

Endocrinology of Fish

MS I (Semester-II)

Maj/Zoo-S-406

Lecture – 01

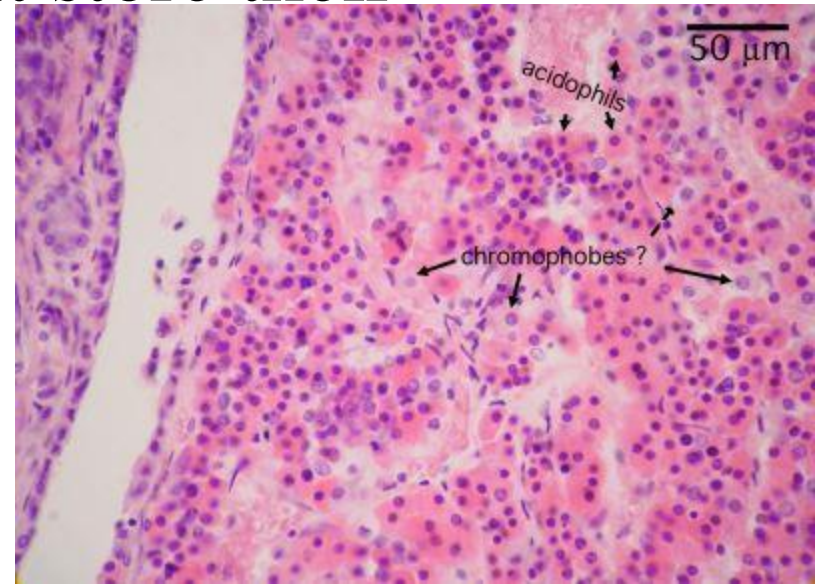
Types of Hormones

Endocrine system

- The endocrine system refers to the collection of glands of an organism that secrete hormones directly into the circulatory system to be carried towards distant target organs.

Endocrine glands

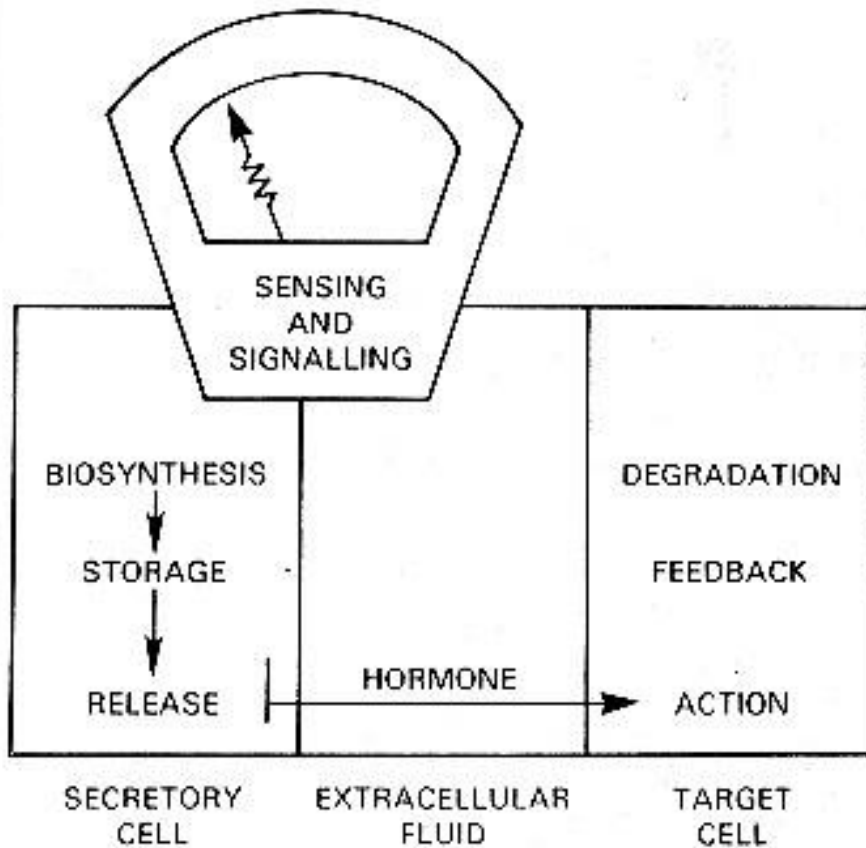
- ductless nature
- their vascularity
- commonly the presence of intracellular vacuoles or granules that store their hormones
- Transporting proteins



