

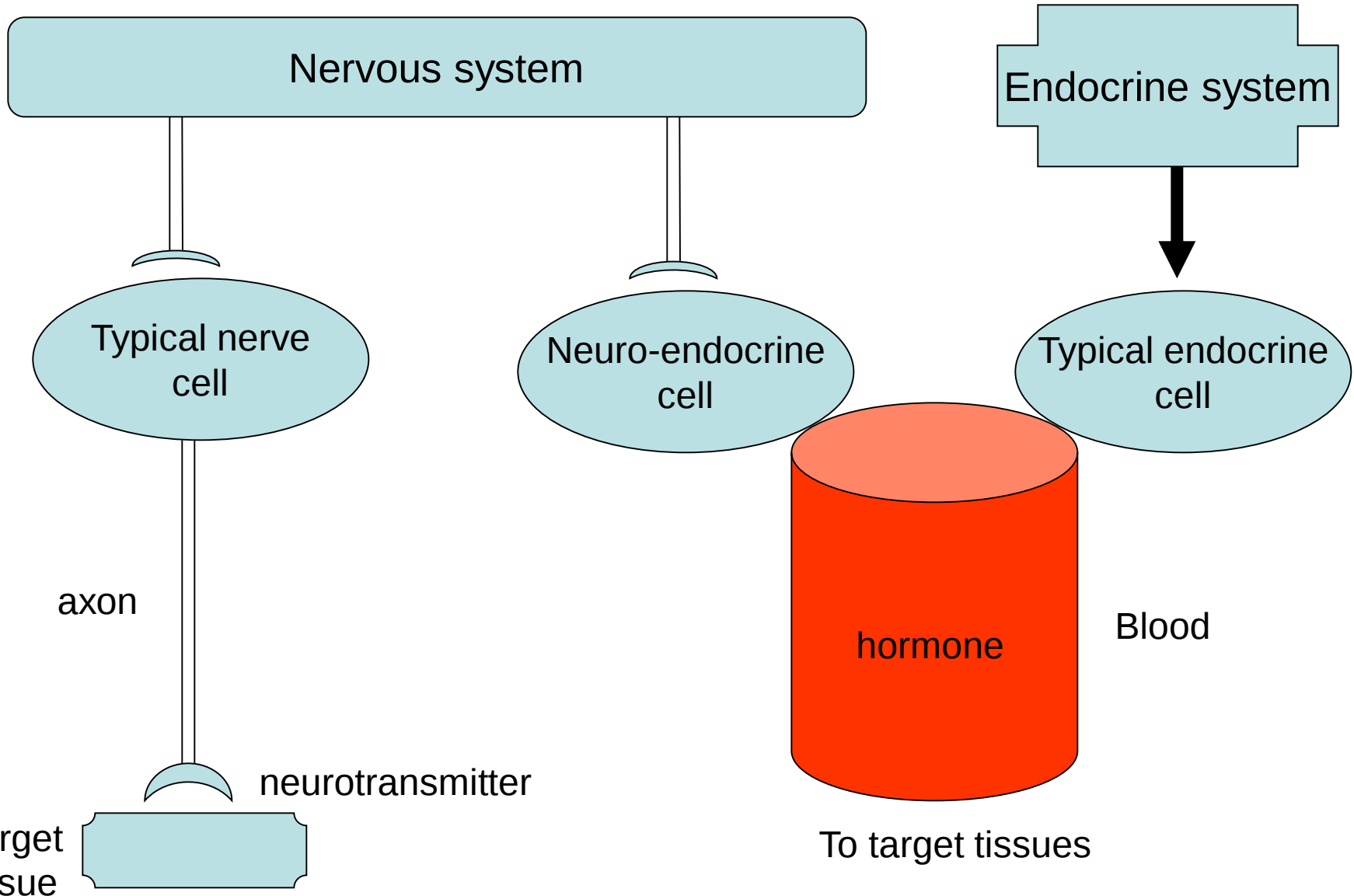
Hormones

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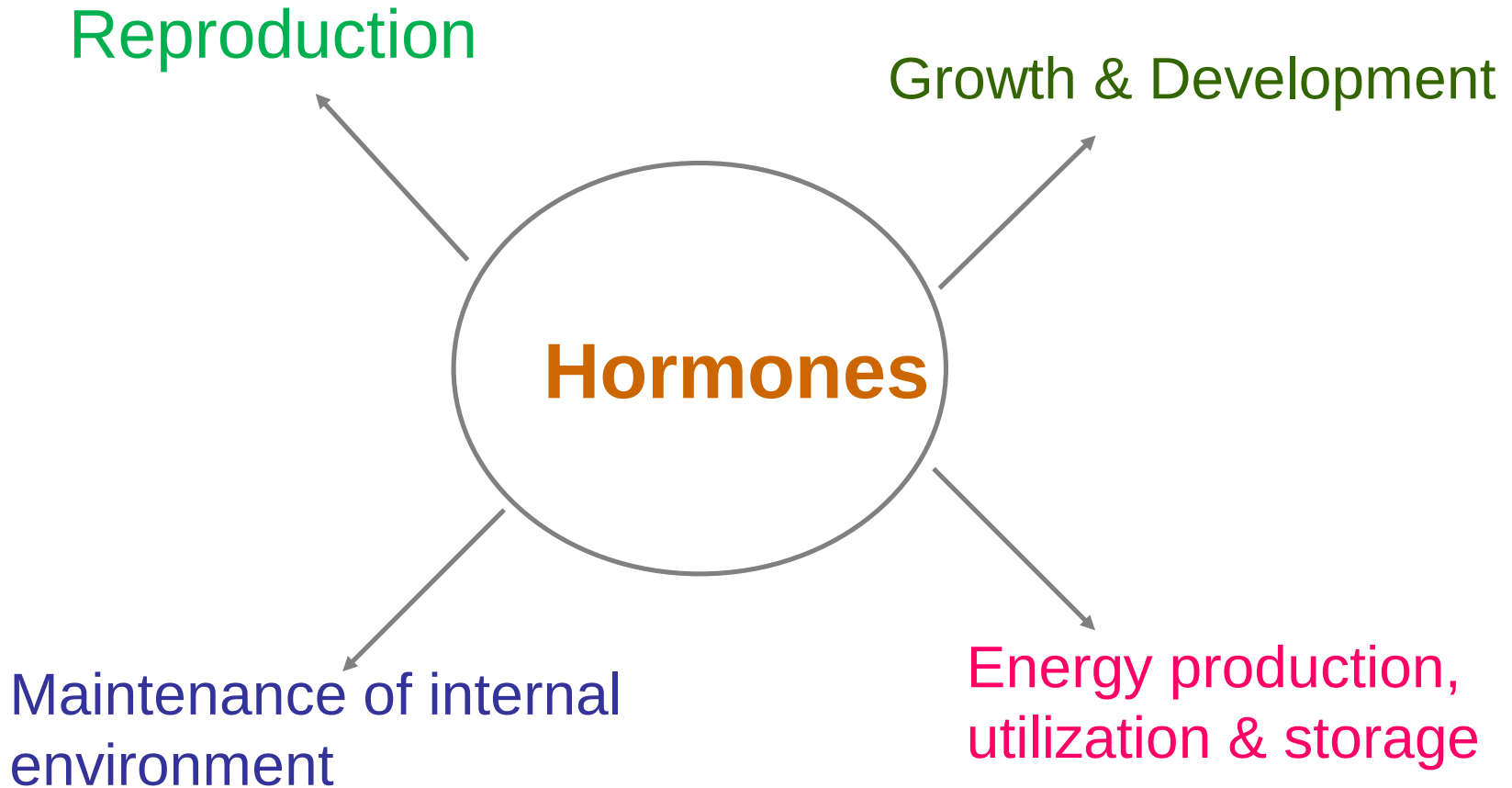
Definitions

- Endocrine** - Refers to the internal secretion of biologically active substances.
- Exocrine** - Refers to secretion outside the body, for example, through sweat glands, mammary glands, or ducts lead to the gastrointestinal.
- Hormone** - Substances released by an endocrine gland and transported through the bloodstream to another tissue where it acts to regulate functions in the target tissue (classic definition).
- Paracrine** - Hormones that act locally on cells that did not produce them.
- Autocrine** - Hormones that act on cells that produced them.
- Receptors** - Hormones bind to receptors molecules on cells. A receptor must specifically recognize the hormone from the numerous other molecules in the blood and transmit the hormone binding information into a cellular specific action.

Nervous vs. endocrine systems



The four primary areas of hormone action



Classification of hormones Chemically

```
graph TD; A[Classification of hormones Chemically] --> B[Peptides]; A --> C[Tyrosine derivatives]; A --> D[Steroids]; B --> E[Most hormones]; C --> F[Thyroid hormones]; C --> G[catecholamines]; D --> H[Sex hormones]; D --> I[Adrenocortical hormones];
```

Peptides

Most hormones

**Tyrosine
derivatives**

Thyroid hormones

catecholamines

Steroids

Sex hormones

**Adrenocortical
hormones**

Classification of hormones

```
graph TD; A[Classification of hormones] --> B[Hydrophilic (water soluble)]; A --> C[Lipophilic (fat soluble)]; B --> D[Catecholamines]; B --> E[Peptide hormones]; C --> F[thyroid hormones]; C --> G[Steroid hormones];
```

