Endocrine System

Vedat Evren

Hormones

- Hormon (Greek) = to stimulate, to excite

- Synthesized and released by specialized cell groups
- Distributed via blood circulation
- Exert their effects by binding their targets

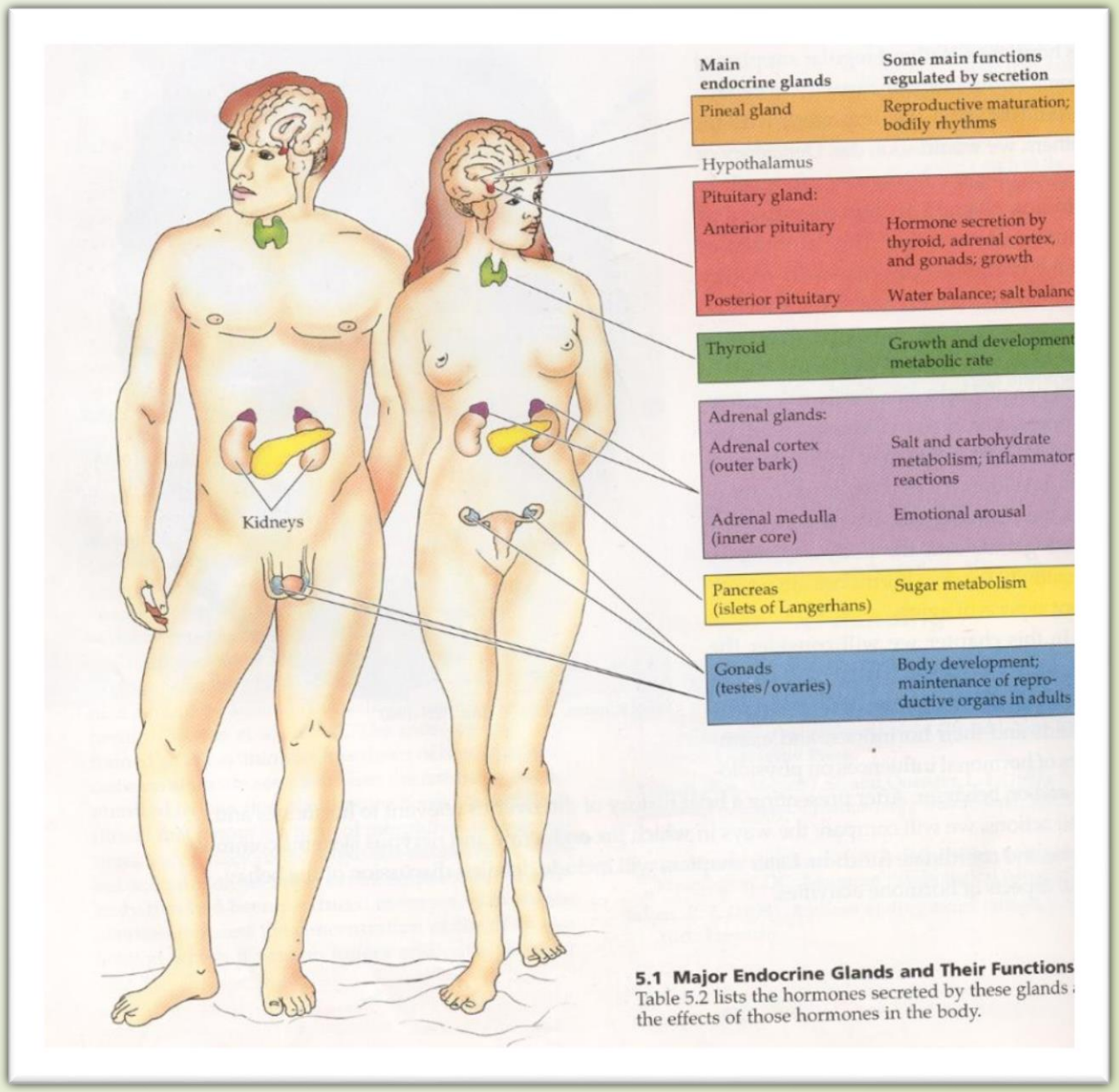
Endocrine Gland

- Endon = inner
- Krinein = secrete

- Glands of the endocrine system
- Ductless !
  - Secrete their products directly into the blood

- Variable size, shape and products (but all hormones)

Major Glands



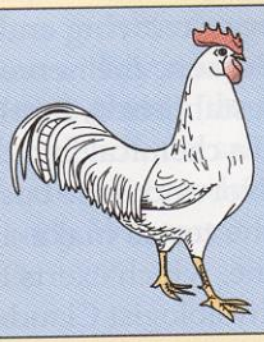
Main endocrine glands	Some main functions regulated by secretion
Pineal gland	Reproductive maturation; bodily rhythms
Hypothalamus	
Pituitary gland:	
Anterior pituitary	Hormone secretion by thyroid, adrenal cortex, and gonads; growth
Posterior pituitary	Water balance; salt balanc
Thyroid	Growth and development metabolic rate
Adrenal glands:	
Adrenal cortex (outer bark)	Salt and carbohydrate metabolism; inflammator reactions
Adrenal medulla (inner core)	Emotional arousal
Pancreas (islets of Langerhans)	Sugar metabolism
Gonads (testes/ovaries)	Body development; maintenance of reproductive organs in adults

5.1 Major Endocrine Glands and Their Functions
Table 5.2 lists the hormones secreted by these glands
the effects of those hormones in the body.