Endocrine hormones

- hormones are chemical signals that are secreted into the circulatory system and communicate regulatory messages within the body.
- Hormones reach all parts of the body, but only target cells are equipped to respond.
- Hormones convey information via the bloodstream to target cells throughout the body.

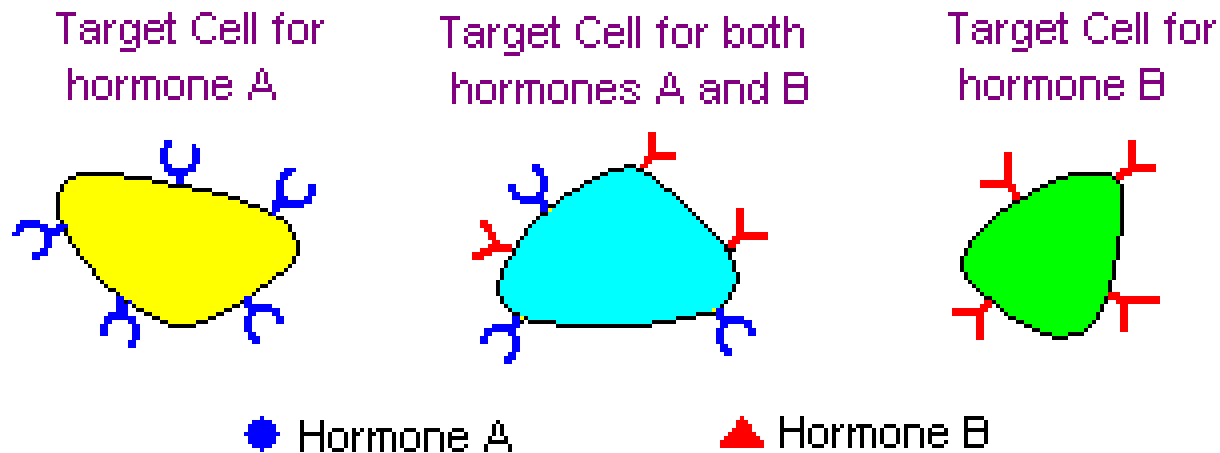
Sensing and signaling



Endocrine “glands” synthesize and store hormones. These glands have a sensing and signaling system which regulate the duration and magnitude of hormone release via feedback from the target cell.

Target Cell

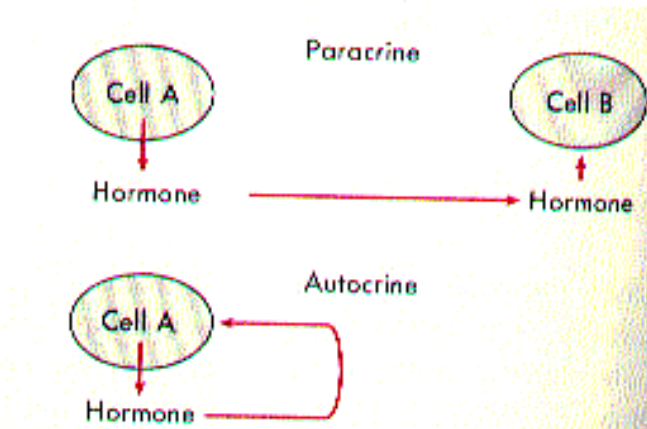
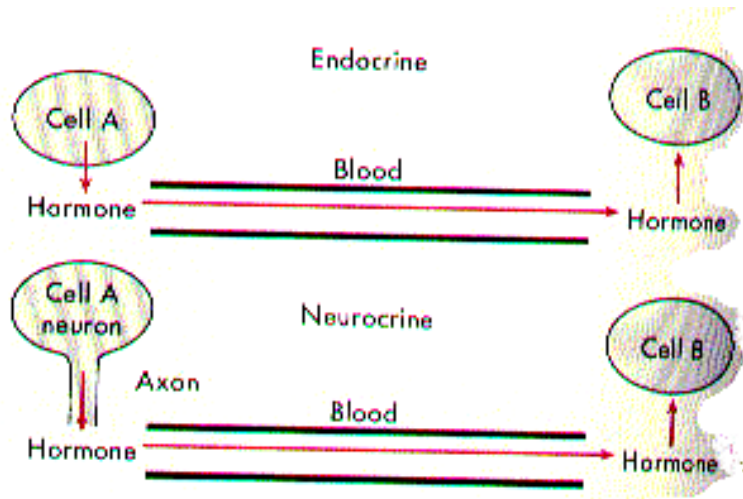
- Most hormones circulate in blood, coming into contact with essentially all cells.
- hormone usually affects only a limited number of cells, which are called target cells.
- A target cell responds to a hormone because it bears receptors for the hormone.