**Hydrophilic
(water soluble)**

Catecholamines

Peptide hormones

**Lipophilic
(fat soluble)**

thyroid hormones

Steroid hormones

Classification of hormones

```
graph TD; A[Classification of hormones] --> B[Hydrophilic (water soluble)]; A --> C[Lipophilic (fat soluble)]; B --> D[Bind with receptors in the cell membrane]; D --> E[Activation of second messenger pathways]; E --> F[Alterations in the preexisting Proteins' activities]; C --> G[Bind with receptors inside the cells]; G --> H[Activation of mRNA]; H --> I[Formation of new proteins]; F --> J[Cell response]; I --> J;
```

Hydrophilic (water soluble)

**Bind with receptors
in the cell membrane**

**Activation of second
messenger pathways**

**Alterations in the preexisting
Proteins' activities**

Lipophilic (fat soluble)

**Bind with receptors
inside the cells**

Activation of mRNA

Formation of new proteins

Cell response

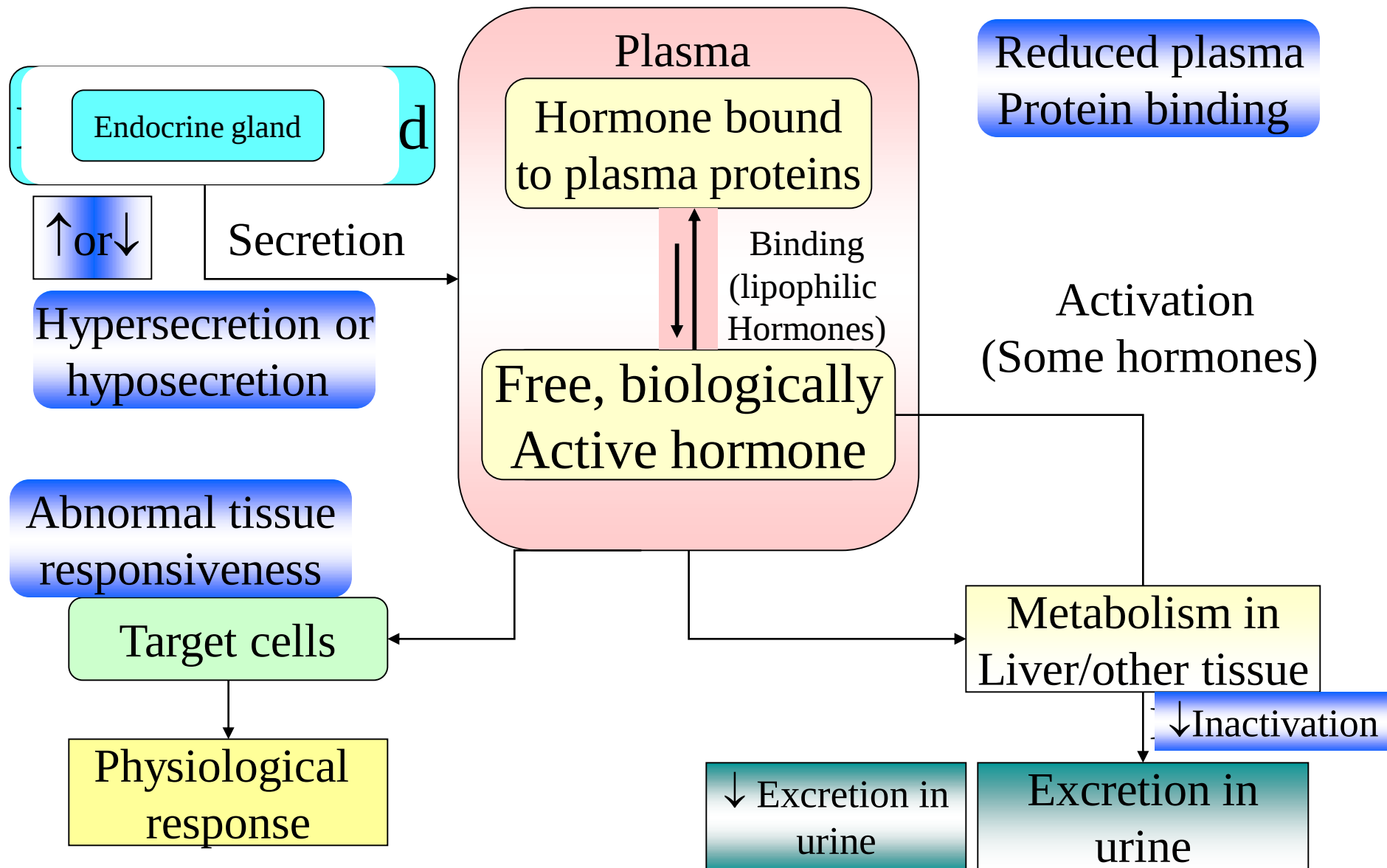
Tropic and non-tropic hormones

- Tropic (to nourish) Hormone: It is primary function to regulate the hormone secretion by another endocrine glands. e.g. Thyroid stimulating hormone (TSH)
- Non-tropic hormone: It affects non endocrine target tissues, e.g. thyroid hormone.