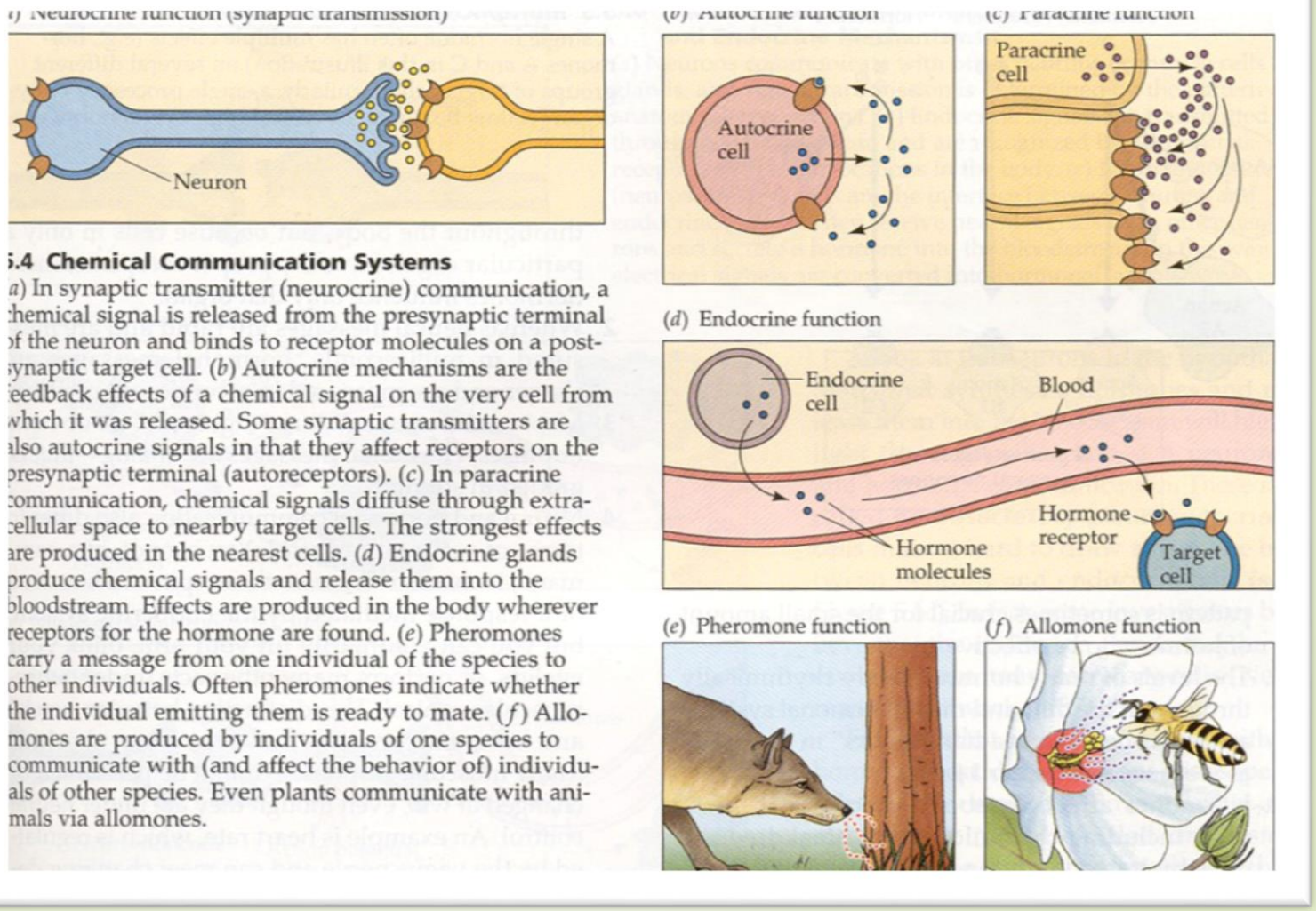
History

- 4th century BC; Aristo
- 19th century AC; relation with body fluids and character
  - Phlegmatic
  - Bilious or Choleric

Arnold Adolph Berthold - 1849

	Group 1	Group 2	Group 3
Appearance of immature roosters			
Manipulation	None	Remove testes	Remove testes and reimplant one in abdomen
Appearance of adult roosters			
Comb and wattles: Mount hens? Aggressive? Crowing?	Normal Yes Yes Normal	Small No No Weak	Normal Yes Yes Normal

Communication in Biology



5.4 Chemical Communication Systems

(*a*) In synaptic transmitter (neurocrine) communication, a chemical signal is released from the presynaptic terminal of the neuron and binds to receptor molecules on a postsynaptic target cell. (*b*) Autocrine mechanisms are the feedback effects of a chemical signal on the very cell from which it was released. Some synaptic transmitters are also autocrine signals in that they affect receptors on the presynaptic terminal (autoreceptors). (*c*) In paracrine communication, chemical signals diffuse through extracellular space to nearby target cells. The strongest effects are produced in the nearest cells. (*d*) Endocrine glands produce chemical signals and release them into the bloodstream. Effects are produced in the body wherever receptors for the hormone are found. (*e*) Pheromones carry a message from one individual of the species to other individuals. Often pheromones indicate whether the individual emitting them is ready to mate. (*f*) Allomones are produced by individuals of one species to communicate with (and affect the behavior of) individuals of other species. Even plants communicate with animals via allomones.

