Lecture 01:
An Overview of Endocrine System

Zana Rafiq Majeed, Ph.D.

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Introduction to Endocrine Principles

- **Homeostasis** involves coordinating the activities of the various organs and systems throughout the body.
- At any given moment, cells of the **nervous** and **endocrine systems** are working together, monitoring and adjusting the body's **physiological activities.**
- The **endocrine system** produces **long-term responses** by releasing chemicals directly into the bloodstream.

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- These chemicals, called **hormones** (meaning “to excite”), alter the **metabolic activities** of many different tissues and organs.
- The endocrine system includes all the endocrine cells and tissues of the body that produce hormones.
- Hormones are **chemical messengers** that stimulate specific cells or tissues into action.

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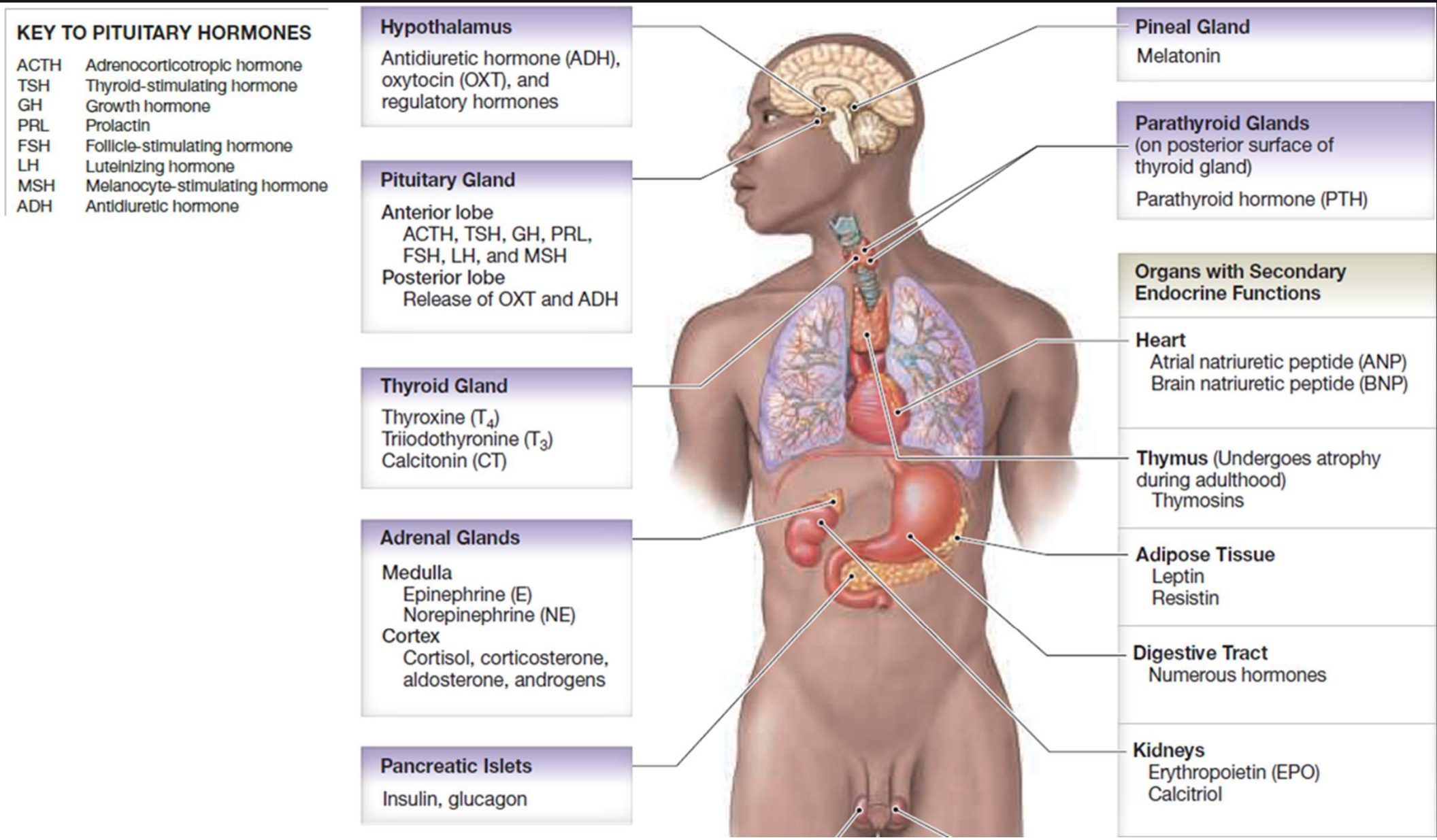

Introduction to Endocrine Principles

- Both **hormones** and **neurohormones** are endocrine chemical signals that are carried in the **blood.**
- They are similar to **neurotransmitters** because they exert their effects by binding to **receptor molecules** expressed by **target cells.**
- The main **difference** is that a neurotransmitter crosses a **narrow synaptic gap**, whereas an endocrine signal **circulates** in the blood over **large distances.**

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- The **chemical signals** reach their targets over different distances, ranging from locally secreted **autocrine** and **paracrine** signals to **neurotransmitters** at synapses to **endocrines** carried greater distances in the blood.
- Because hormone and neurohormone molecules are carried throughout the **bloodstream**, they can **influence large populations** of target cells, as long as the target cells express **receptor molecules** for the hormone.

