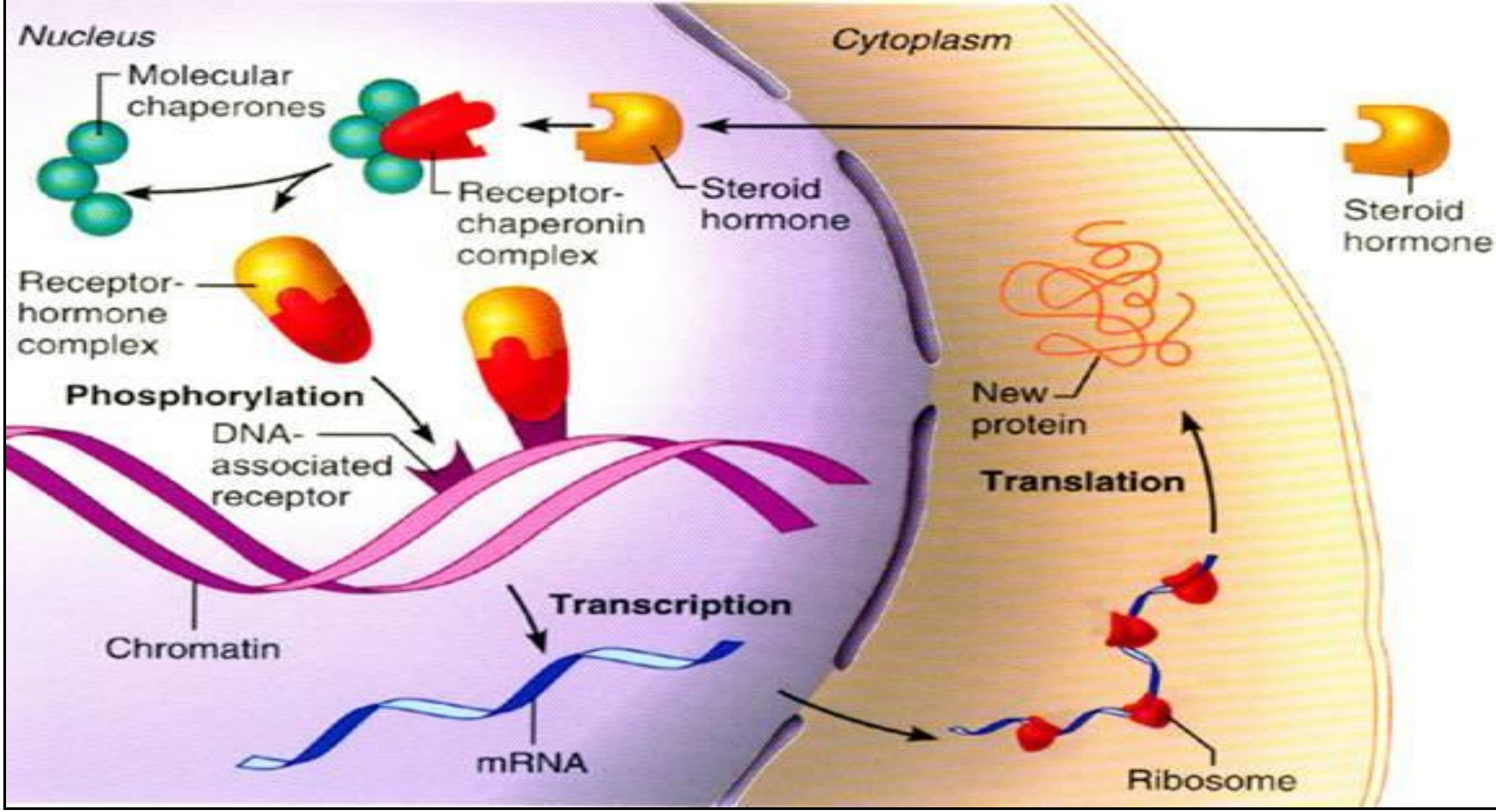
1- The cell membrane (surface) receptors: Hormones that are water soluble, such as **peptide hormones, catecholamines and other neurotransmitters interact with receptors on the surface of target cells**



Mechanism of action of protein hormones.

2. The intracellular receptors:

- **Steroid and thyroid hormones enter the cells by pinocytosis**.
- They exert these actions on target cells by **binding to specific receptors, which are located within the nucleus (thyroid) or the cytoplasm (cortisol**).
- Inside the nucleus, **the hormone – receptor complex** stimulates the transcription of **DNA** to **mRNA**.
- **mRNA activates the synthesis of specific protein molecules with enzyme activity**
- **This mechanism also applies to *active vitamin D***.



: Schematic representation of a steroid hormone responsive cell.

Control of hormone secretion:

1- Neurohumor or neurosecretion:

- It is released **by a nerve cell or group of cells and reaches the endocrine glands via blood vessels or nerve fibres**.

