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Biochemistry

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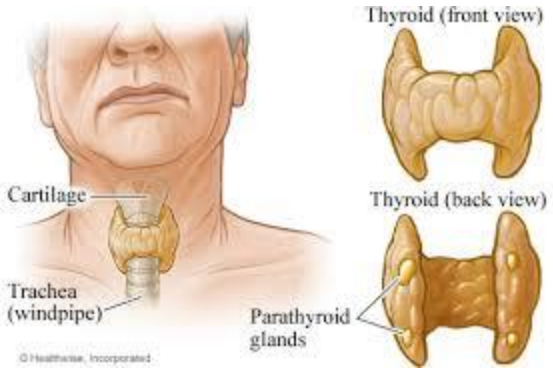
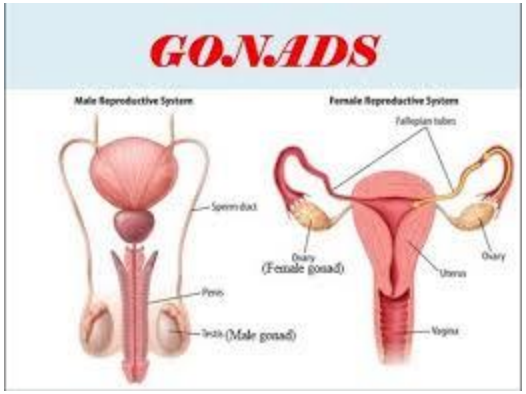
Hormones and Signal Transduction

- Hormones are chemical messengers secreted by special cells in an endocrine gland and transported in the blood stream to the target cells.
- There are about 220 types of differentiated cells in animal body. Only a few produce hormones, but virtually all of the 75 trillion cells in a body are targets of one or more of the over 55 known hormones.

Endocrinology: study of endocrine glands and their secretions (hormones). Endocrine gland: a group of cells which secret "messenger" molecules directly into the blood stream. Endocrine Glands:

1. Gonads.
2. Pancreas.
3. Adrenals.
4. Thyroid.
5. Parathyroid.
6. Pituitary



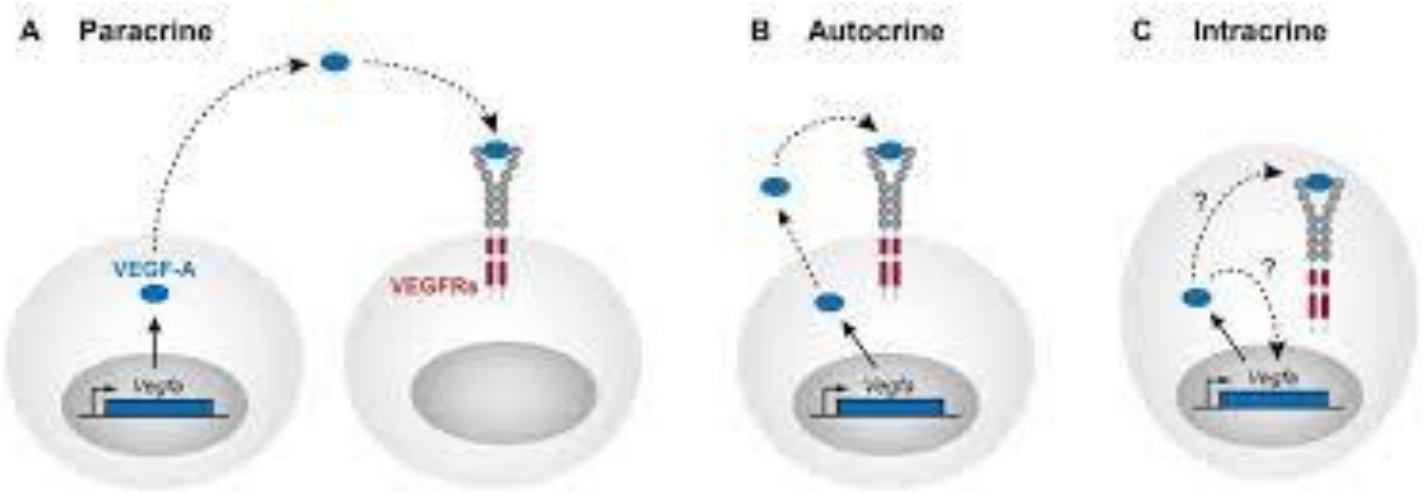


Types of chemical messengers :

