# Endocrinology

## Introduction to Endocrinology

# OBJECTIVES

- Introduction of endocrine glands
- basic differences between nervous & endocrine control
- Types of chemical messenger systems/ Various forms of intercellular communication
- Chemical nature of hormones

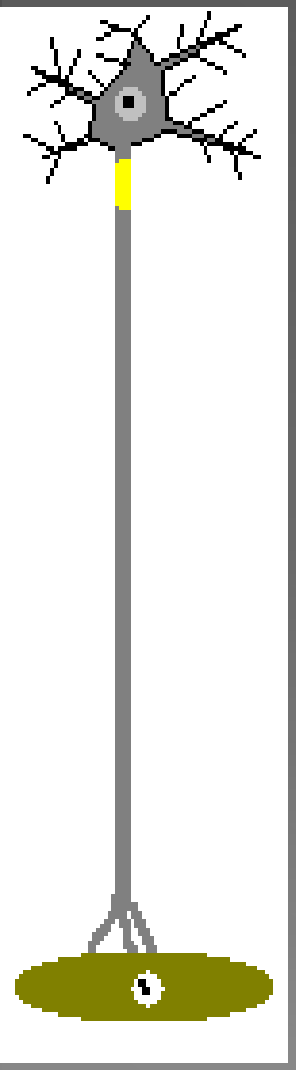
# OBJECTIVES

- Secretion, transport and clearance of hormones from the blood
- Feedback control systems of hormones
- Measurement of hormone conc in blood

# CONTROL SYSTEMS OF THE BODY

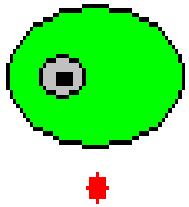
- The following two systems are called the control systems of the body.
- 1. Nervous system
- 2. Endocrine system

# Nervous system

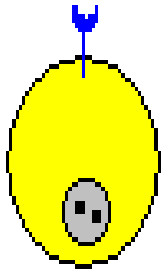


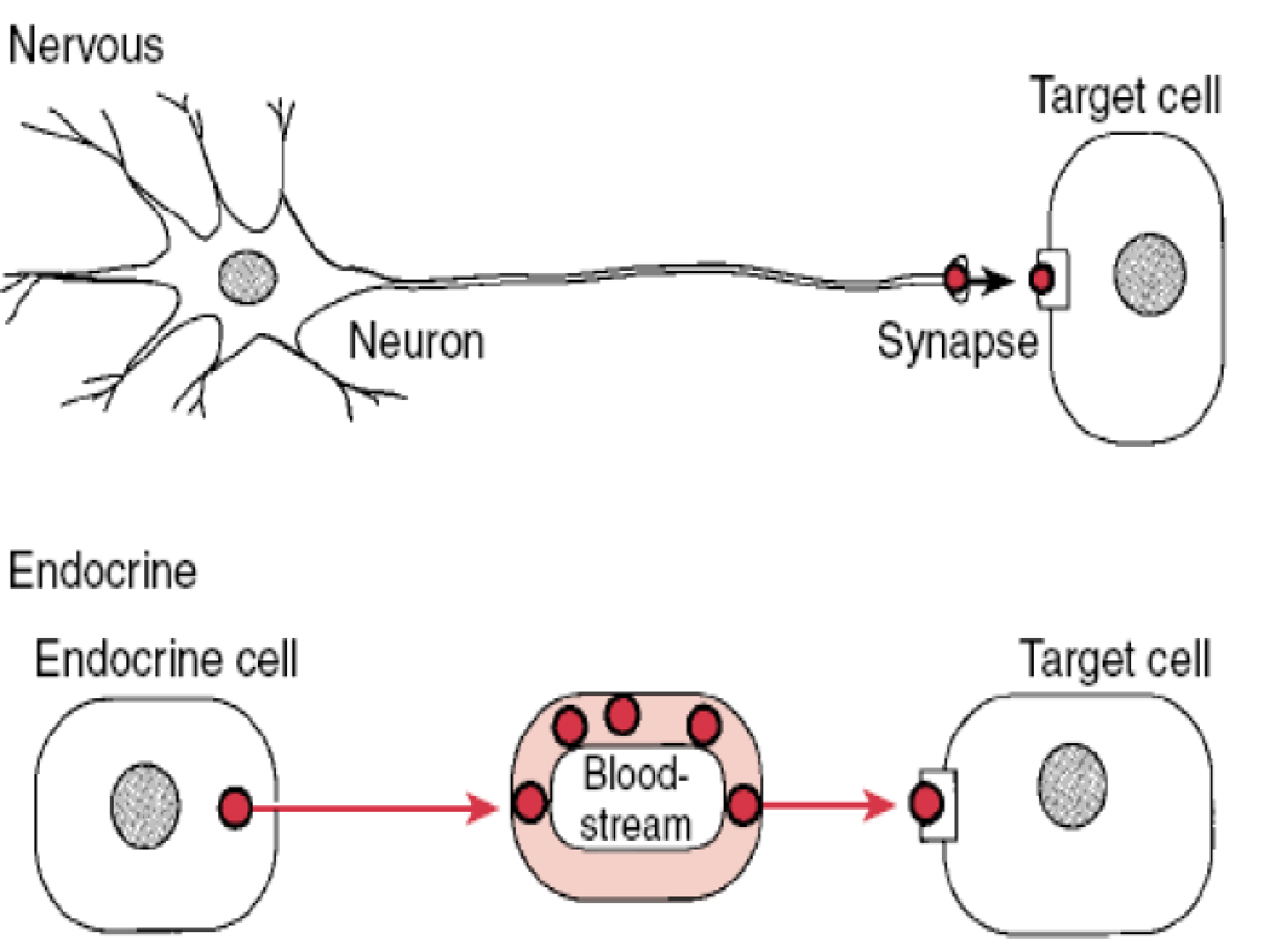
- Nervous control is electrical in nature and fast.
- co-ordinates body functions through transmission of electro- chemical impulses.
- Chemical messenger is neurotransmitters.
- exerts point-to-point control through nerves, similar to sending messages by conventional telephone.