Principal functions of the endocrine system

- Homeostasis- Maintenance of the internal environment in the body (maintaining the optimum biochemical environment).
- Integration and regulation of growth and development.
- Control, maintenance and instigation of sexual reproduction, including gametogenesis, fertilization, embryonic growth and development and nourishment of the juvenile.

Types of cell-to-cell signaling



Classic endocrine hormones travel via bloodstream to target cells e.g.

LH

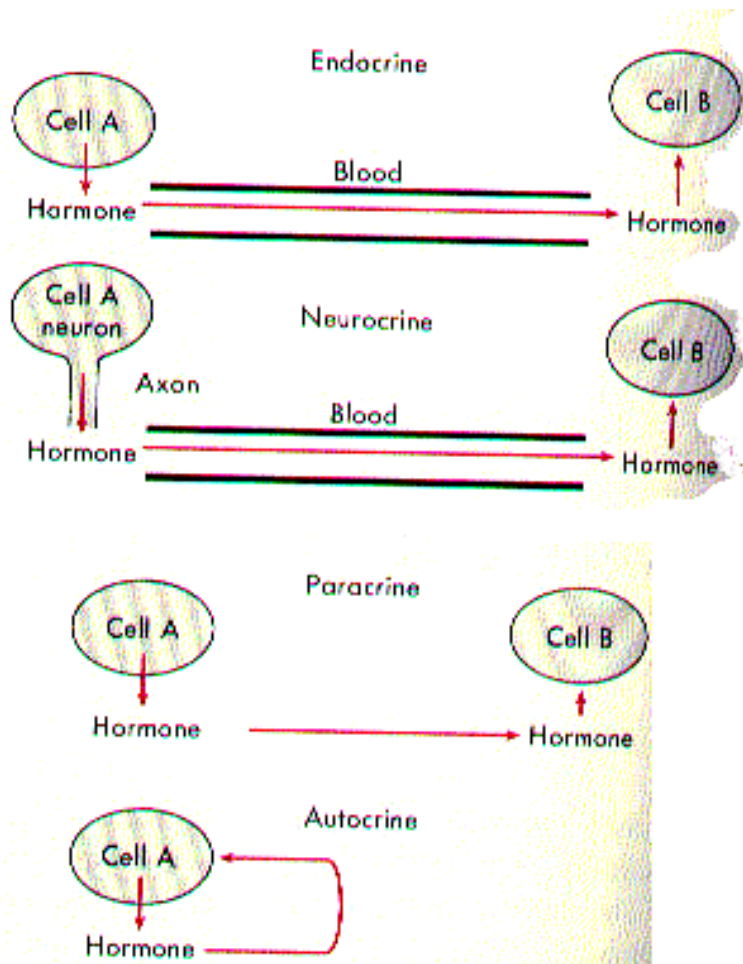
FSH

1. neurohormones are released via synapses and travel via the blood stream

e.g. Thyrotropin-releasing hormone

Corticotropin-releasing hormone

Types of cell-to-cell signaling



2. Paracrine hormones act on adjacent cells e.g. growth factors

3. Autocrine hormones are released and act on the cell that secreted them e.g. cytokines, interleukins

4. Intracrine hormones act within the cell that produces them e.g. several peptide hormones like insulin

Response vs. distance traveled

Endocrine action: the hormone is distributed in blood and binds to distant target cells.