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- Therefore, **circulation** of hormones and neurohormones **permits** widespread responses. These responses occur with a **delay**, relative to responses to **neural signals.**
- Two **main factors** contribute to **slowed responses** to endocrine signals.
- **First**, hormones require **travel time** to reach target cells.

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- And **second**, certain hormones control **gene transcription** and the **synthesis of proteins** by target cells, so the responses they **initiate** are exhibited only after a **delay**, when protein synthesis is **accomplished.**
- **Responses** to hormones may be **brief** or last as long as hours or days.
- A **hormone** is a chemical substance produced and released by **endocrine cells**; it exerts **regulatory influences** on the function of other, **distant cells** reached via the **blood.**

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- Hormones released **by neurons** are often referred to as **neurohormones**, and the neurons as **neuroendocrine** or **neurosecretory cells.**
- The **secretory cells** that produce hormones **secrete** them into the surrounding **extracellular fluid (ECF)**, from which they **diffuse** into **capillaries.**
- The **secretory cells** may be organized into **discrete organs** termed **endocrine glands**, or they may be **isolated cells** or **clusters of cells** distributed among the cells of other tissues.

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- For example, the **thyroid gland** is a discrete structure that secretes **thyroid hormones.** By contrast, G cells, which secrete **gastrin**, are distributed in the gastric mucosa of the **mammalian stomach.**

- Interestingly, the **same molecule** may serve both as a **hormone** and as another type of **chemical signal** in the same organism.

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- In mammals, for example, **cholecystokinin (CCK)** is not only a **hormone** secreted by cells in the intestine, but also functions as a **neurotransmitter** or **neuromodulator** in the central nervous system (CNS).
- Alternatively, a hormone can circulate widely in the general circulation and also serve locally as a **paracrine.**
- For example, **testosterone** exerts widespread effects **as a hormone** and also functions as a **paracrine** within the testis to support **spermatogenesis.**

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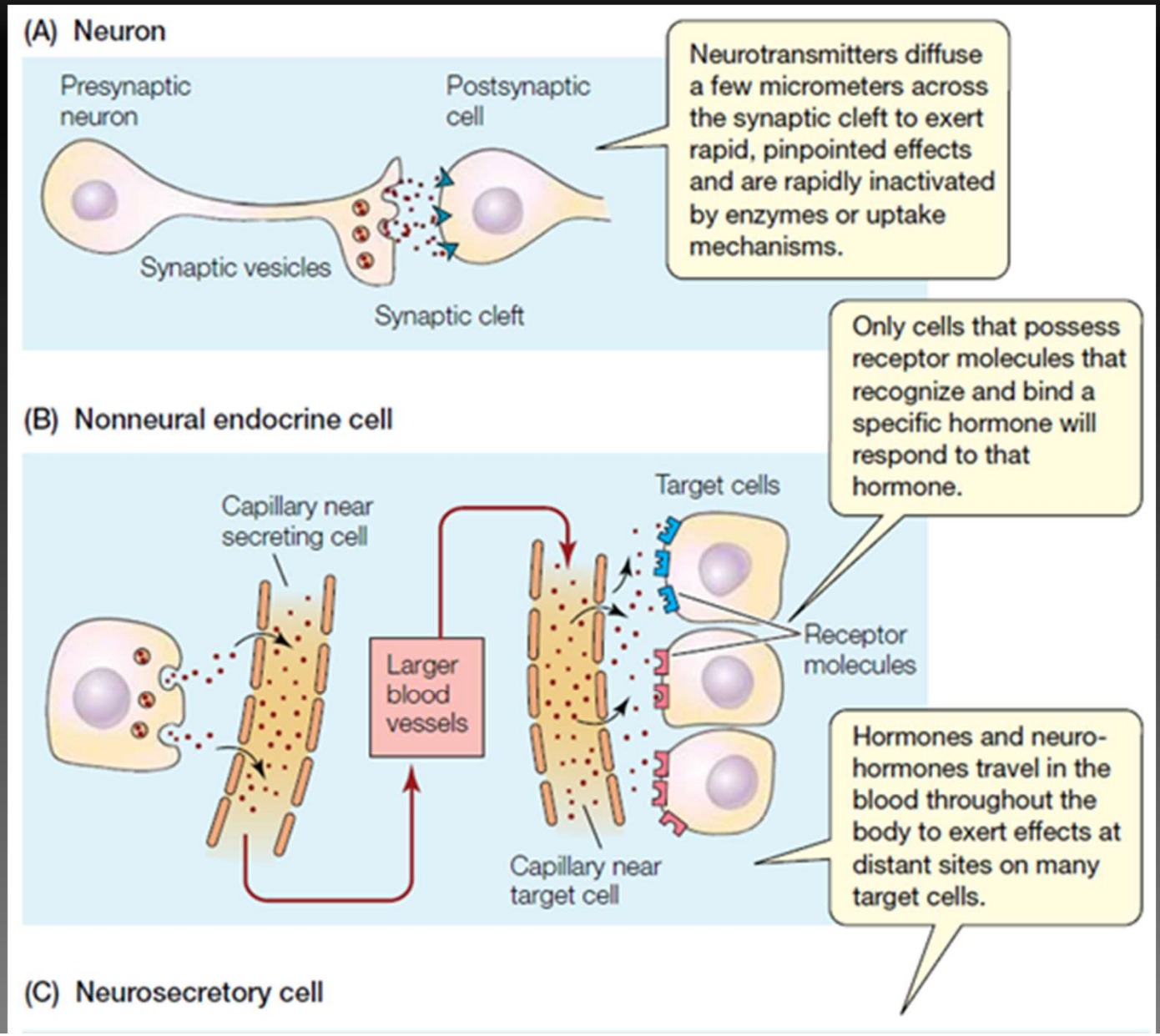