# Endocrine system



- co-ordinates body functions by a chemical messenger called hormone
- sends its messages to essentially all cells by secretion of hormones into blood and extracellular fluid.
- Like a radio broadcast, it requires a receiver to get the message
- cells must bear a *receptor* for the hormone being broadcast in order to respond.
- slow




Nervous
Target cell
Neuron
Synapse
Endocrine
Endocrine cell
Target cell
Blood-
stream

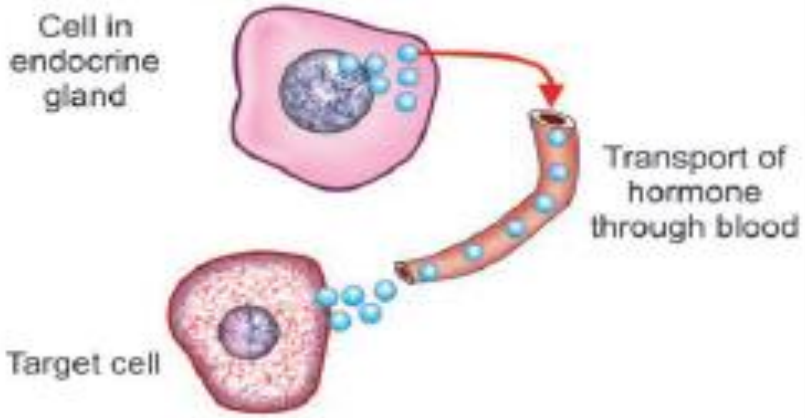
# Coordination of Body Functions by Chemical Messengers

Cells communicate with one another via chemical messengers.

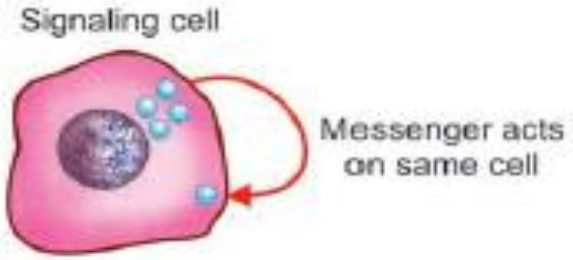
- Neurotransmitters
- Endocrine hormones
- Neuroendocrine hormones
- Paracrines
- Autocrines
- Cytokines

| Chemical Messengers | Released by | Function |
|---|---|---|
| Neurotransmitters | Axon terminals of neurons into the synaptic junctions | Act locally to control nerve cell functions |
| Endocrine hormones | Glands or specialized cells into the circulating blood | Influence the function of target cells at another location in the body |
| Neuroendocrine hormones | Secreted by neurons into the circulating blood | Influence the function of target cells at another location in the body |
| Paracrines | Secreted by cells into the extracellular fluid | Affect neighboring target cells of a different type. |
| Autocrines | Secreted by cells into the extracellular fluid | Affect the function of the same cells that produced them. |
| Cytokines | Secreted by cells into the extracellular fluid | Can function as autocrines, paracrines, or endocrine hormones. |