Hormonal Principles

- Effects are generally gradual
- Hormones change the intensity and probability of behaviors
- Secretion is influenced by external and internal factors
- Hormones may have different effects on different organs
- Secreted as bursts and in small amounts
- Secretion may exhibit rhythmic changes
- Most of them change metabolism of their targets
- May interact with other hormones
- Structure is almost same in vertebrates but function may differ

Main Principle

- Hormones can only be effective on the cells which have a receptor that recognize the hormone !!

Comparison with Nervous System

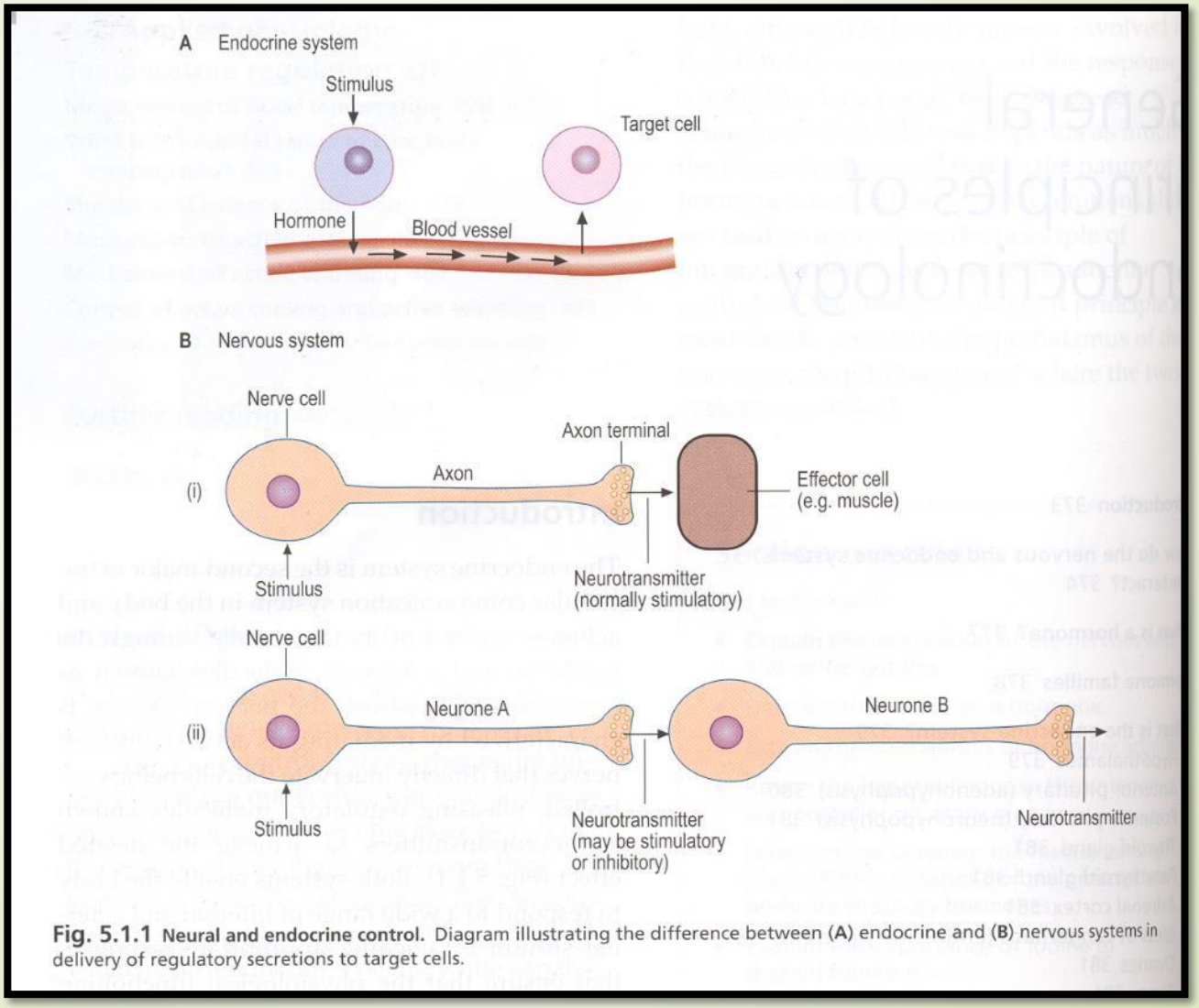


Fig. 5.1.1 Neural and endocrine control. Diagram illustrating the difference between (**A**) endocrine and (**B**) nervous systems in delivery of regulatory secretions to target cells.

Comparison with Nervous System

- **Similarities**

1. Both are chemicals
2. Both synthesized and stored for further use
3. Some are both hormones and neurotransmitters
4. Both require receptors
5. Similar secondary messengers

- **Differences**

1. Nervous system requires anatomical connections
2. Neural messages are fast
3. Neural digital, hormones analogous
4. Some neural messages are voluntary

Chemistry of Hormones

- Steroids
- Peptides and proteins
- Amines (thyrosine derivatives)

Hormones: What do they do..