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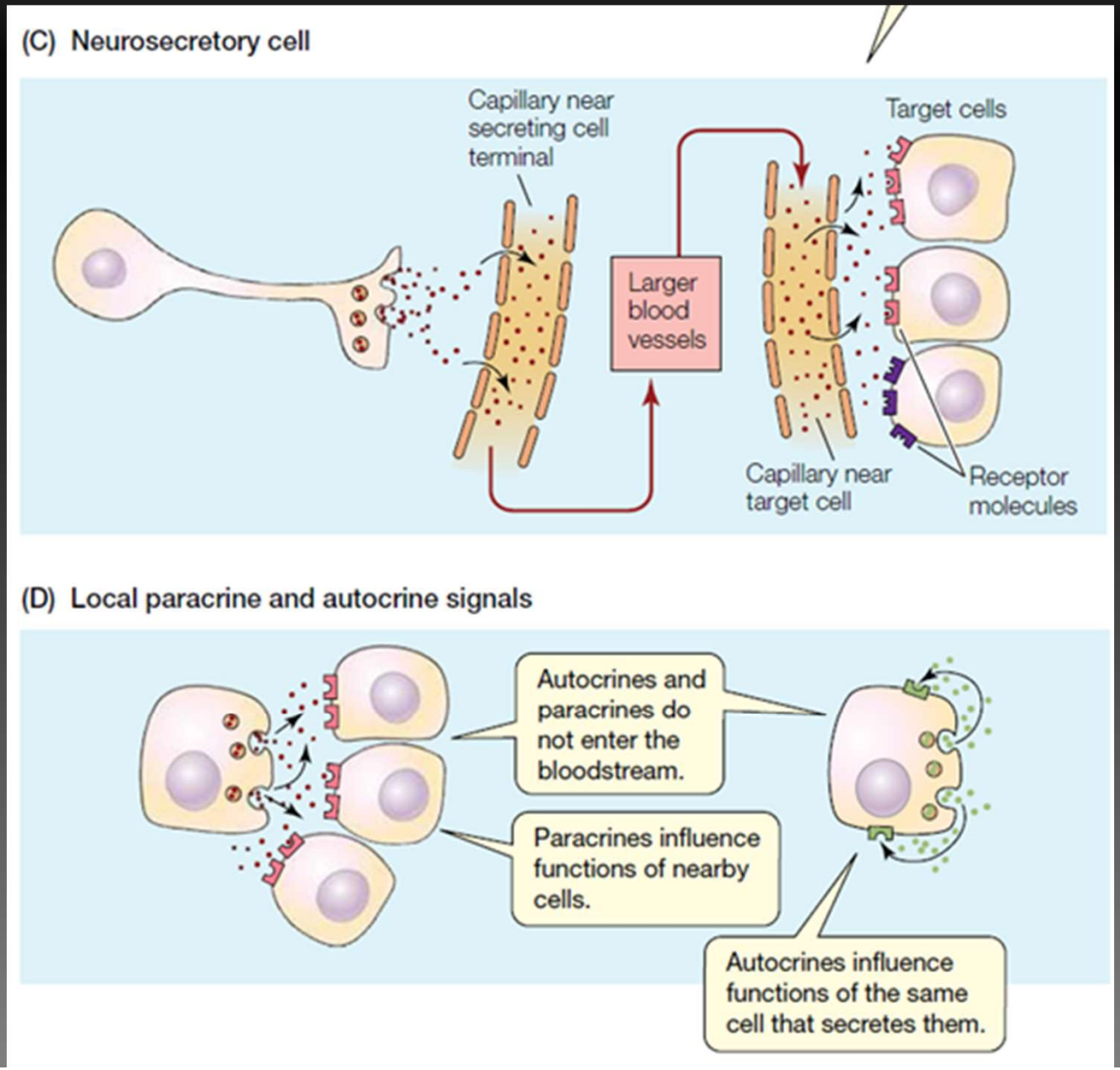