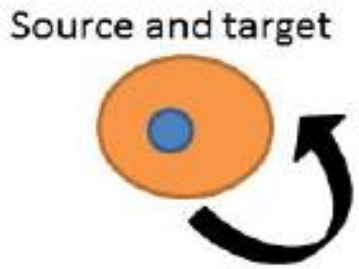
- **True hormones** : are secreted into the blood by endocrine glands. e.g. insulin.
- **Paracrine hormones** : are secreted by regulator cells and travel only a short distance to adjacent target cells. e.g : prostaglandins .
- **Pheromones** : are air-borne signals secreted by exocrine glands and stimulate target cells in another animal, usually of the opposite sex. Sex pheromones have been found in insects, mammals, reptiles.
- **Neurotransmitters** : are chemical messengers that are secreted by nerve cells to adjacent cells to signal nerve impulses, e.g: acetylcholine

According to the kind of chemical messenger action, they can be classified into:

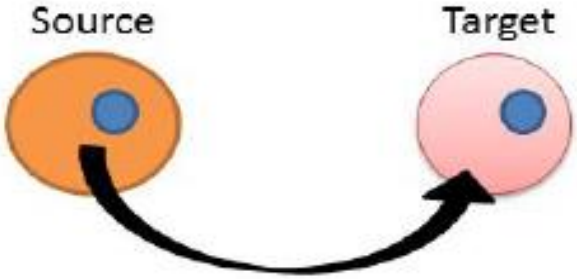
- **Endocrine:** molecule's act on target cells at a distance away from their source (usually transmitted by blood stream).
- **Paracrine**: molecule's act on target cells within near area (local action).
- **Autocrine**: molecule's act on own cell of source.
- **Intracrine**: molecule's act on the source cell without leaving it.



Endocrine



Autocrine



Paracrine

Intracrine

Classification of hormones:

A. Based on the chemical nature:

1. Protein (peptide) hormones: e.g: oxytocin
2. Steroid hormones: e.g: aldosteron
3. Amino acid derivatives: e.g: Epinephrine

B. Based on mechanism of action:

1. **Binds to intracellular receptor**: they are lipophilic in nature, and commonly derived from cholesterol, e.g: estrogens.

2. **Bind to cell surface (plasma membrane) receptors**: stimulate release (or activation) of special substance (**second messengers**), because hormone consider first messenger. This group subdivided into three categories depending on the chemical nature of second messengers.

I. The second messenger is cAMP, e.g: FSH.

II. The second messenger is cGMP, e.g: ANF.

III. The second messenger is phosphatidylinositol/calcium, e.g: TRH.

IV. The second messenger is a kinase or phosphatase, e.g: Insulin.

Stages of hormone action:

1.Biosynthesis of specific hormone in particular tissue.

2.Storage and/or secretion of the hormone.

3.Transport of the hormone to the target tissue (cell).

4.Recognition of the hormone by specific receptor.

5.Relay and amplification of the received signal causing cellular specific response.

6.Breakdown of the hormone

Hormone secretion can be stimulated and inhibited by:

1.Other hormones (stimulating- or releasing -hormones).

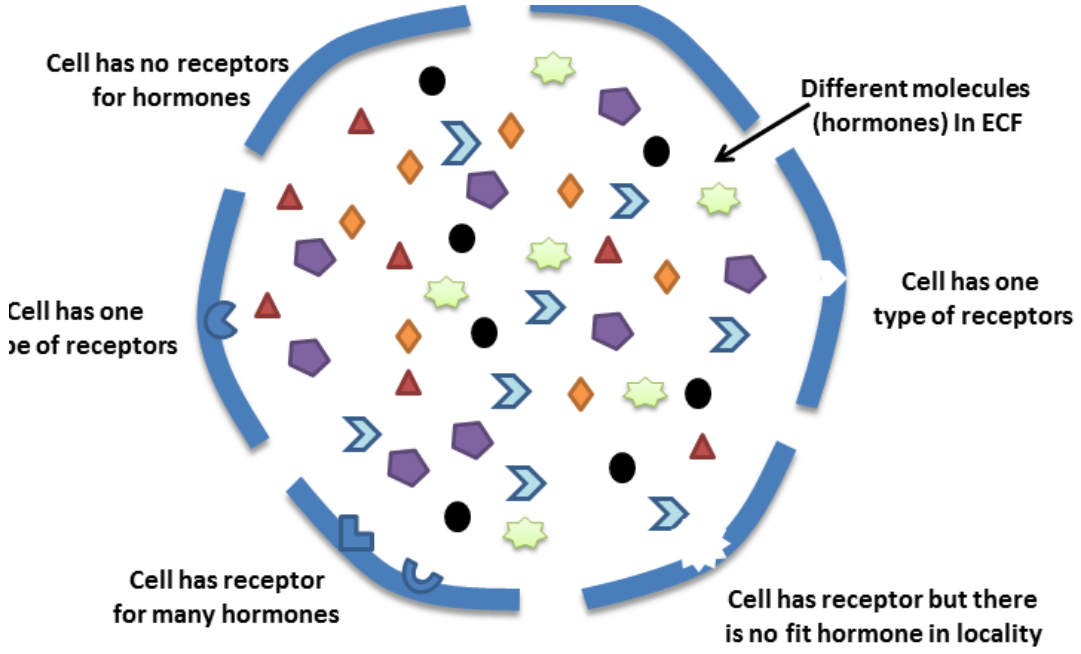
2.Plasma concentrations of ions or nutrients, as well as binding globulins.