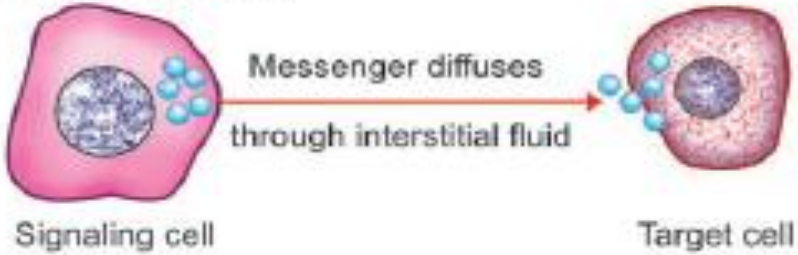
**Endocrine messenger**




**Autocrine messenger**

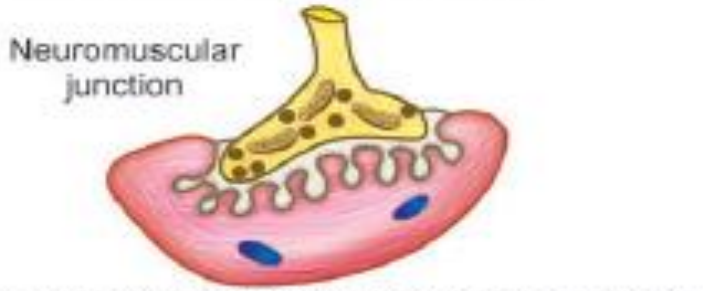



**Paracrine messenger**

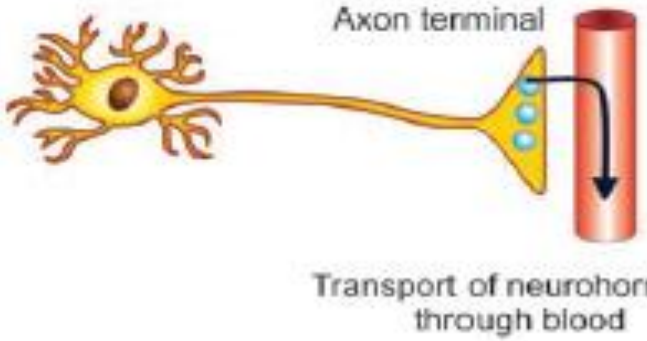


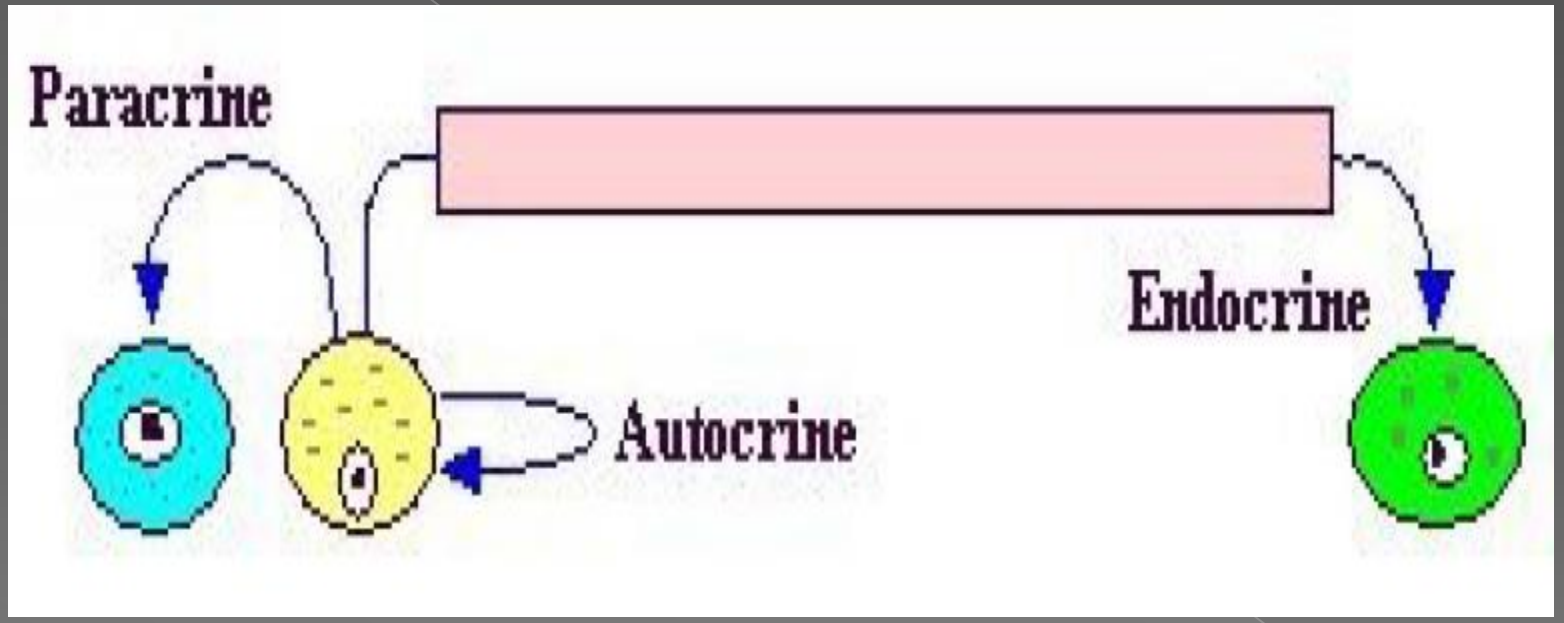

**Paracrine messenger – juxtacrine messenger**

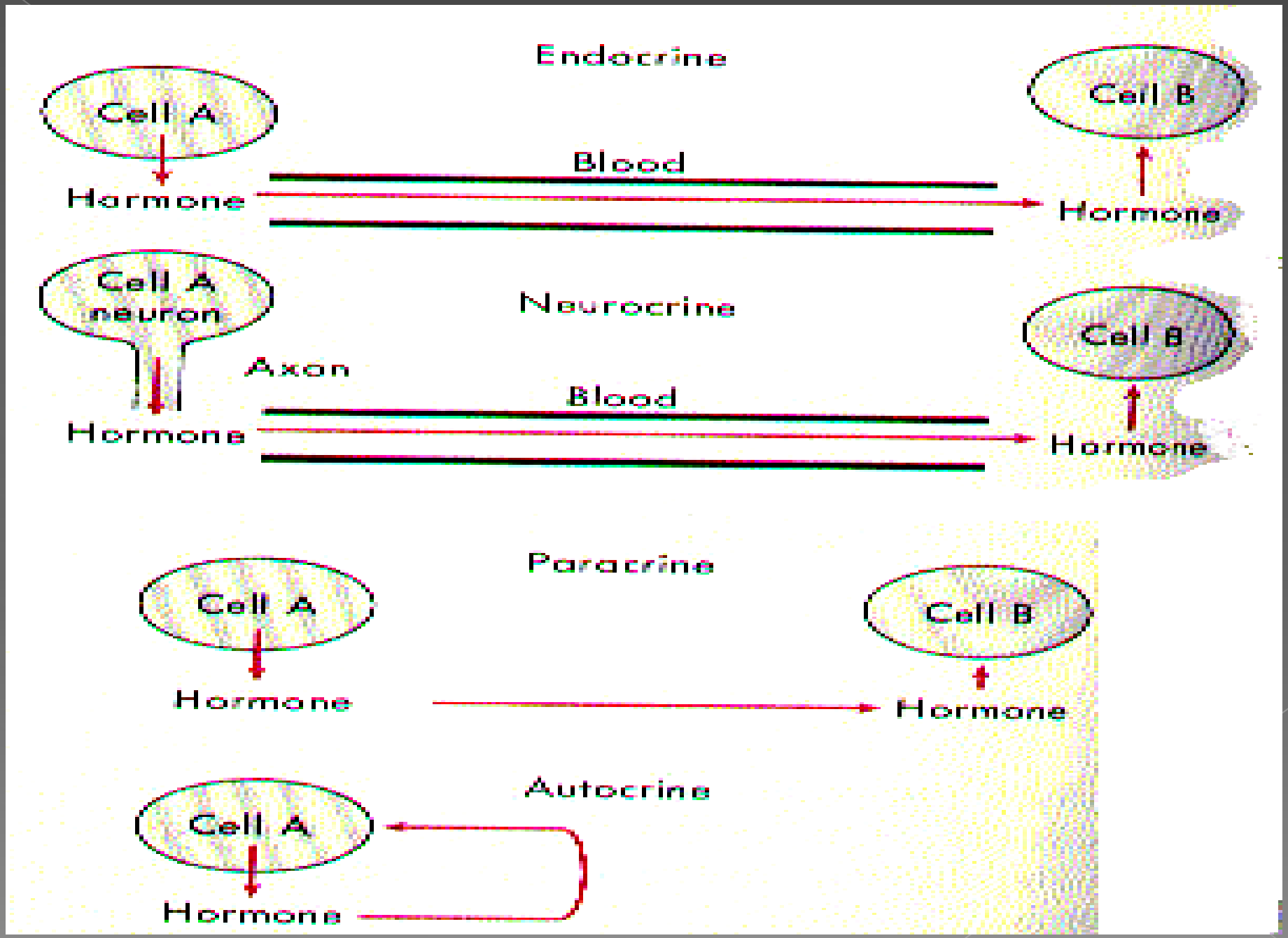

**Neurocrine messenger – neurotransmitter**




**Neurocrine messenger – neurohormone**




Paracrine
Endocrine
Autocrine


Endocrine
Cell A
Hormone
Blood
Cell B
Hormone