- Hypothalamic production of releasing and inhibitory factors or hormones is an example of this type of control.

- ***Also the release of posterior pituitary hormones from terminals of the hypothalamohypophyseal tract is another example.***

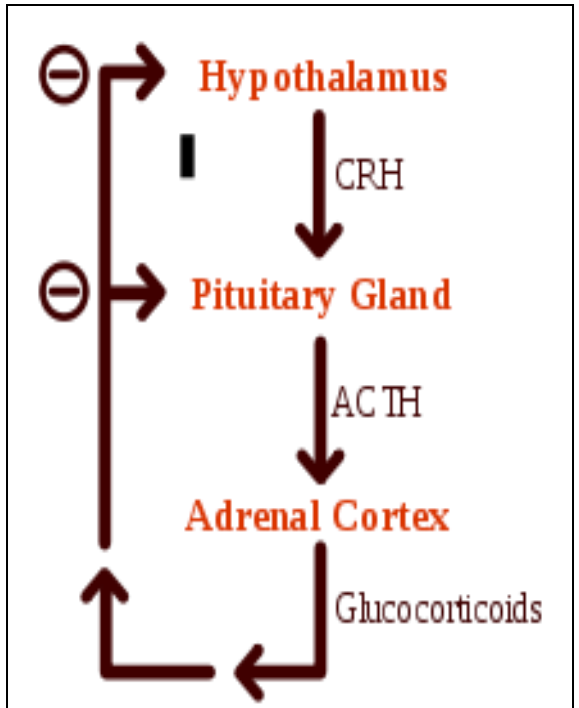
2- Direct innervation, usually **done by autonomic fibres e.g. sympathetic control of the adrenal medulla.**

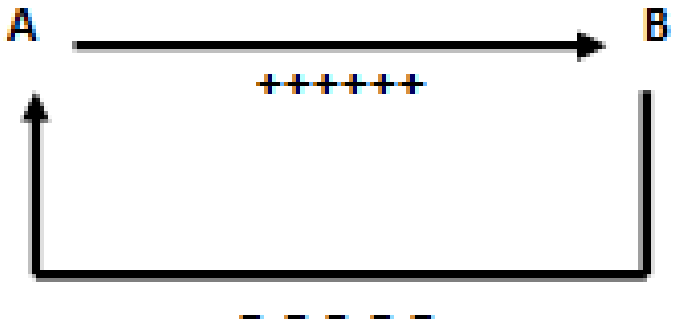
3- Feed-back control:

a) Negative feed-back: (More common).

Definition:

A relation in which "if the ***target gland hormone (B)*** **is increased, the rate of secretion of its *pituitary tropic & hypothalamic releasing hormones (A)* will be decreased**".





Example:

Control of cortisol hormone secretion.

b) Positive feed-back: (Less common).

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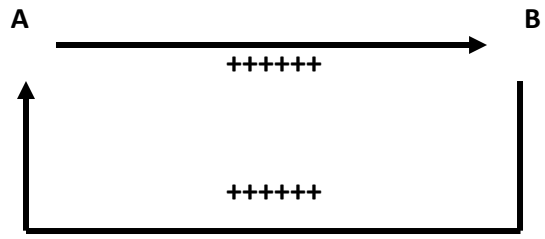


A relation in which "if the ***target gland hormone (B)***

is <u>increased</u>, the rate of secretion of its

pituitary tropic & hypothalamic releasing hormones (A) will be <u>increased"</u>.