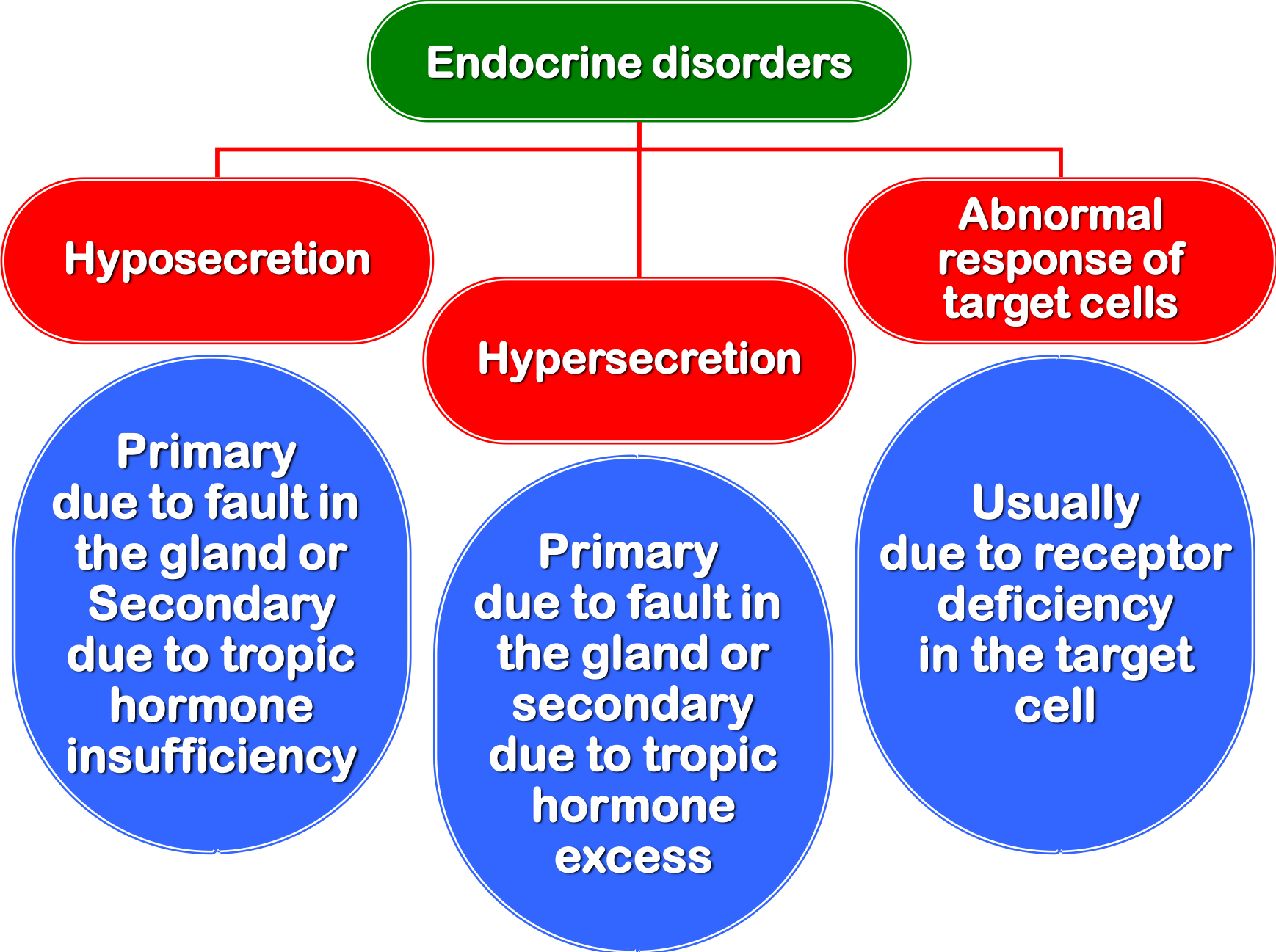
Functions of endocrine glands (hormones)

- **Regulating metabolism**
- **Regulating water and electrolyte balance**
- **promoting growth and development**
- **Controlling reproduction**
- **Regulating blood cell production**
- **Controlling activities of different systems**

Means by which endocrine disorders can arise



Endocrine disorders



```
graph TD; A[Endocrine disorders] --> B[Hyposecretion]; A --> C[Hypersecretion]; A --> D[Abnormal response of target cells]; B --> E["Primary due to fault in the gland or Secondary due to tropic hormone insufficiency"]; C --> F["Primary due to fault in the gland or secondary due to tropic hormone excess"]; D --> G["Usually due to receptor deficiency in the target cell"];
```

Hyposecretion

Primary
due to fault in
the gland or
Secondary
due to tropic
hormone
insufficiency