Paracrine action: the hormone acts locally by diffusing from its source to target cells in the neighborhood.

Autocrine action: the hormone acts on the same cell that produced it.



Types of hormones

- **Hormones are categorized into four structural groups, with members of each group having many properties in common:**
 - Peptides and proteins
 - Amino acid derivatives
 - Steroids
 - Fatty acid derivatives - Eicosanoids

Peptide/protein hormones

- Range from 3 amino acids to hundreds of amino acids in size.
- Often produced as larger molecular weight precursors that are proteolytically cleaved to the active form of the hormone.
- Peptide/protein hormones are water soluble.
- Comprise the largest number of hormones—perhaps in thousands

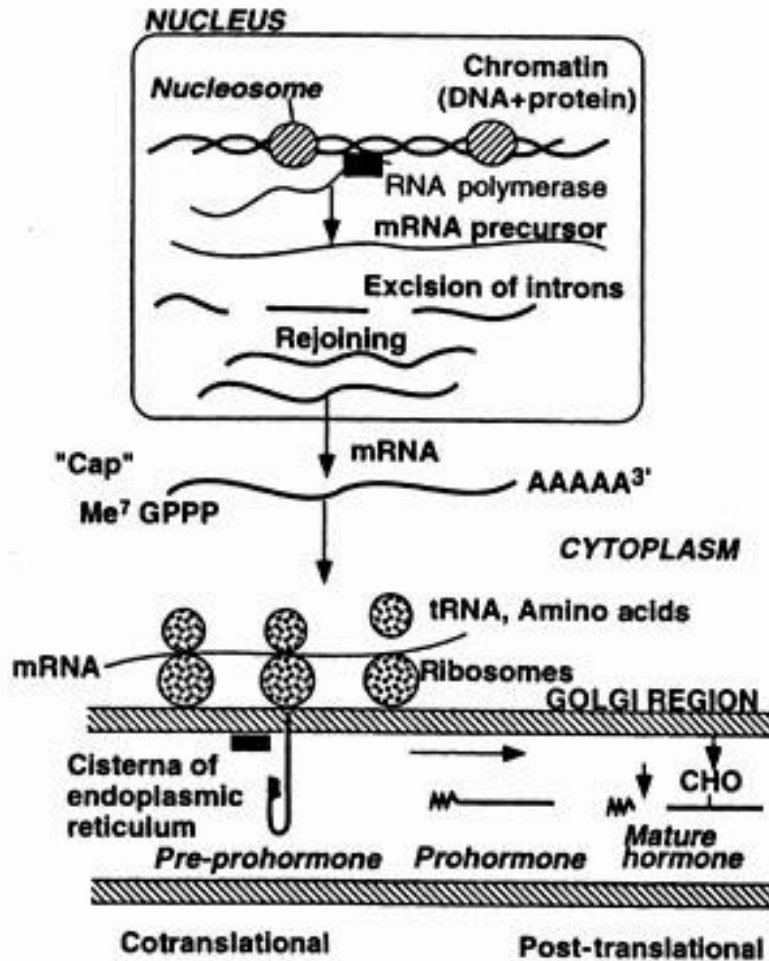
Peptide/protein hormones

- Are encoded by a specific gene which is transcribed into mRNA and translated into a protein precursor called a preprohormone
- Preprohormones are often post-translationally modified in the ER to contain carbohydrates (glycosylation)
- Preprohormones contain signal peptides (hydrophobic amino acids) which targets them to the golgi where signal sequence is removed to form prohormone
- Prohormone is processed into active hormone and packaged into secretory vesicles