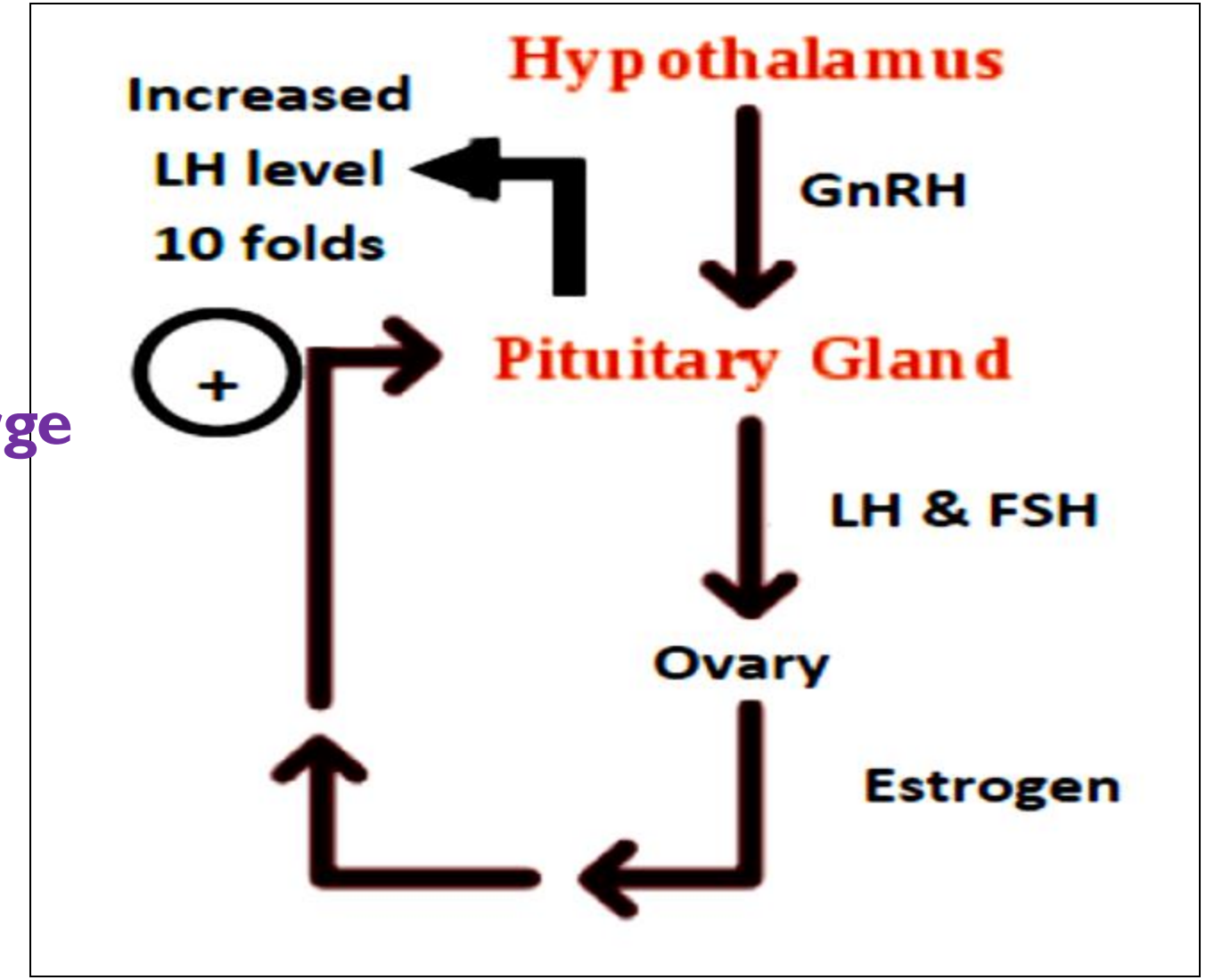
This relation increases the target gland hormone more and more. **When the target gland hormone reaches sufficient level *negative feedback* r**eturns again to reduce the hormone to its final level.

Significance:

Temporary amplification of the biological effects of the hormone.

Example:

Pre-ovulatory LH surge



: **Positive feedback**

N.B.: According to level of action, this feed-back control system may be:

- **- Long loop feed-back**: **It represents the relationship of trophic anterior pituitary hormones** and their target gland hormones.
- **- Short loop feed-back:** The inter-relation **between pituitary trophic hormones and the hypothalamic releasing** and release-inhibiting hormones.

4- Blood level of:

a) Organic substances other than hormones e.g. **the relation between blood glucose level and the secretion of pancreatic hormones**.

b) Inorganic substances e.g. **the relation of blood calcium level and parathyroid and calcitonin hormones**. Another example is the relation between Na and K with aldosterone. **The plasma level of the inorganic substances also determines the osmotic pressure of the blood, thus their concentration is monitored by the hypothalamus through the release of the antidiuretic hormone (ADH).**

5- Effect of cytokines:

- **Cytokines are small proteins produced by various cell types in response to stimuli arising** from **different physiological and pathophysiological states**.
- These cytokines modulate endocrine functions **by acting on the endocrine glands and on the hormonally responsive tissues.**
- ***Example: Cytokine hormones*** (e.g., leptin) produced by adipocytes are sometimes **called *adipokines*. *Leptin* suppresses growth hormone** (GH) **through stimulation of somatostatin, suppresses gonadotropins and stimulates the pituitary–adrenal axis.**

1-Which of these hormones are considered a primary hormone of the anterior pituitary gland?

a) ACTH

Oxytocin (b

TSH (c

ADH (d

Growth hormone (e

2-Which of these hormones produces its actions through binding to intracellular receptors?

a. Catecholamines

Anterior pituitary hormones .b

Pancreatic hormones .c

Thyroid hormone .d

Calcitonin .e

3-Which is an example of positive feedback mechanism regulating hormonal action?

a) ACTH on hypothalamic CRH

Glucocorticoid on ACTH (b

TSH on TRH (c

Preovulatory LH surge (d

GH on GHRH of hypothalamus (e

4- Which of these hormones is considered a cytokine hormone?

Epinephrine (a

Leptin (b

Growth hormone (c

Insulin (d

Endorphin (e