Neurocrine
Cell A
neuron
Axon
Hormone
Blood
Cell B
Hormone
Paracrine
Cell A
Hormone
Cell B
Hormone
Autocrine
Cell A
Hormone

## Cytokines

peptides secreted by cells into the extracellular fluid and can function as autocrines, paracrines, or endocrine hormones.

**Examples**

interleukins and other lymphokines that are secreted by **helper cells** and act on other cells of the immune system.

**Cytokine** hormones **(e.g.**, leptin) produced by adipocytes are sometimes called **adipokines**.

# ENDOCRINE GLANDS

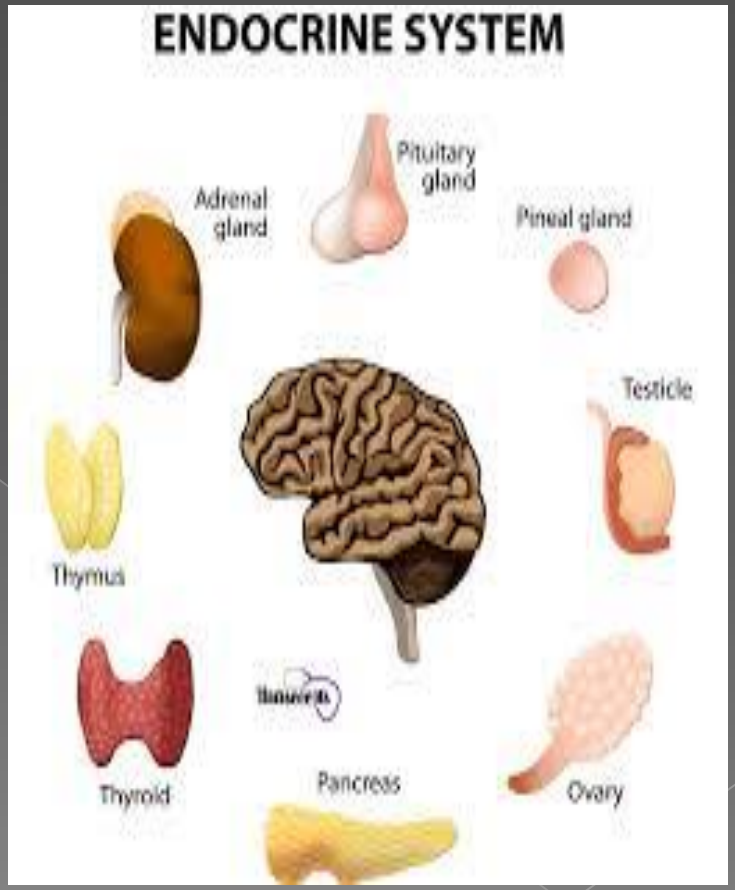
- Endocrine glands synthesize and release classical hormones into the blood.
- also called **ductless glands**
- hormones are released directly into blood without any duct.
- are distinct from exocrine glands which release their secretions through ducts.

# WHAT IS HORMONE?

- A hormone is a chemical substance which is secreted into the internal body fluids by one cell or a group of cells and exerts physiological control effect on other cells of the body.