- They act on cellular growth and activity
  - Support proliferation, growth and differantiation
  - Regulates activity

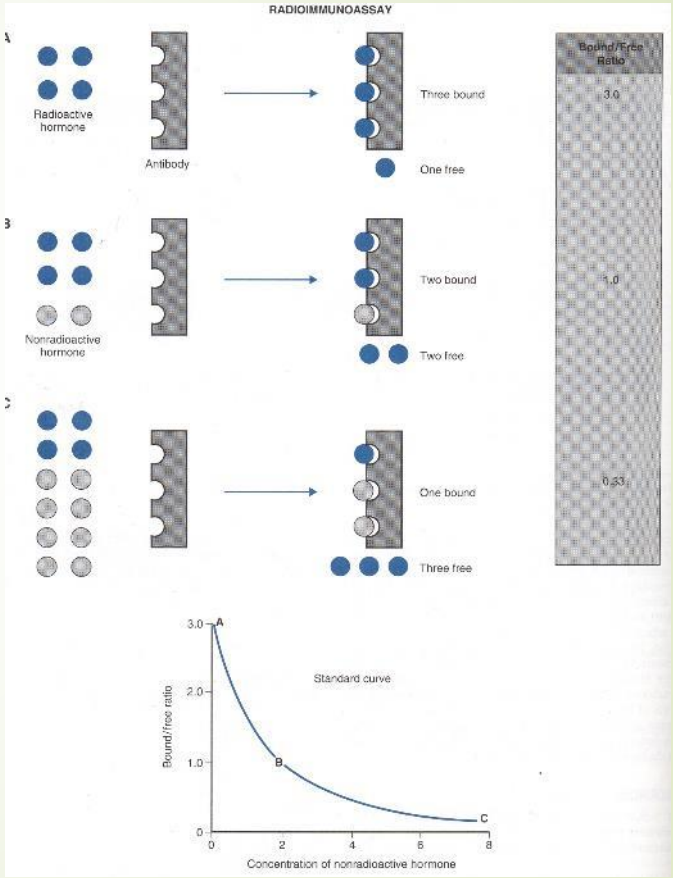
First: Receptor

- PROTEIN HORMONES
- Receptor
- Second messenger
- Alter cellular program

- STEROID HORMONES
- Cross cell membrane
- Receptor (Cytosolic)
- Hormone-receptor-DNA
- Alter gene transcription

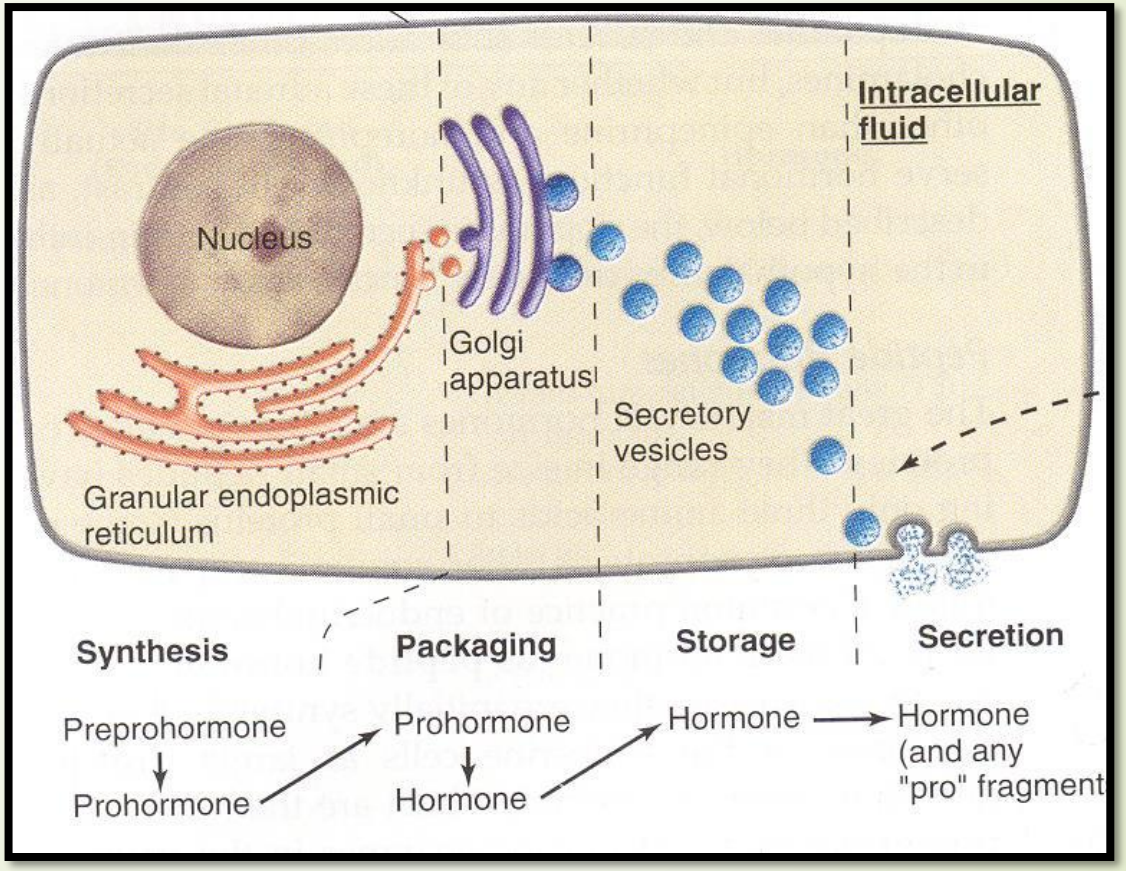
Measurement

- Hormone level : Very low in plasma (nanomolar..)
  - Bioassay technique
  - RIA (radioimmunoassay) (measures not the biology but immune activity)