Hypersecretion

Primary
due to fault in
the gland or
secondary
due to tropic
hormone
excess

**Abnormal
response of
target cells**

Usually
due to receptor
deficiency
in the target
cell

Hormone Receptors and Signal Transduction

Hormone Receptors

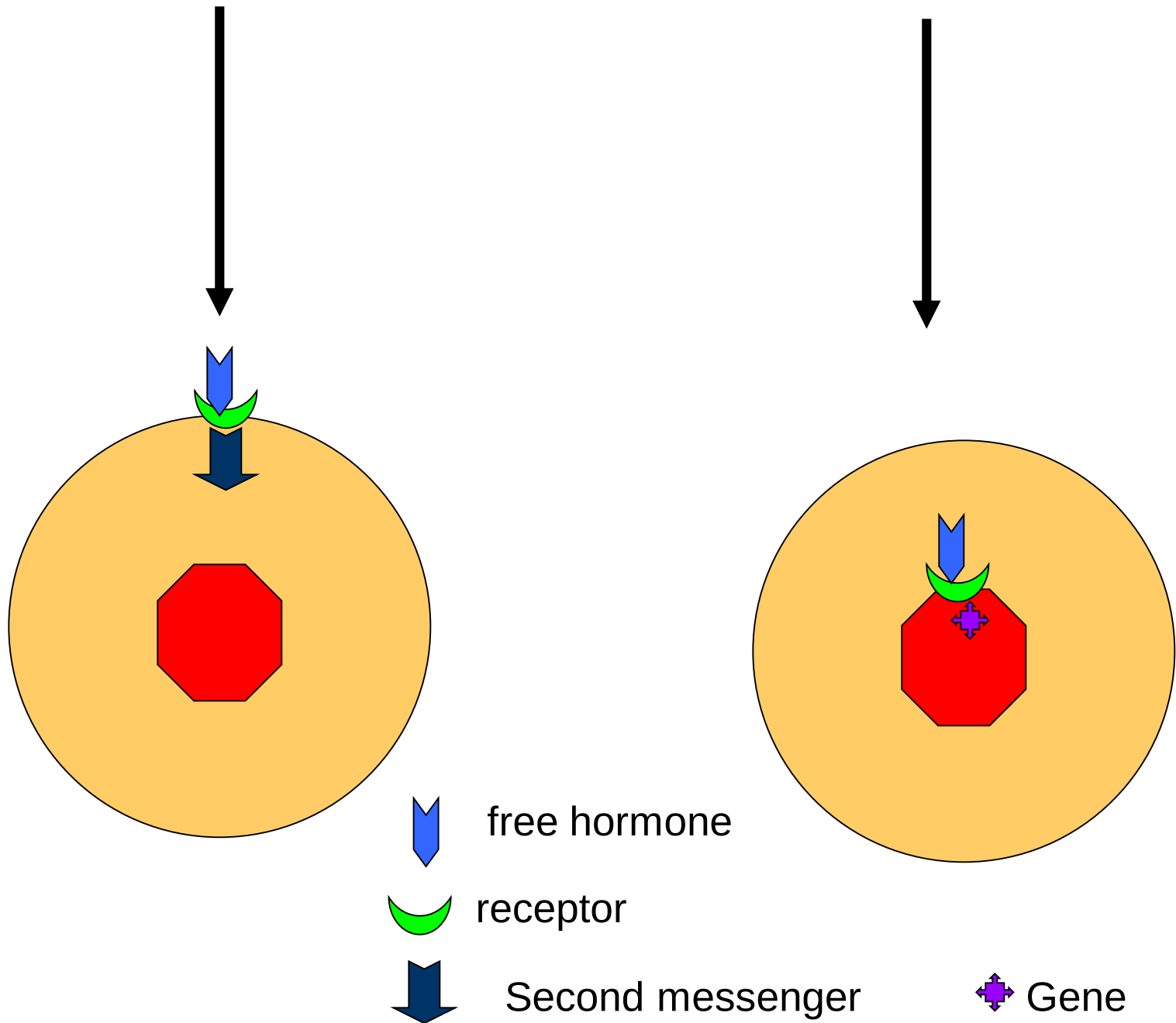
Nuclear receptors
estrogens

Cytoplasmic receptors
Most steroid and thyroid hormones

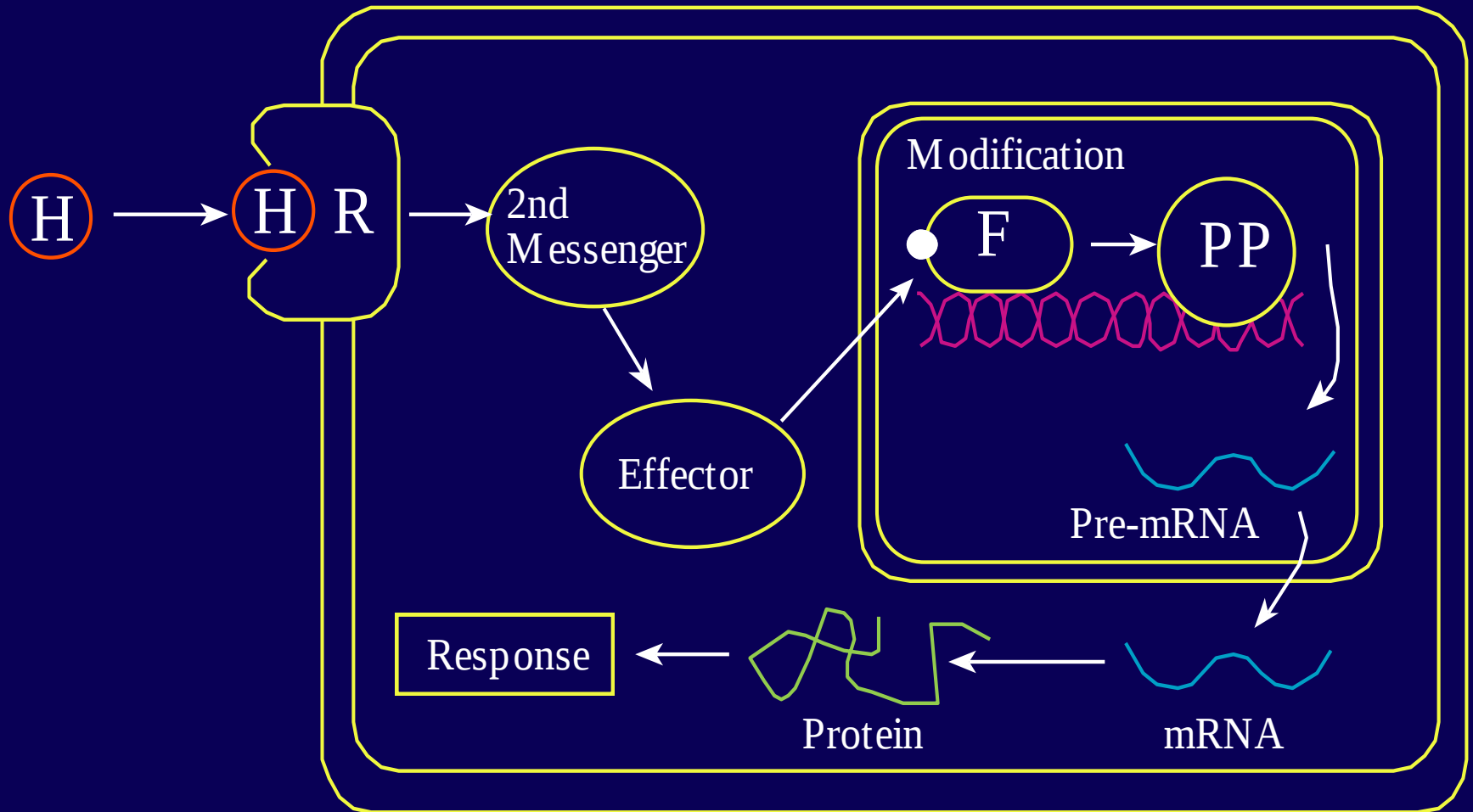
Cell surface **membrane** receptors
Polypeptide hormones and
catecholamines