# ENDOCRINE GLANDS

- 1. Pituitary gland
- 2. Thyroid gland
- 3. Parathyroid gland
- 4. Islets of Langerhans of pancreas
- 5. Adrenal glands
- 6. Testes or ovaries
- **Temporary endocrine glands:**
- 1. Placenta
- 2. Corpus luteum



**Organs or tissues having endocrine functions:**

| **Organs** | Hormones |
|---|---|
| Hypothalamus | Releasing hormones |
| Heart | Atrial Natriuretic peptide (ANP) |
| Kidney | Renin, Erythropoietin, 1,25-dihydrocholecalciferol |
| Stomach | Gastrin |
| Small intestine | Secretin, CCK |
| Adipocytes | Leptin |

# Chemical Classification of Hormones

**1. Polypeptides and proteins.**

Polypeptide hormones generally contain less than 100 amino acids; an example is antidiuretic hormone.

Protein hormones are polypeptides with more than 100 amino acids; growth hormone is an example.

**2. Amines.**

hormones derived from the amino acids tyrosine and tryptophan. They include the hormones secreted by the adrenal medulla and thyroid

# Chemical Classification of Hormones

**3. Steroids.**

These are lipids derived from cholesterol. They include

- testosterone
- estrogen
- progesterone
- cortisol

| Hormone | Secreted from | Example |
| --- | --- | --- |
| Proteins and polypeptide hormones | 1. Pituitary gland<br>2. Parathyroid gland<br>3. Pancreas (Islets of Langerhans)<br>4. Placenta<br>5. Hypothalamus | 1. Growth hormone<br>2. Parathormone<br>3. Insulin<br>4. HCG<br>5. TRH |
| Derivatives of the amino acid tyrosine | 1. Thyroid gland<br>2. Adrenal Medulla | 1. Thyroxin<br>2. Adrenaline. |
| Steroid hormones | 1. Adrenal cortex<br>2. Testes<br>3. ovaries<br>4. Placenta | 1. Aldosterone<br>2. Testosterone<br>3. Estrogen<br>4. Progesterone |

# According to the locations of hormone receptors

| Hormone | Example |
| --- | --- |
| Cell Membrane | Protein, peptide and catecholamine hormones. |
| Cell Cytoplasm | Steroid hormones |
| Cell Nucleus | Thyroid hormones |

- **hydrophilic**
- peptide hormones
- catecholamines

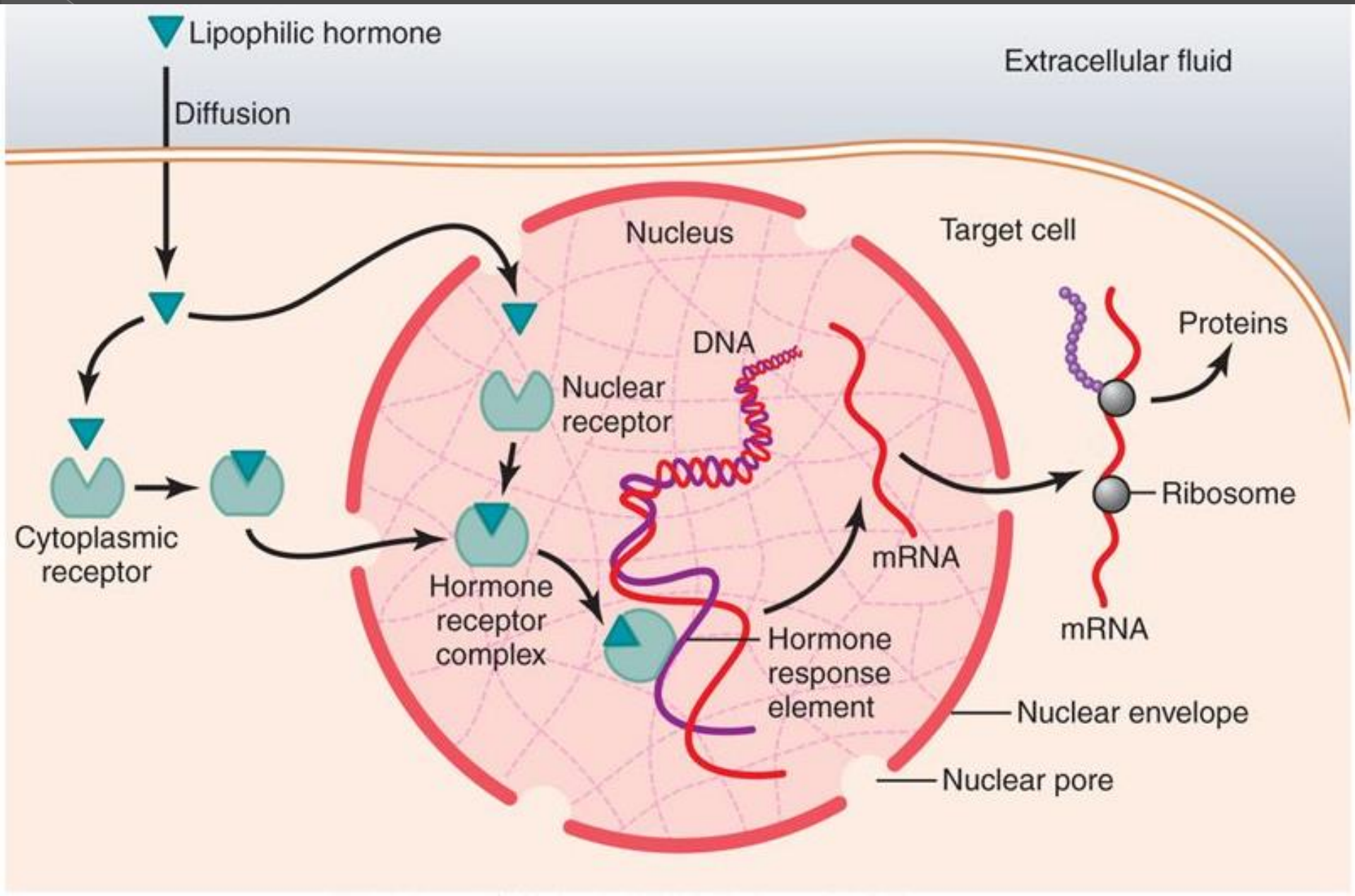
- **Lipophilic**
- steroid hormones
- thyroid hormone