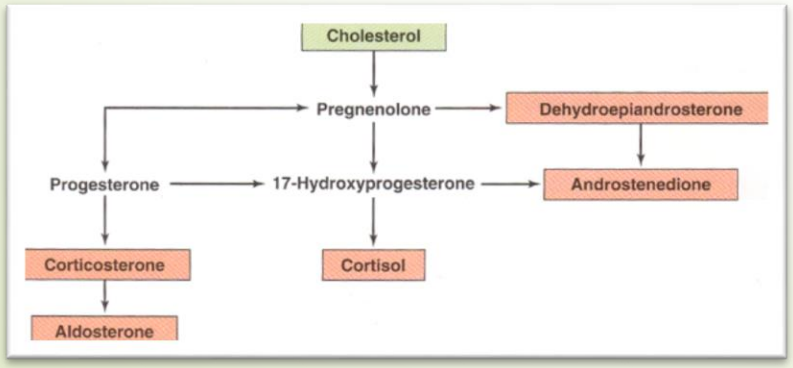
Synthesis of Hormones

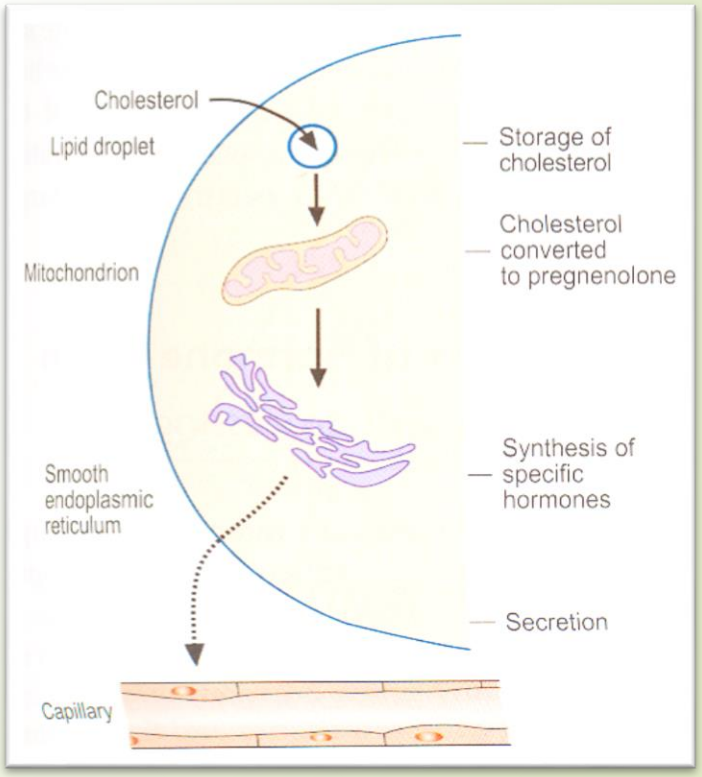
Synthesis (protein / peptide)



Synthesis (steroid)

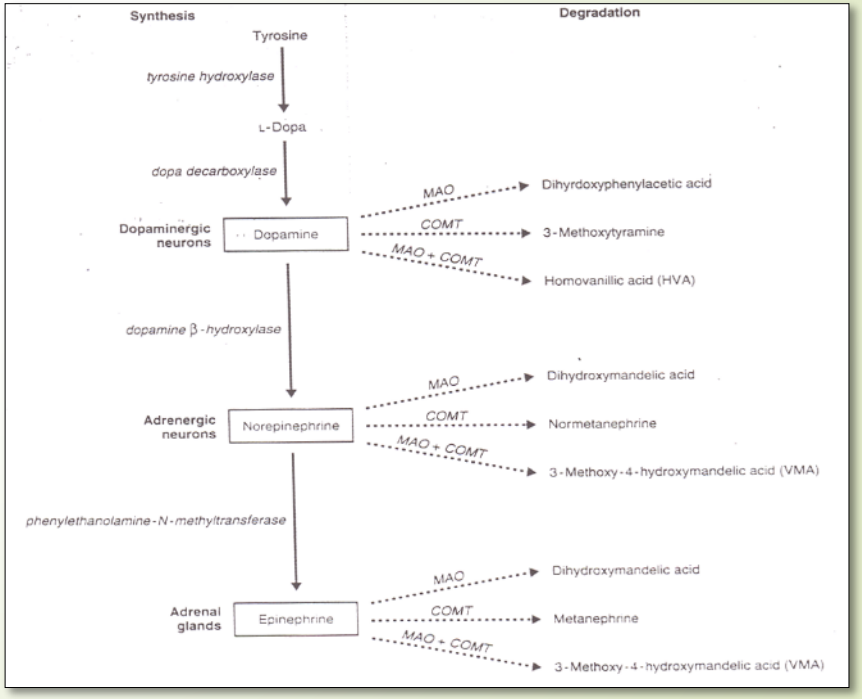
- All of them are cholesterol derivatives
  - Cortisol
  - Aldosterone
  - Estrogen
  - Progesterone
  - Testosterone





Synthesis (amines)

- All of them are tyrosine amino acid derivatives,
  - Catecholamines
    - Adrenaline
    - Noradrenaline
    - Dopamine
  - Thyroid hormone