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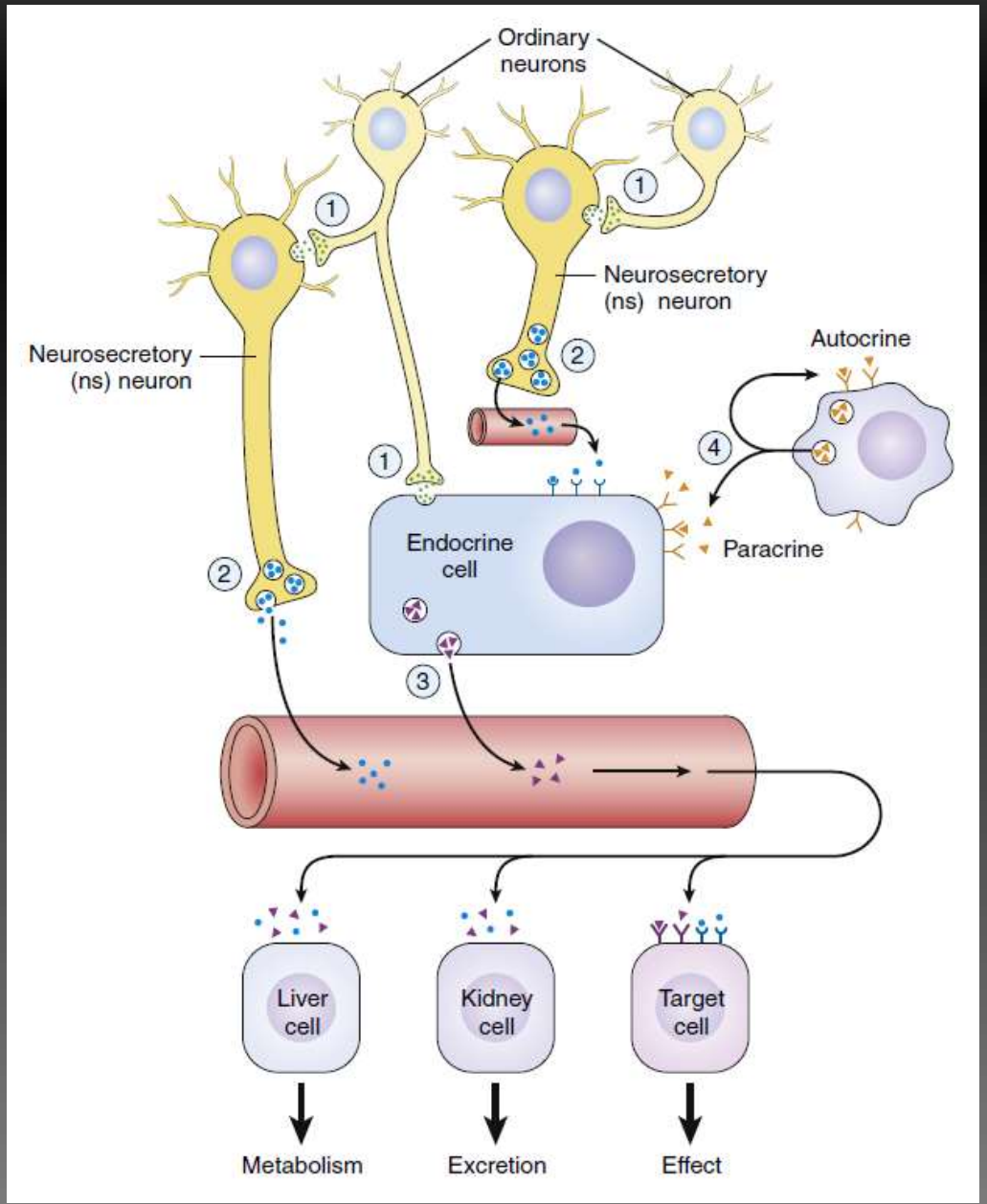


Most hormones fall into three chemical classes

- Hormones are **organized** into **three main classes** based on their chemical structure:

1. Steroid hormones are synthesized from cholesterol.

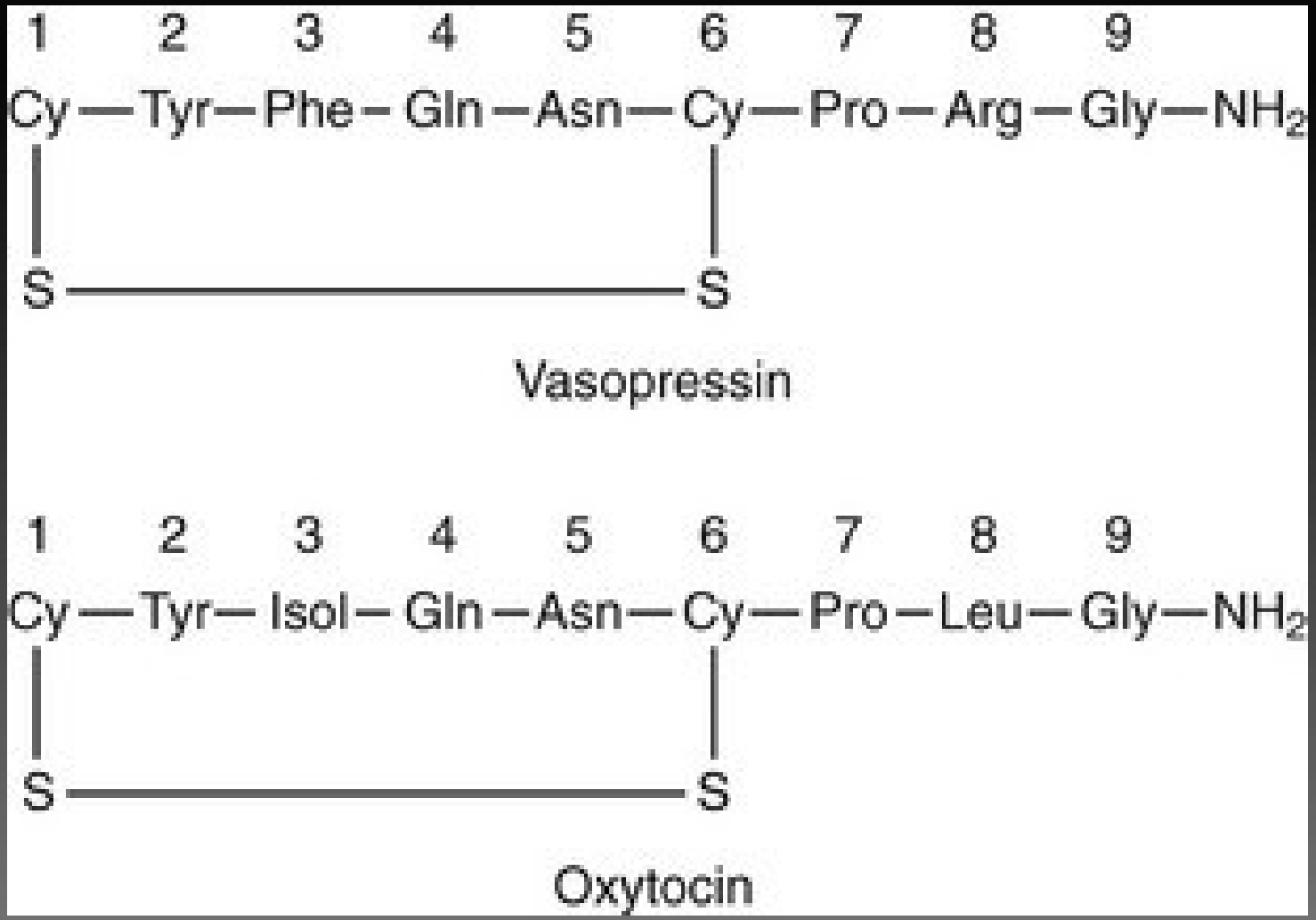
- In vertebrates, the **gonads** and the **adrenal cortex** secrete **steroid hormones** and, in pregnant mammals, the **placenta** secrete **human chorionic gonadotropin (hCG)**.
- Steroid hormones are **lipid-soluble**, so they can pass through **cell membranes** to reach **receptor molecules** located **inside** their target **cells.**
- A **few steroid hormones** also exert their effects by binding to receptors expressed on the **surface membrane** of the target cells.