**hydrophilic hormones**

on binding with surface membrane receptors primarily act through second-messenger systems to alter the activity of preexisting proteins, such as enzymes, within the target cell to produce their physiologic response.

**Lipophilic hormones**

Steroid and thyroid hormone activate genes on binding with receptors inside the cell, thus bringing about formation of new proteins in the target cell that carry out the desired response.

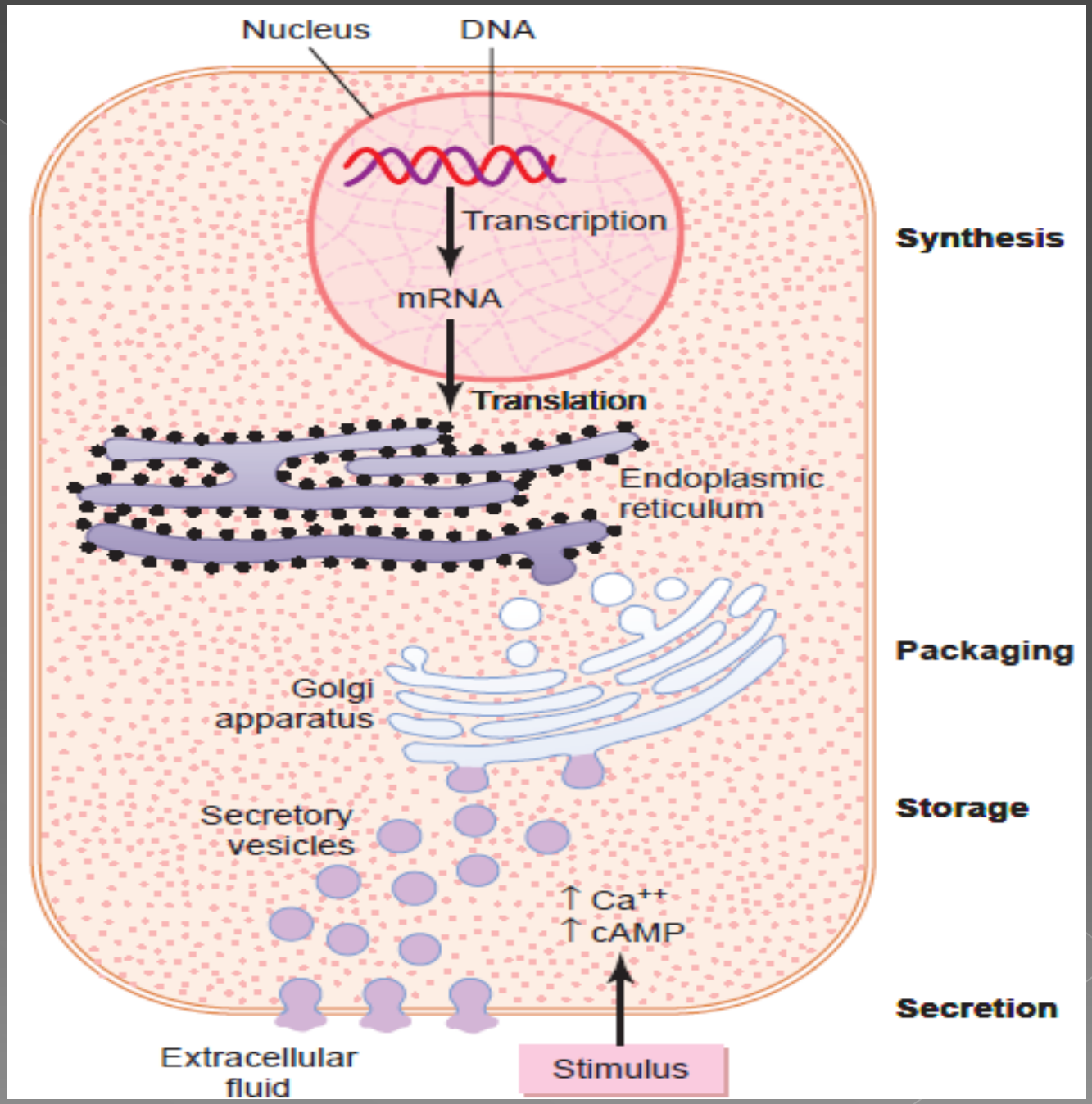

Lipophilic hormone
Diffusion
Extracellular fluid
Nucleus
Target cell
DNA
Nuclear receptor
Proteins
Ribosome
Cytoplasmic receptor
Hormone receptor complex
mRNA
mRNA
Hormone response element
Nuclear envelope
Nuclear pore

# Synthesis of Hormones

# 1. Polypeptides and proteins.

- synthesized on the rough endoplasmic reticulum
- Synthesized first as larger proteins ***preprohormones*** that are not biologically active
- cleaved to form smaller ***prohormones*** in ER
- transferred to the Golgi apparatus for packaging into secretory vesicles
- enzymes in the vesicles cleave prohormones to produce smaller, biologically active **hormones**

- vesicles are stored within the cytoplasm, and many are bound to the cell membrane until their secretion is needed.
- Secretion of the hormones occurs when the secretory vesicles fuse with the cell membrane and the
- granular contents are extruded into the interstitial fluid or directly into the blood stream by *exocytosis*


Nucleus
DNA
Transcription
mRNA
Translation
Endoplasmic reticulum
Golgi apparatus