Regulation of Secretion

Feedback Mechanism

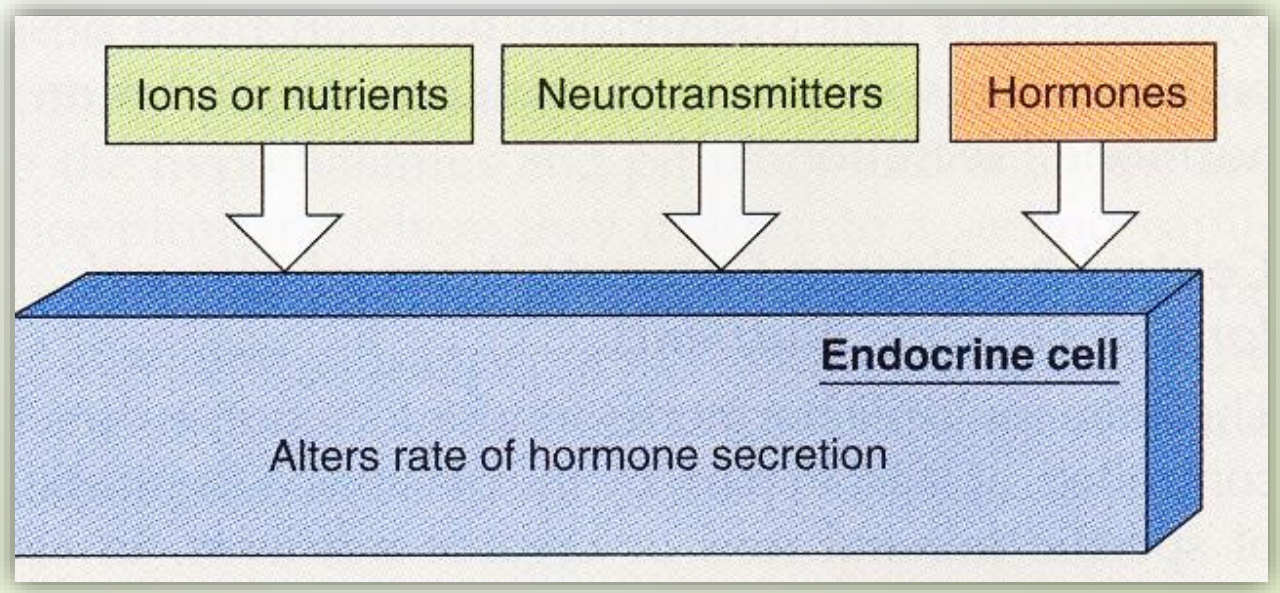
- Could be negative or positive (mostly negative)
- Provides adequate hormone levels
- Activeness of a hormone prevents the continuity of secretion

Regulation Types

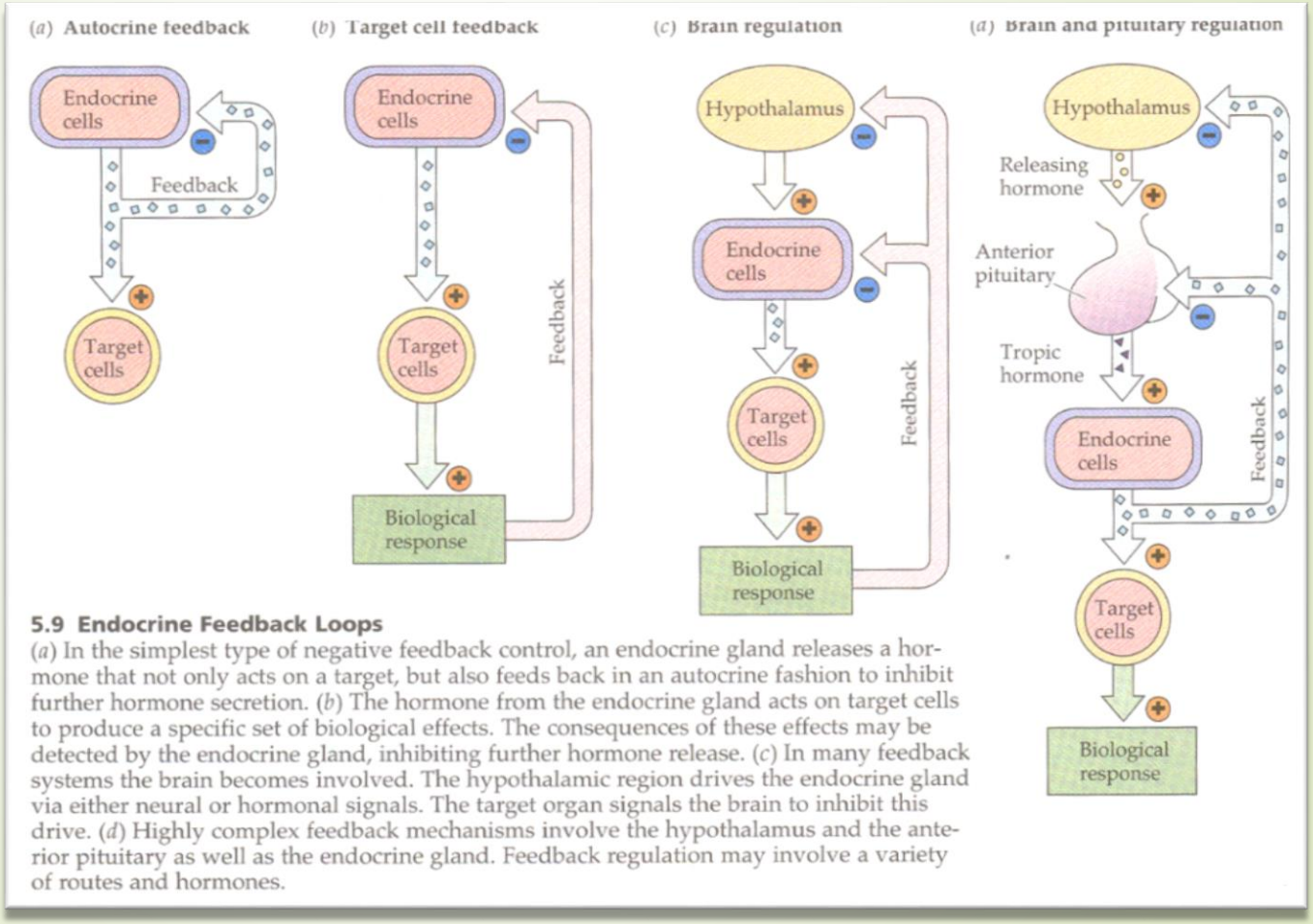
- Autocrine feedback
- Feedback from target cells
- Regulation by brain
- Regulation by brain-pituitary