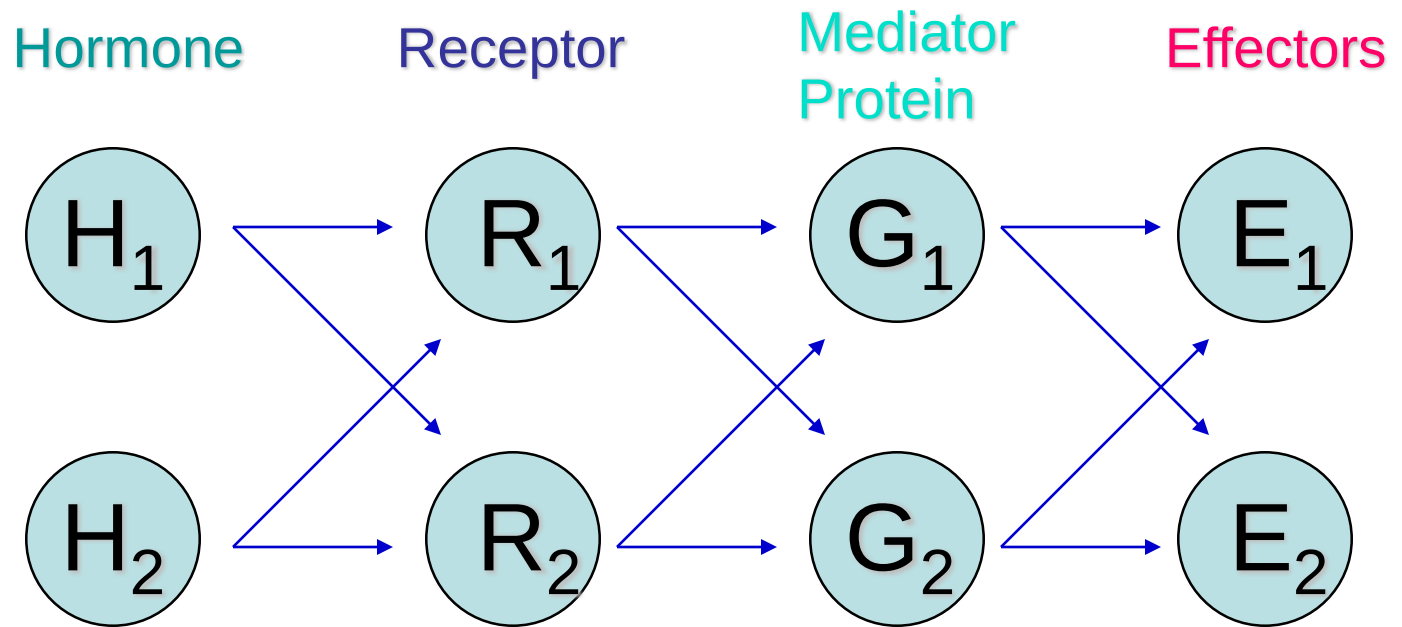
Hydrophilic hormone

lipophilic hormone



Regulation of transcription by hormones through cell surface receptors





Possible pathways of transmission of hormonal signal. Each **hormone** can work through one or more **receptors**; each hormone-receptor complex can work through one or more **mediator** proteins (either G proteins or other signaling mechanism), and each mediating protein or enzyme activated by hormone-receptor complexes can affect one or more **effectors** functions.

Primary messengers:

- Hormones,
- Humoral factors – histamine,
- Growth factors – IGF, EGF, NGF,
- Neurotransmitters – dopamine, Ach,
- Limfokines – IL,
- Drugs.

Secondary messengers

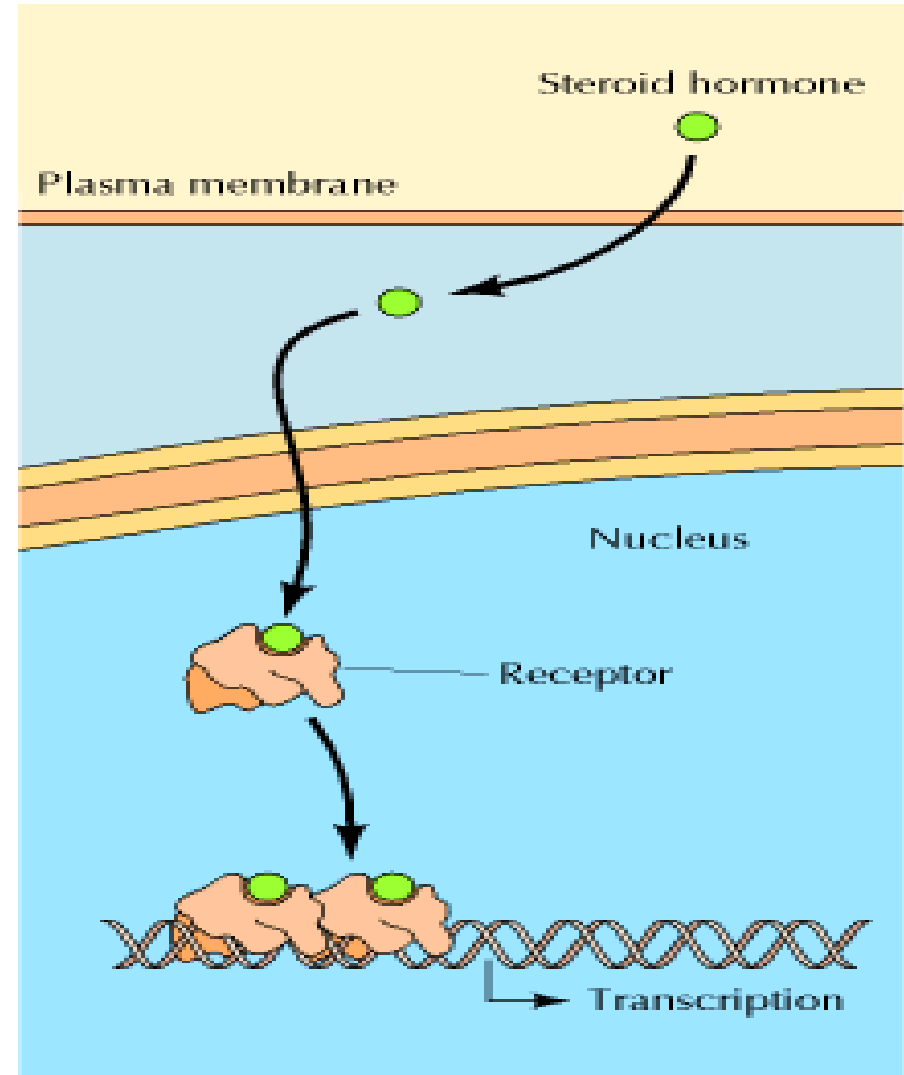
- They mediate the **intracellular effects** of a hormone.
- There are **three basic types of secondary messenger** molecules:
- **Hydrophobic molecules:** water-insoluble molecules, like diacylglycerol, IP3, and phosphatidylinositols, which are membrane-associated and diffuse from the plasma membrane into the juxtamembrane space where they can reach and regulate membrane-associated effector proteins.
- **Hydrophilic molecules:** water-soluble molecules, like cAMP, cGMP, and Ca^{2+} , that are located within the cytosol.
- **Gases:** nitric oxide (NO) and carbon monoxide (CO), which can diffuse both through cytosol and across cellular membranes.