Most hormones fall into three chemical classes

2. Peptide and protein hormones are structured from chains of amino acids.

- In vertebrates, they include **antidiuretic hormones** (ADH), **insulin**, and **growth hormone (GH).**
- Peptide and protein hormones **vary** in **molecular size**, from **tripeptides** (such as thyrotropin-releasing hormone, which consists of 3 amino acids) to proteins containing nearly 200 amino acids (such as growth hormone).

Most hormones fall into three chemical classes



Most hormones fall into three chemical classes

3. Amine hormones are modified amino acids (Amino acid derivatives).

- **Amino acid derivatives** are small molecules that are structurally similar to amino acids.
- The derivatives of **tyrosine**, such as the **thyroid hormones** released by the thyroid gland and the **catecholamines** released by the adrenal medulla.
- **Melatonin**, secreted by the vertebrate **pineal gland**, is derived from **tryptophan**, whereas the **catecholamines** and **iodothyronines** are derived from **tyrosine**.

Most hormones fall into three chemical classes

- **3. Amine hormones are modified amino acids (Amino acid derivatives).**
- **Catecholamines** are found widely as **synaptic transmitter** substances.
- However, three catecholamines also serve as **hormones** in vertebrates: **epinephrine** (adrenaline), **norepinephrine** (noradrenaline), and **dopamine.**
- Whereas **melatonin** and the **catecholamines** are **soluble in water**, the **iodothyronines (thyroid hormones)** are soluble in **lipids.**

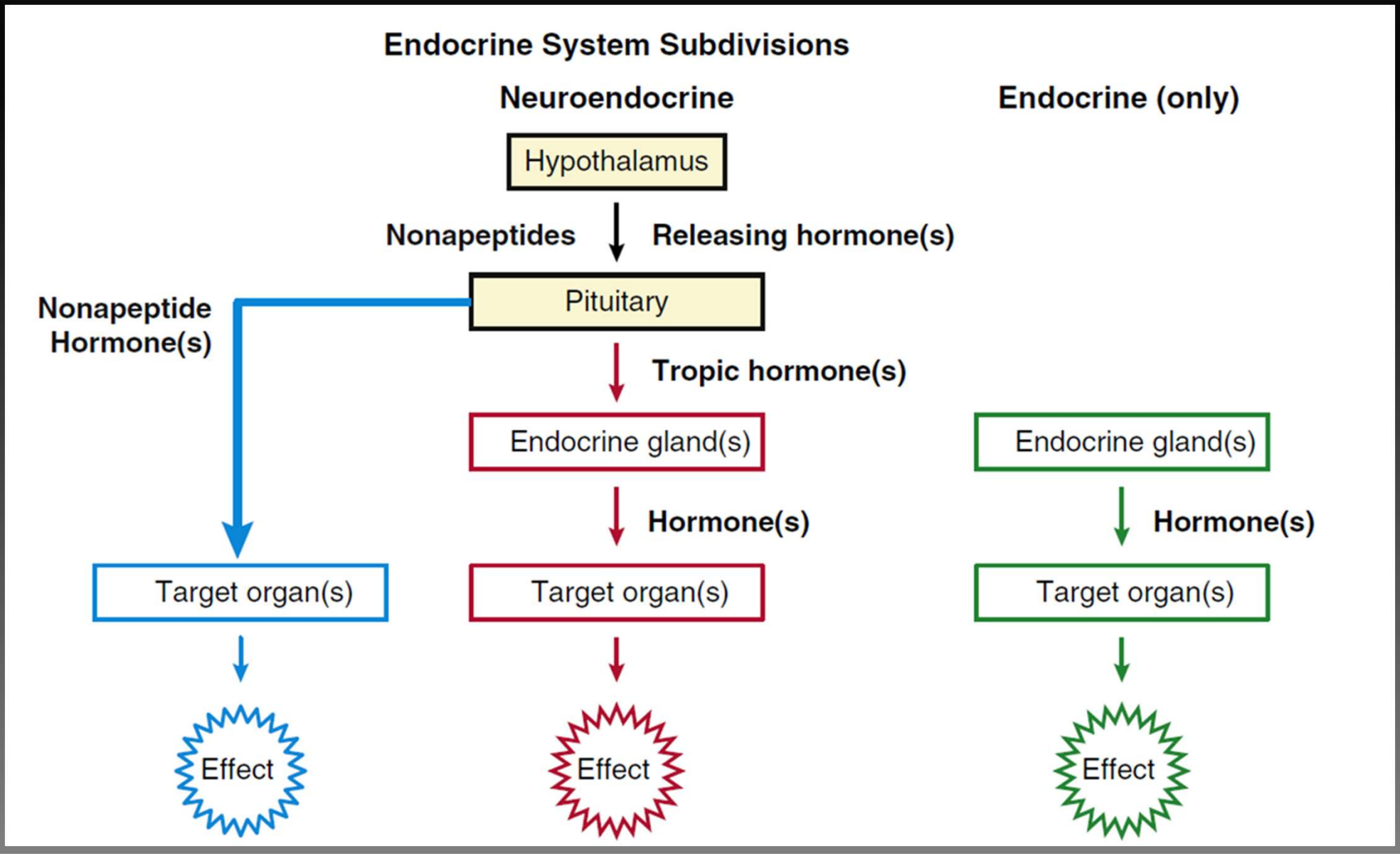
Hormone molecules exert their effects by producing biochemical changes in target cells