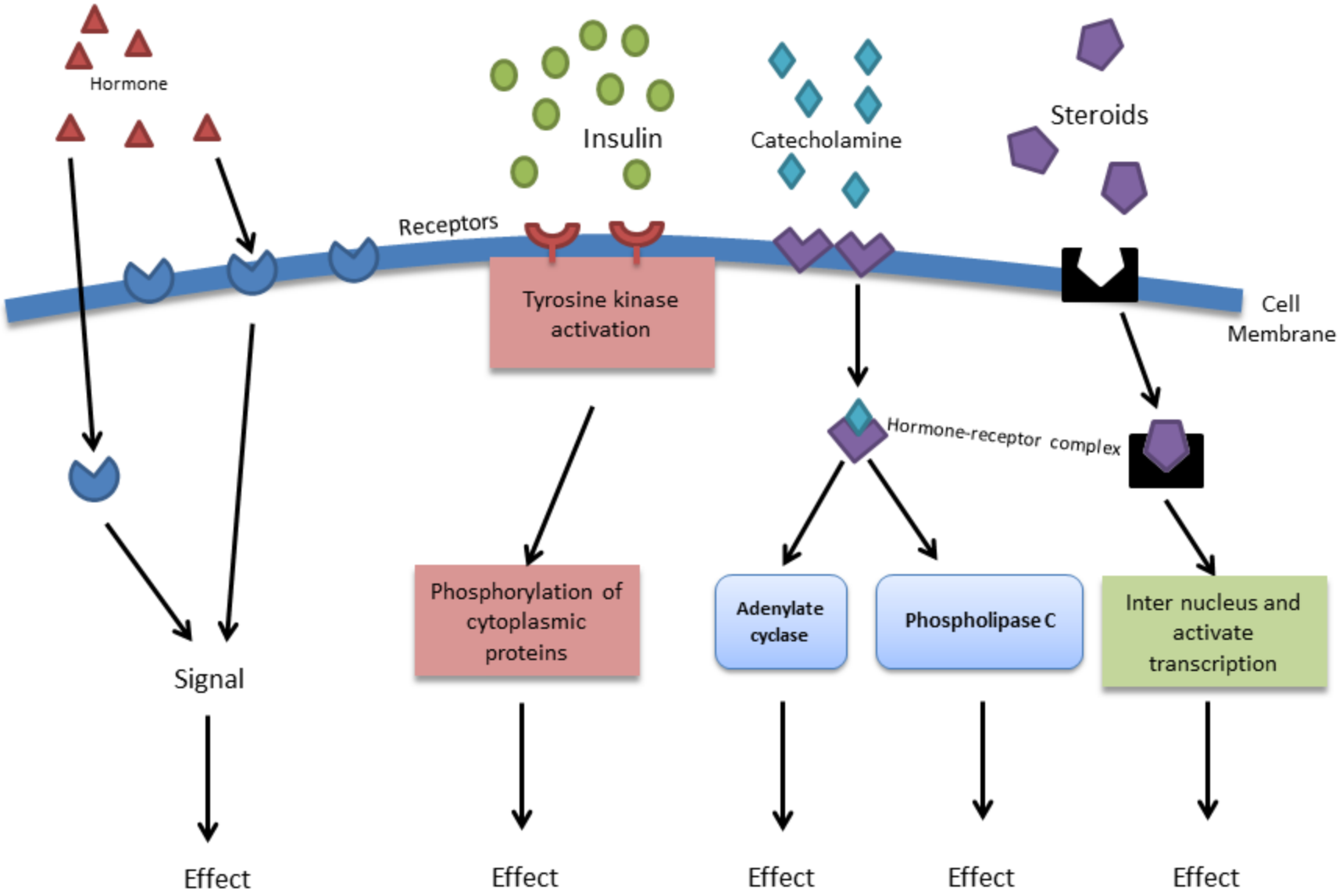
3.Neurons and mental activity.