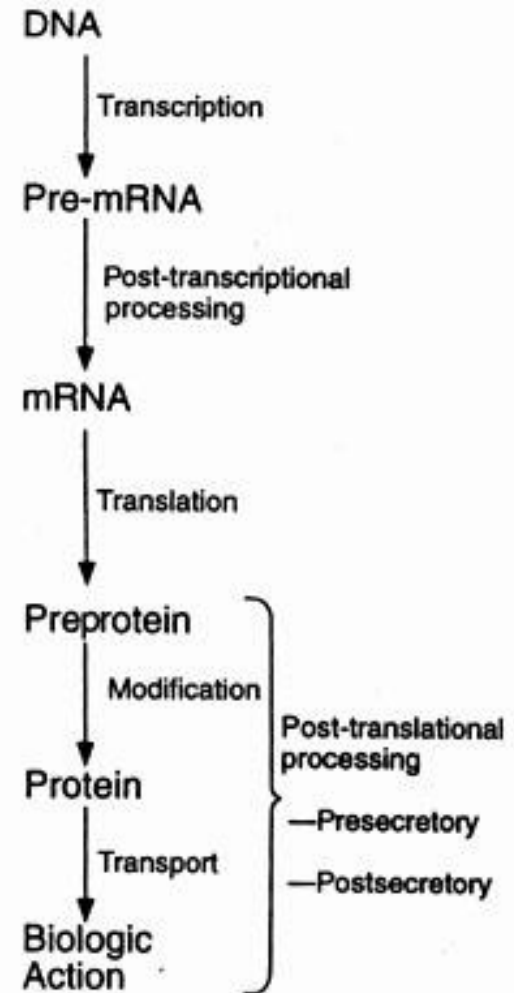
Peptide/protein hormones

- Secretory vesicles move to plasma membrane where they await a signal. Then they are exocytosed and secreted into blood stream
- In some cases the prohormone is secreted and converted in the extracellular fluid into the active hormone: an example is angiotensin is secreted by liver and converted into active form by enzymes secreted by kidney and lung