- Each hormone has **target cells**, specific cells that have **receptors** needed to bind hormones and respond to their presence.
- To **initiate changes** in target cells, hormones first **bind** to specific receptor molecules.
- **Nonpolar (hydrophobic) hormones** bind to intracellular receptors and **polar hormones (hydrophilic)** to cell-surface receptors.

Hormone molecules exert their effects by producing biochemical changes in target cells

- **Three types of receptor molecules** are important in mediating hormone actions: intracellular receptors, G protein–coupled membrane receptors (GPCRs), and enzyme-linked membrane receptors.
- **Enzymes** control all **cellular activities** and **metabolic reactions**. Hormones influence **cellular operations** by changing the types, activities, or quantities of key cytoplasmic enzymes.

Hormone molecules exert their effects by producing biochemical changes in target cells



Extracellular signals initiate their effects by binding to receptor proteins

- Extracellular signaling molecules such as neurotransmitters or hormones **initiate** their **actions** on **a cell** by binding with certain protein molecules of the cell, called **receptors.**
- A molecule that binds **specifically** and **noncovalently** to a receptor protein is considered a **ligand** of the receptor. Ligand binding occurs at a specific **receptor site** (or sites) on the receptor protein and results in a change in the **molecular conformation** of the receptor protein, a process that sets in motion a further response by the cell.

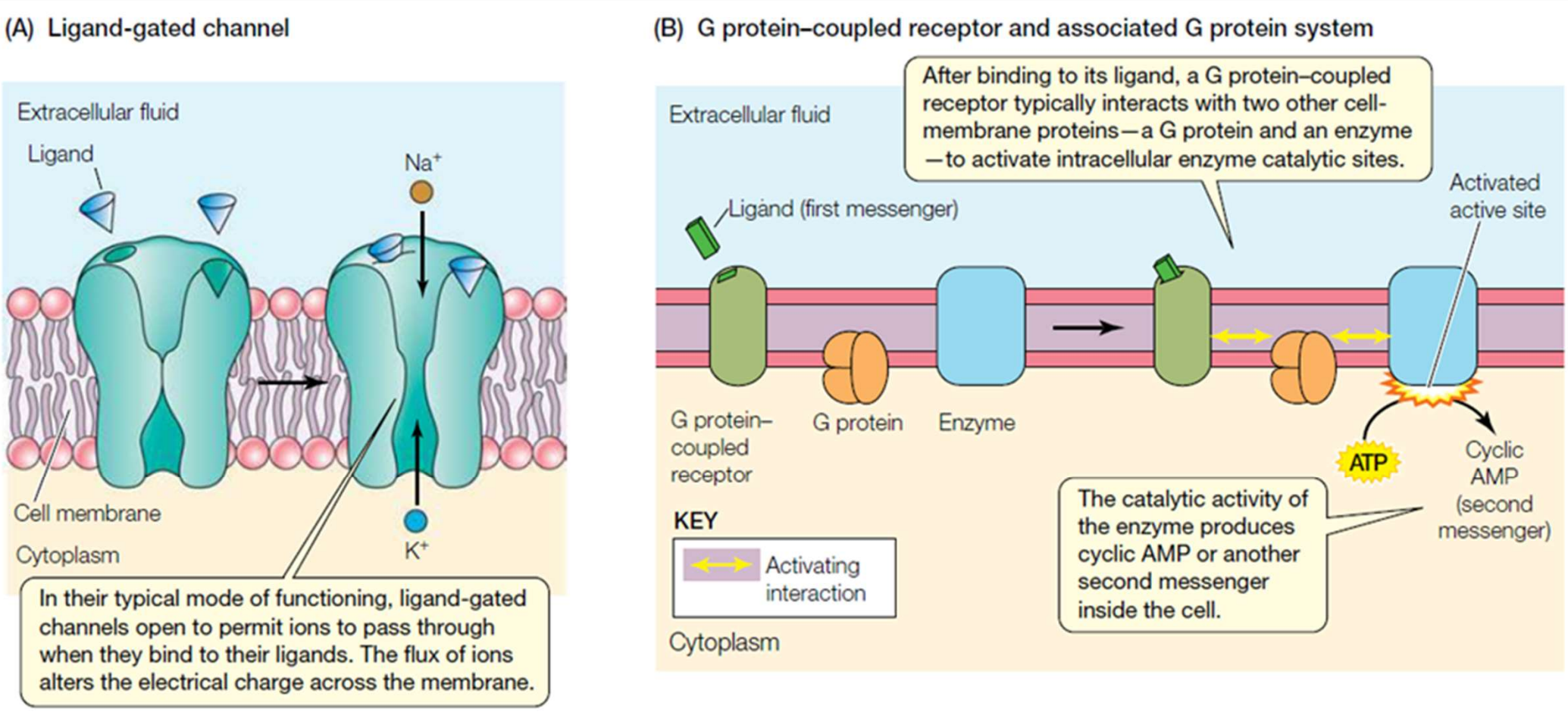
Extracellular signals initiate their effects by binding to receptor proteins