4.Environmental changes, e.g., light or temperature

Receptor Hormones are exists in very low concentration to extracellular fluid, in the range of attomolar **(10^{-15})**to nanomolar **(10^{-9})** mol/L . At this extra low concentration, target cells must be recognize specific hormone and distinguish between different types of hormones, for more than 220 kind of cells in farm animal body there are at least 55 type of hormones recorded until now.

This high degree of discrimination is provided by cell-associated recognition molecules, receptors. Hormones initiate their biological effects by binding to specific receptors




Hormone
Insulin
Catecholamine
Steroids
Receptors
Tyrosine kinase activation
Cell Membrane
Hormone-receptor complex
Signal
Phosphorylation of cytoplasmic proteins
Adenylate cyclase
Phospholipase C
Inter nucleus and activate transcription
Effect
Effect
Effect
Effect
Effect

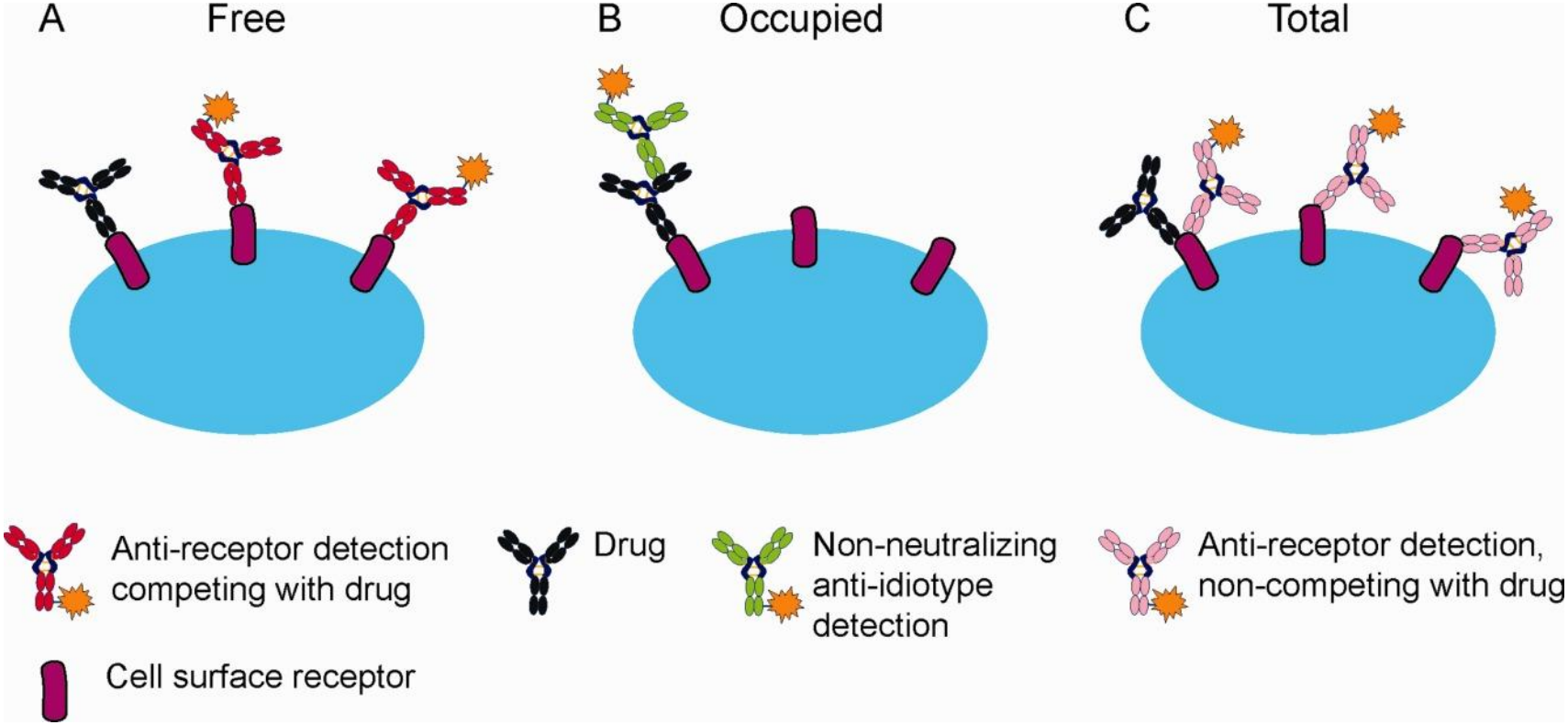
Hormones are formed and modified by various ways:

1. Certain hormones are synthesizing in **final form and immediately secreted**, for example steroid hormones.
2. Other hormones are synthesized in the **final form and stored** in the producing cells, as catecholamines.
3. Some hormones are **made from precursor** molecules in producing cells, and they are processed and secreted according to the physiological demand, as insulin.
4. Final kind of hormones are **prepared and secreted in inactive form**, and it is activation occur after secretion, like T3.

Measurement of hormones: Hormones are measured by a variety of analytical techniques, including :

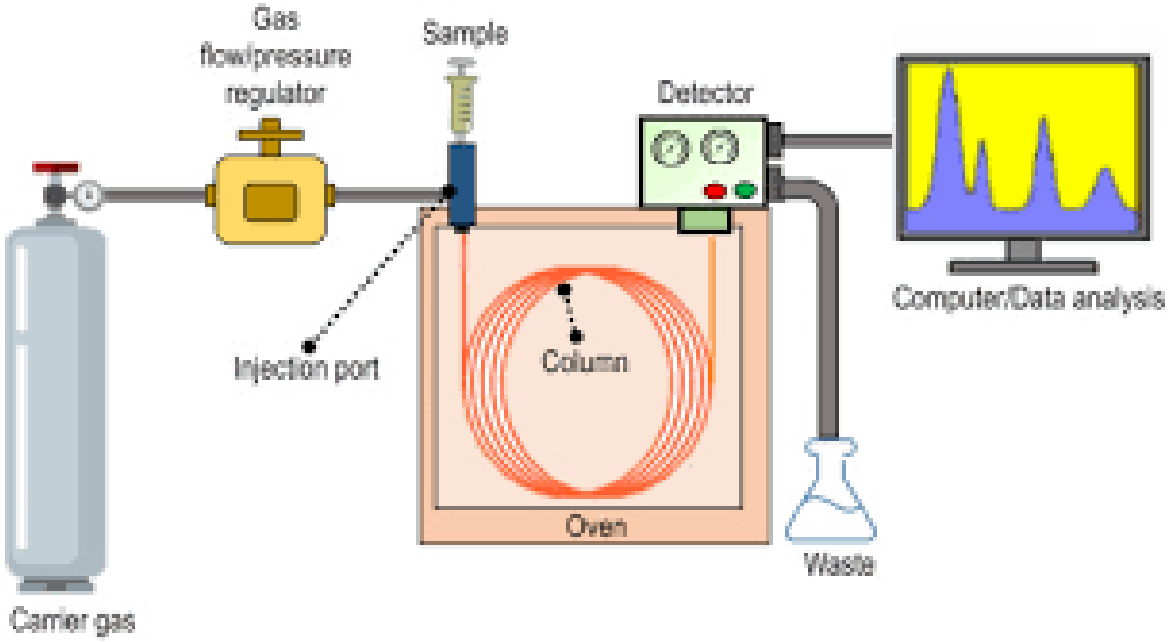
1- **Bioassays** are based on observations of physiological responses specific for the hormone being measured. In **vivo bioassays** usually involve the injection of test materials (such as blood or urine from a patient) into suitably prepared animals. Target gland responses, such as growth or steroidogenesis, are then measured. In **vitro bioassays** involve the incubation of tissue, membranes, dispersed cells, or permanent cell lines in a defined culture medium, with subsequent measurement of an appropriate hormone response.

2- **Receptor assay**: Receptor-based assays depend on the in **vitro** interaction of a hormone with its biological receptor. In this type of assay, unlabeled hormone displaces trace amounts of radioactively labeled hormone from receptor sites.



3-Immunoassay: hormonal immunoassay is a biochemical test that measures the presence or concentration of a hormone in a solution through the use of an antibody or immunoglobulin. Possibly one of the most popular labels to use in immunoassays is enzymes. Immunoassays which employ enzymes are referred to as **enzyme-linked immunosorbent assay** (ELISA) . Radioimmunoassay (RIA) is a very sensitive in vitro assay technique used to measure concentrations of antigens (for example, hormone levels in blood) by use of antibodies.

4- Instrumental techniques: such as mass spectrometry interfaced with either liquid or gas chromatography . Mass spectrometers are powerful qualitative and quantitative analytical tools that are widely used to measure hormones.

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