Regulation Inputs

- 3 types of inputs control secretion
  - Mineral ions (or plasma chemicals)
  - Neurotransmitters
  - Other hormones

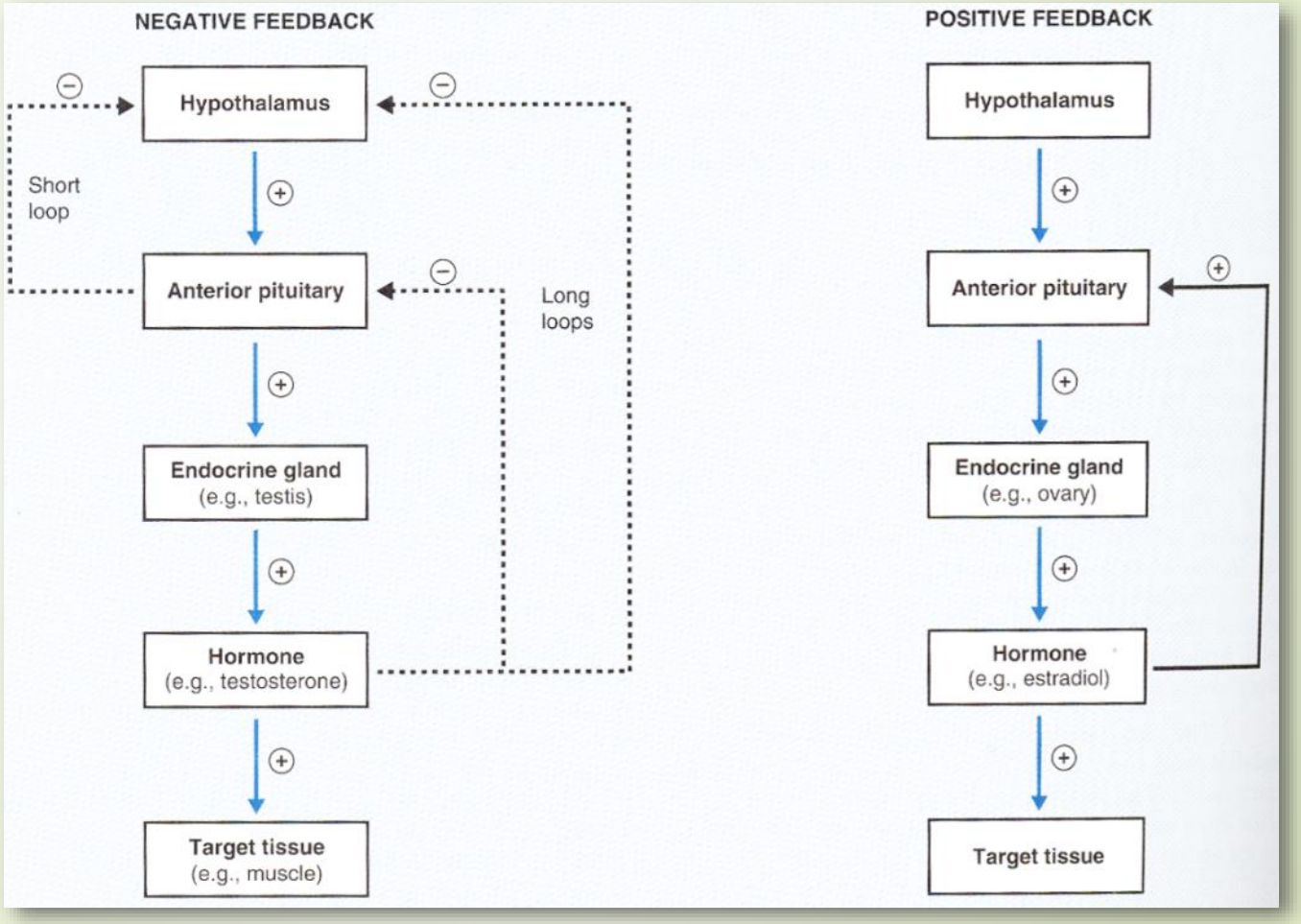


Regulation Types

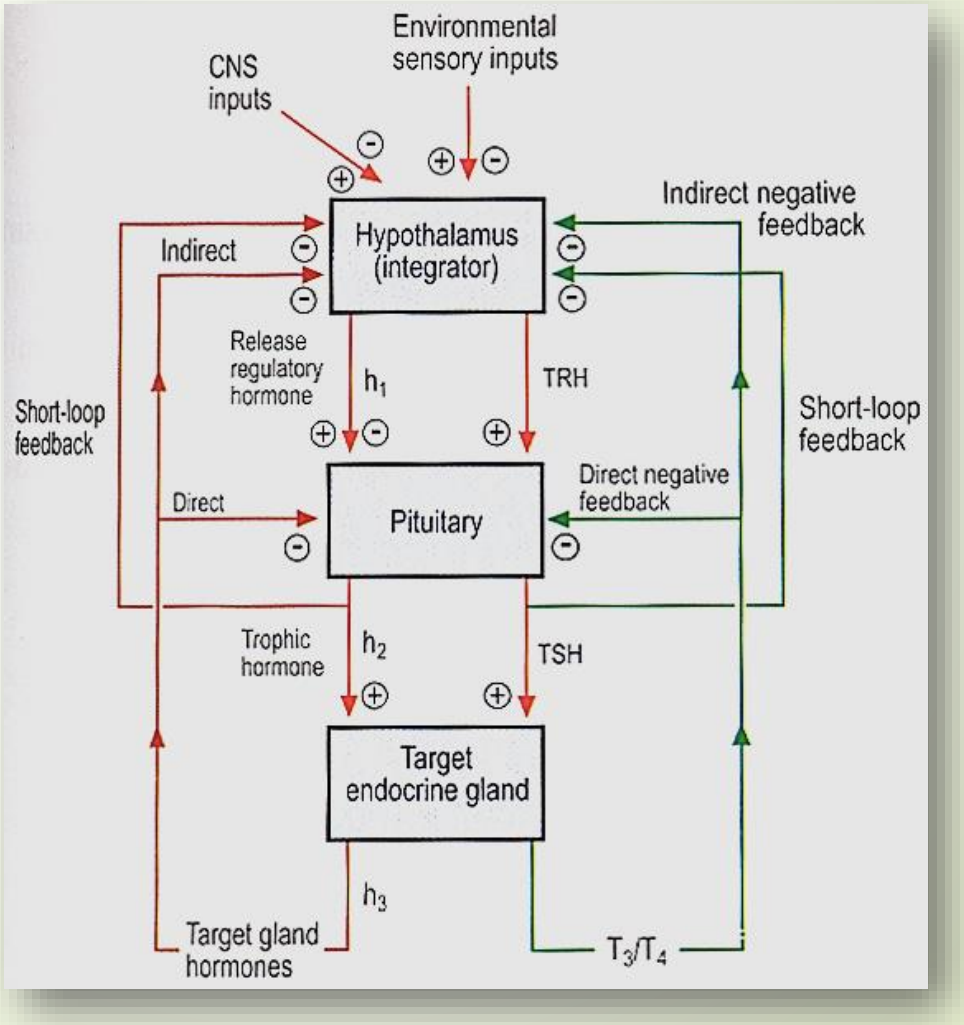


5.9 Endocrine Feedback Loops
(*a*) In the simplest type of negative feedback control, an endocrine gland releases a hormone that not only acts on a target, but also feeds back in an autocrine fashion to inhibit further hormone secretion. (*b*) The hormone from the endocrine gland acts on target cells to produce a specific set of biological effects. The consequences of these effects may be detected by the endocrine gland, inhibiting further hormone release. (*c*) In many feedback systems the brain becomes involved. The hypothalamic region drives the endocrine gland via either neural or hormonal signals. The target organ signals the brain to inhibit this drive. (*d*) Highly complex feedback mechanisms involve the hypothalamus and the anterior pituitary as well as the endocrine gland. Feedback regulation may involve a variety of routes and hormones.

Feedback


NEGATIVE FEEDBACK
Hypothalamus
Short loop
Anterior pituitary