Secretory vesicles
↑ Ca++
↑ cAMP
Extracellular fluid
Stimulus
Synthesis
Packaging
Storage
Secretion

# 2. Steroid Hormones

- Steroid Hormones Are Usually Synthesized from Cholesterol
- Are Not Stored
- Much of the cholesterol in steroid-producing cells comes from the plasma, but there is also de novo synthesis of cholesterol in steroid-producing cells.
- steroids are highly lipid soluble, once they are synthesized, they simply diffuse across the cell membrane and enter the interstitial fluid and then the blood.

# 3. Amine Hormones

- Are Derived from Tyrosine

- The two groups of hormones derived from tyrosine, the thyroid and the adrenal medullary hormones, are formed by the actions of enzymes in the cytoplasmic compartments of the glandular cells.

# Thyroid hormones

- synthesized and stored in the thyroid gland
- Incorporated into macromolecules of the protein *thyroglobuli*
- stored in large follicles within the thyroid gland.
- Hormone secretion occurs when the amines are split from thyroglobulin
- free hormones are then released into the blood stream.
- In blood, most of the thyroid hormones combine with plasma proteins, especially *thyroxine-binding globulin*
- *Slowly* releases the hormones to the target tissues.

# Catecholamines
# Epinephrine and norepinephrine

- formed in the adrenal medulla
- taken up into preformed vesicles and
- Stored in secretory granules until secreted.
- released by exocytosis.
- Once enter the circulation, can exist in the plasma in free form or in conjugation with other substances.