- Receptors may be categorized into **four functional classes**: (1) ligand-gated channels, (2) G protein–coupled receptors (GPCRs), (3) enzyme/enzyme-linked receptors, and (4) intracellular receptors.
- Receptors in the first three categories reside in the cell membrane. This prevalence of receptors at the cell surface reflects the fact that most signaling molecules **cannot enter cells.**

Extracellular signals initiate their effects by binding to receptor proteins

- For the most part, **signaling molecules** are proteins or other **hydrophilic** molecules that are unable to pass through the hydrophobic interior of the cell membrane.
- Instead of entering cells, these signaling molecules bind to receptors on the **cell-membrane surface**, and the receptors then initiate their intracellular effects.
- Only hydrophobic or very small signaling molecules can enter a cell at meaningful rates through the cell membrane; once inside, such molecules bind to **intracellular receptors**.

Extracellular signals initiate their effects by binding to receptor proteins



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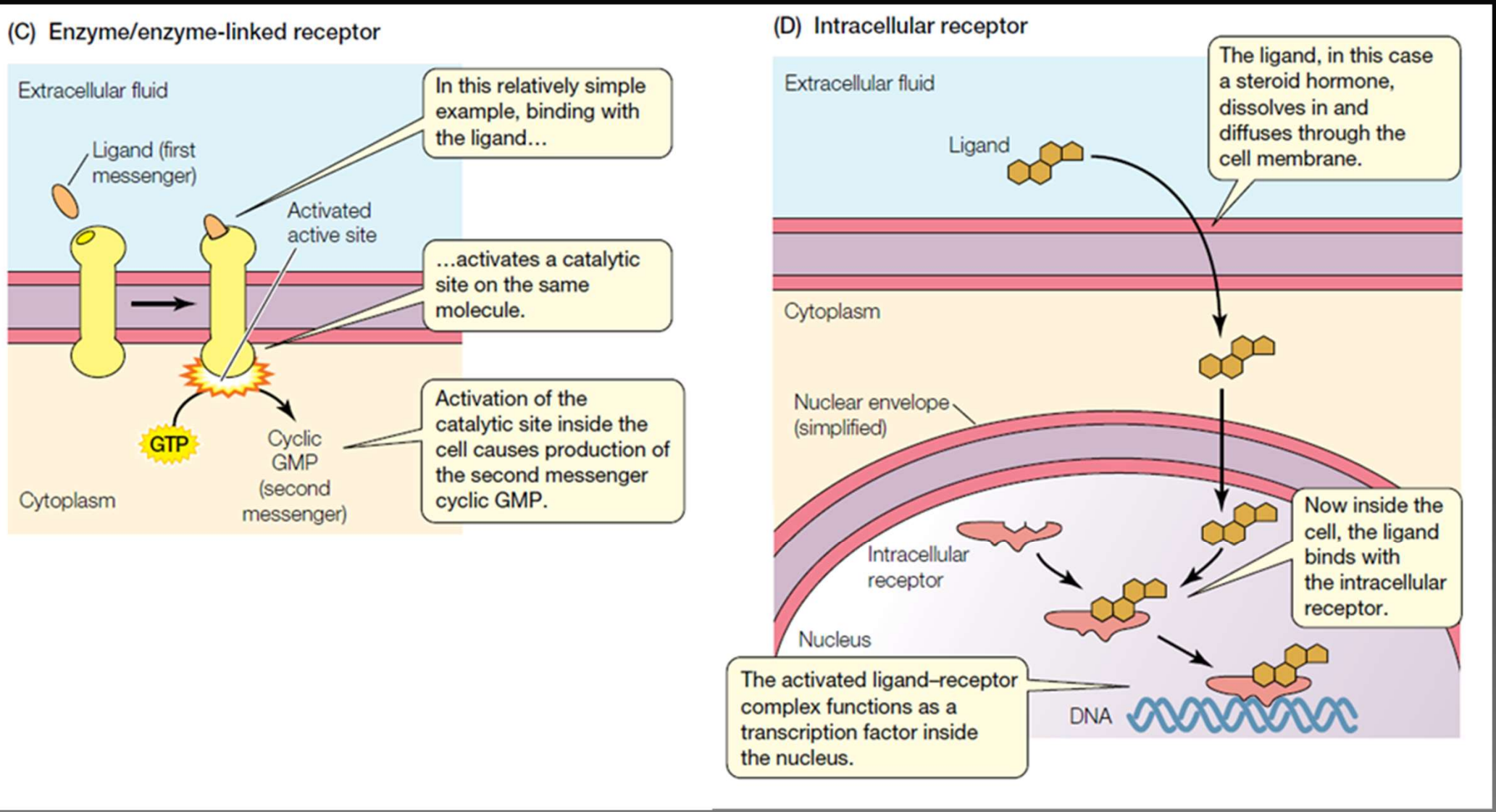