Intracellular Receptors for steroid and thyroid hormones

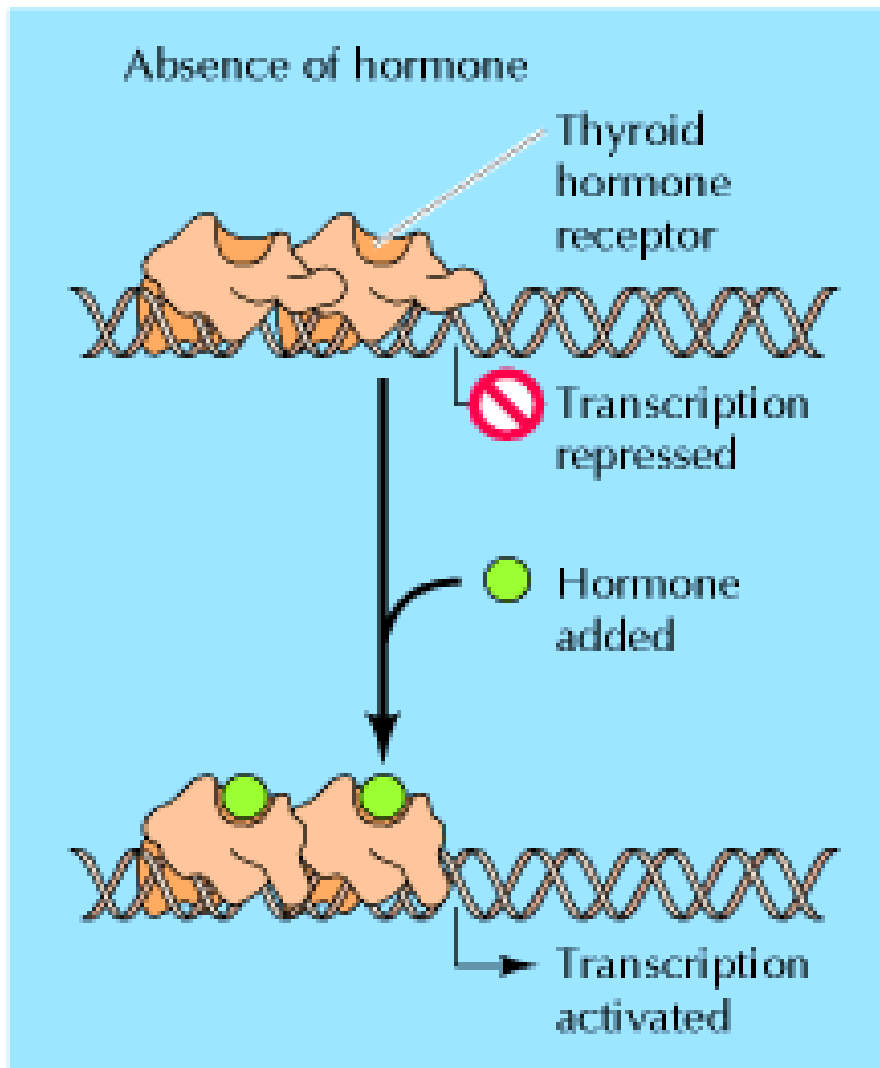
1. Receptors located in the nucleus or cytoplasm.
2. They are hormone-regulated transcription factors.
3. They are proteins.
4. Hormone-receptor complex is translocated to chromatin and binds to it.

Action of steroid hormones

- The steroid hormones diffuse across the plasma membrane and bind to nuclear receptors, which directly stimulate transcription of their target genes.
- The steroid hormone receptors bind DNA as dimers



Gene regulation by the thyroid hormone receptor



- Thyroid hormone receptor binds DNA in either the presence or absence of hormone.
- However, hormone binding changes the function of the receptor from a repressor to an activator of target gene transcription.