Peptide/protein hormone synthesis



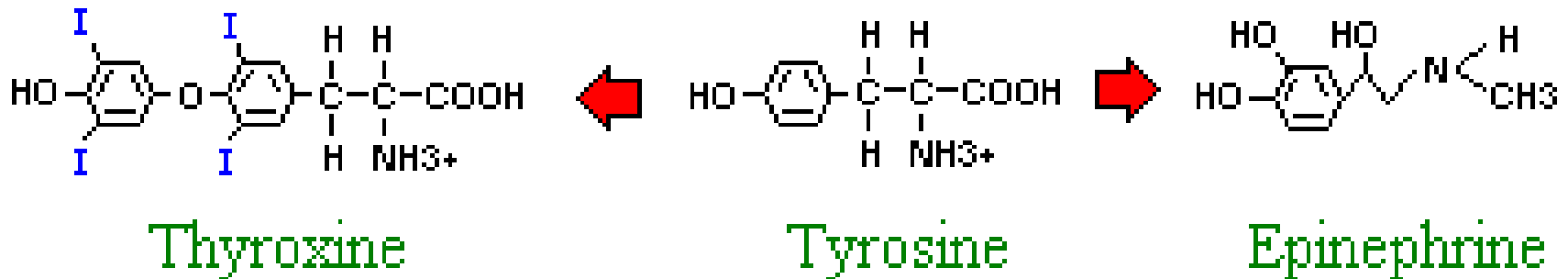
Secretion



Amine hormones

There are two groups of hormones derived from the amino acid tyrosine

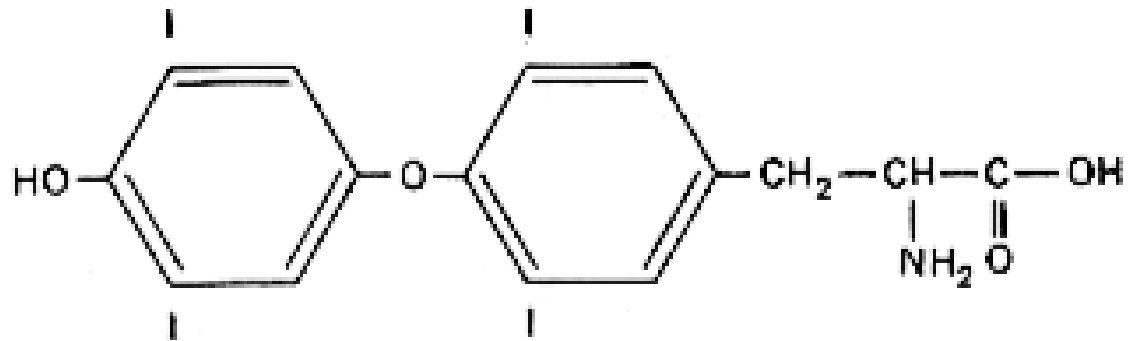
Thyroid hormones and **Catecholamines**



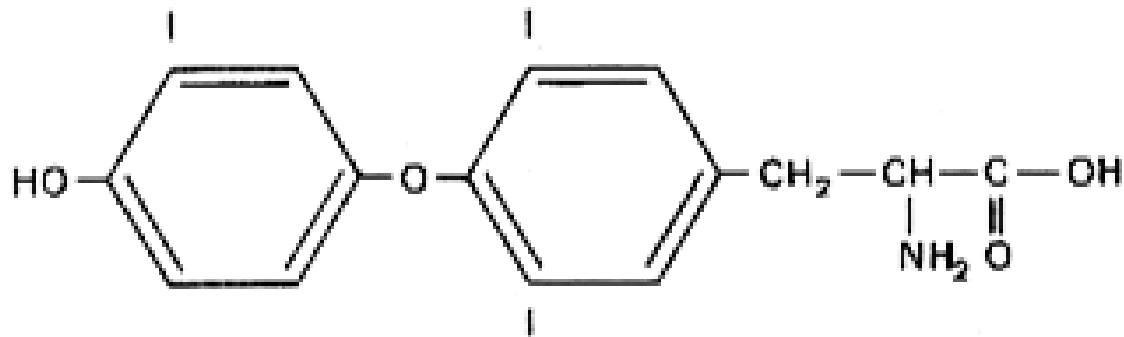
Thyroid Hormone

- **Thyroid hormones** are basically a "double" tyrosine with the critical incorporation of 3 or 4 iodine atoms.
 - Thyroid hormone is produced by the thyroid gland and is lipid soluble
- Thyroid hormones are produced by modification of a tyrosine residue contained in thyroglobulin, post-translationally modified to bind iodine, then proteolytically cleaved and released as T4 and T3. T3 and T4 then bind to thyroxin binding globulin for transport in the blood

Thyroid hormones



3, 5, 3', 5' - Tetraiodothyronine (thyroxine, T₄)