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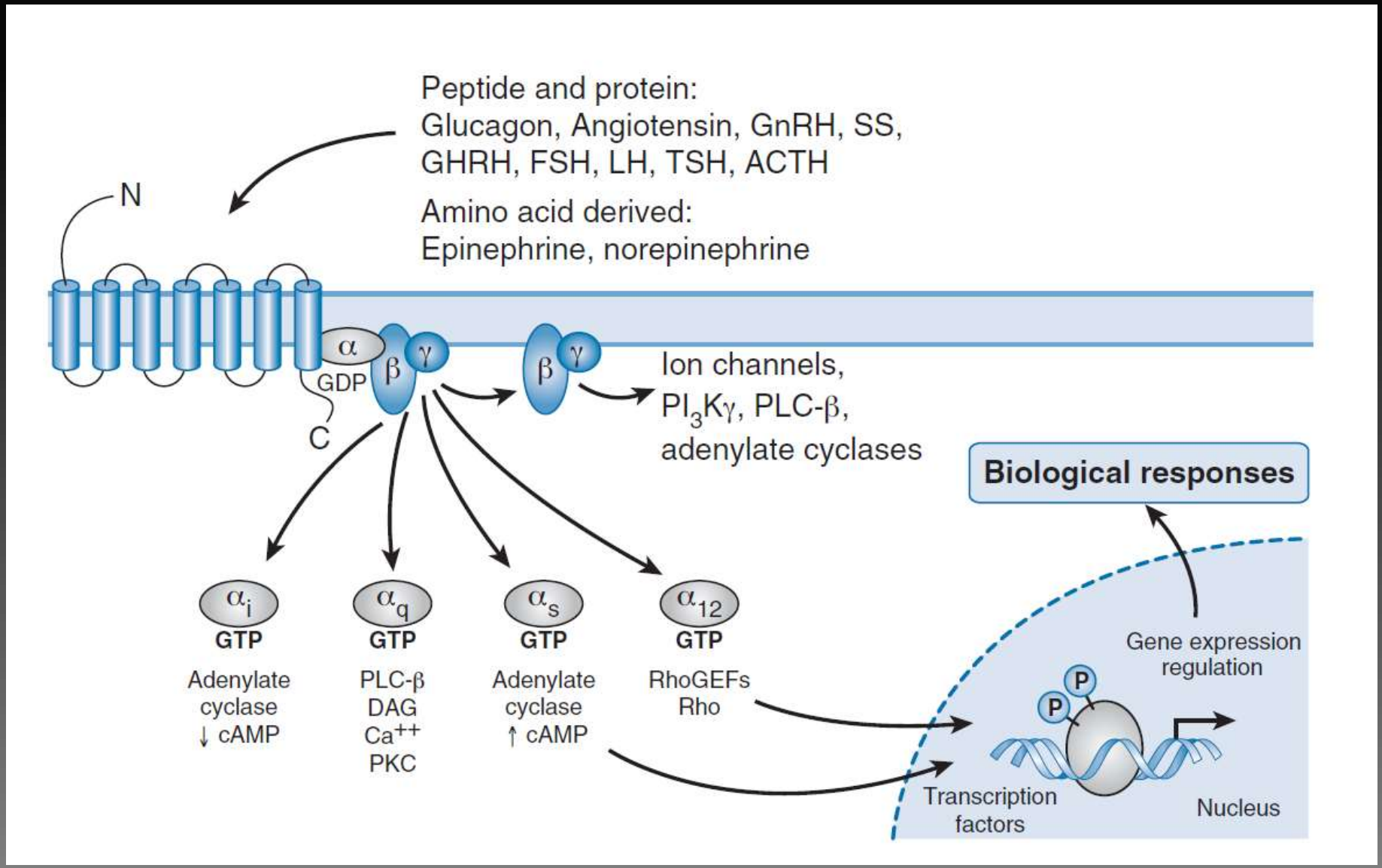

Some of the key functions of the endocrine system include:

- Regulation of sodium and water balance and control of blood volume and pressure
- Regulation of calcium and phosphate balance to preserve extracellular fluid concentrations required for cell membrane integrity and intracellular signaling
- Regulation of energy balance and control of fuel mobilization, utilization, and storage to ensure that cellular metabolic demands are met.

Some of the key functions of the endocrine system include:

- Coordination of the host hemodynamic and metabolic counterregulatory responses to stress
- Regulation of reproduction, development, growth, and senescence.

Questions?