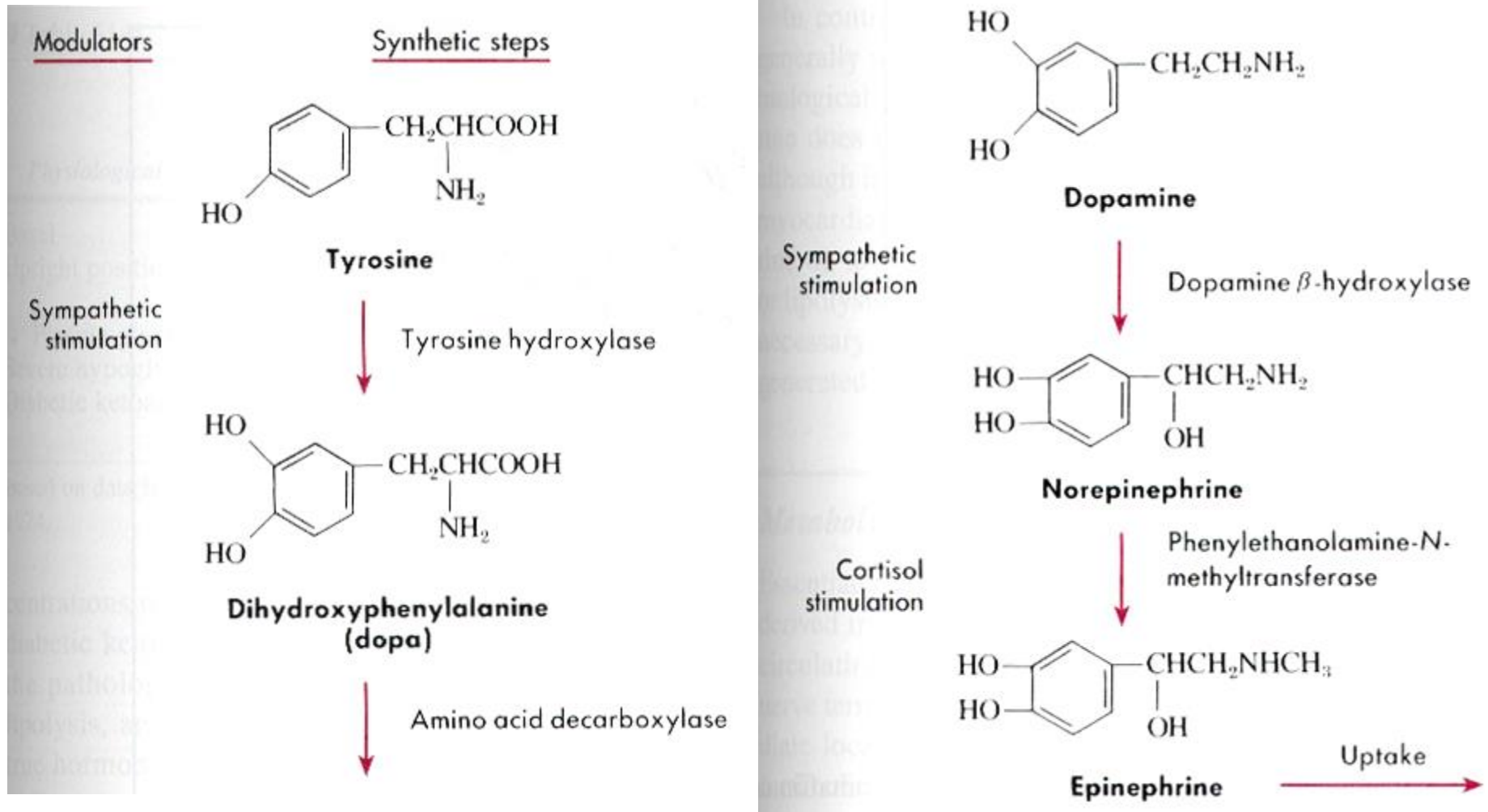


3, 5, 3'-Triiodothyronine (T₃)

Catecholamine hormones

- **Catecholamines** are both neurohormones and neurotransmitters.
 - These include epinephrine, and norepinephrine
 - Epinephrine and norepinephrine are produced by the adrenal medulla both are water soluble
- Secreted like peptide hormones

Synthesis of catecholamines

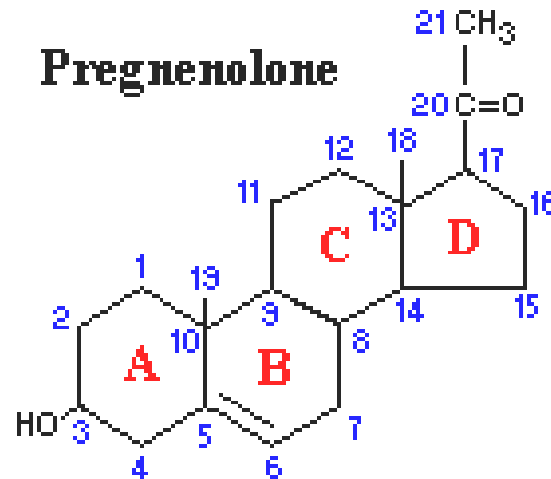


Amine Hormones

- **Two other amino acids are used for synthesis of hormones:**
- **Tryptophan** is the precursor to serotonin and the pineal hormone melatonin
- **Glutamic acid** is converted to histamine

Steroid hormones

- All steroid hormones are derived from cholesterol and differ only in the ring structure and side chains attached to it.
- All steroid hormones are lipid soluble



Types of steroid hormones

- **Glucocorticoids;** cortisol
- **Mineralocorticoids;** aldosterone
- **Androgens;** testosterone
- **Estrogens;** estradiol and estrone
- **Progestogens** (also known a progestins) such as progesterone

Steroid hormones

- Are not packaged, but synthesized and immediately released
- Are all derived from the same parent compound: Cholesterol
- Enzymes which produce steroid hormones from cholesterol are located in mitochondria and smooth ER
- Steroids are lipid soluble and thus are freely permeable to membranes so are not stored in cells

Steroid hormones

- Steroid hormones are not water soluble so have to be carried in the blood complexed to specific binding globulins.
- Corticosteroid binding globulin carries cortisol
- Sex steroid binding globulin carries testosterone and estradiol
- In some cases a steroid is secreted by one cell and is converted to the active steroid by the target cell: an example is androgen which secreted by the gonad and converted into estrogen in the brain

1,25-Dihydroxy Vitamin D3

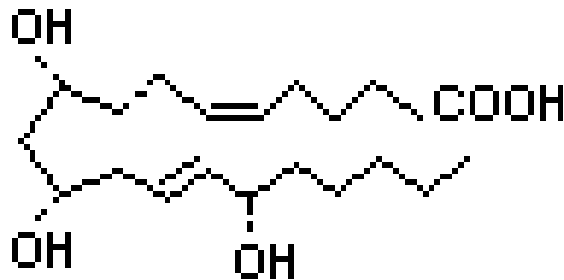
- 1,25-dihydroxy Vitamin D3 is also derived from cholesterol and is lipid soluble
- Not really a “vitamin” as it can be synthesized de novo
- Acts as a true hormone

Fatty Acid Derivatives - Eicosanoids

- **Arachadonic acid is the most abundant precursor for these hormones.** Stores of arachadonic acid are present in membrane lipids and released through the action of various lipases. The specific eicosanoids synthesized by a cell are dictated by the battery of processing enzymes expressed in that cell.
- These hormones are rapidly inactivated by being metabolized, and are typically active for only a few seconds.

Fatty Acid Derivatives - Eicosanoids

- **Eicosanoids** are a large group of molecules derived from polyunsaturated fatty acids.
- The principal groups of hormones of this class are prostaglandins, prostacyclins, leukotrienes and thromboxanes.



Prostaglandin F₂ α

Regulation of hormone secretion

- Sensing and signaling: a biological need is sensed, the endocrine system sends out a signal to a target cell whose action addresses the biological need. Key features of this stimulus response system are:
- receipt of stimulus
 - synthesis and secretion of hormone
 - delivery of hormone to target cell
 - evoking target cell response
 - degradation of hormone

Signal Transduction

- Signal transduction occurs when an extracellular signaling molecule activates a specific receptor located on the cell surface or inside the cell.
- In turn, this receptor triggers a biochemical chain of events inside the cell, creating a response.

General features of hormone classes

GROUP I

1. TYPES

- Steroids
- Thyroid H
- Vitamin A and D
- Endogenous metabolites
e.g. oxysterols and
xenobiotics

2. Solubility

- Lipophilic

GROUP II

- Polypeptides
- Proteins
- Glycoproteins
- Catecholamines
- prostaglandins

- Hydrophilic

3. Transport proteins

➤ Yes

➤ No

4. Plasma half life

➤ Long(hrs-days)

➤ Short(mins)

5. Receptor

➤ Intracellular

➤ Plasma membrane

6. Mediators

➤ Receptor -hormone complex

➤ cAMP,

➤ cGMP,

➤ Ca/phosphoinositol

➤ Kinase cascade