Long loops
Endocrine gland (e.g., testis)
Hormone (e.g., testosterone)
Target tissue (e.g., muscle)
POSITIVE FEEDBACK
Hypothalamus
Anterior pituitary
Endocrine gland (e.g., ovary)
Hormone (e.g., estradiol)
Target tissue

Feedback


Environmental sensory inputs
CNS inputs
Indirect negative feedback
Hypothalamus (integrator)
Indirect
Release regulatory hormone
h_1
TRH
Short-loop feedback
Short-loop feedback
Direct negative feedback
Direct
Pituitary
Trophic hormone
h_2
TSH
Target endocrine gland
h_3
Target gland hormones
T_3/T_4

Receptor Modification

- Sensitivity : Level that causes 50% of the maximal response

- Sensitivity may be modified in two ways:
  - Changing the number of receptors

  or..

  - Changing the receptor affinity
- Up – Down regulation of receptors (number)
  - Why?

Types of Second Messengers

- cAMP (adenylyl cyclase)
- Phospholipase C – cAMP
- Phospholipase C – IP_3/Ca^{2+}
- Gene transcription / protein synthesis for Steroid
- Insulin and insulin like growth hormone (IGF), tyrosine kinase
- Guanylyl cyclase - cGMP

Hormone Transport in Blood

- Dissolved in plasma
- Hormone – protein complex
- Hormone concentration:
  - Free
  - Bound

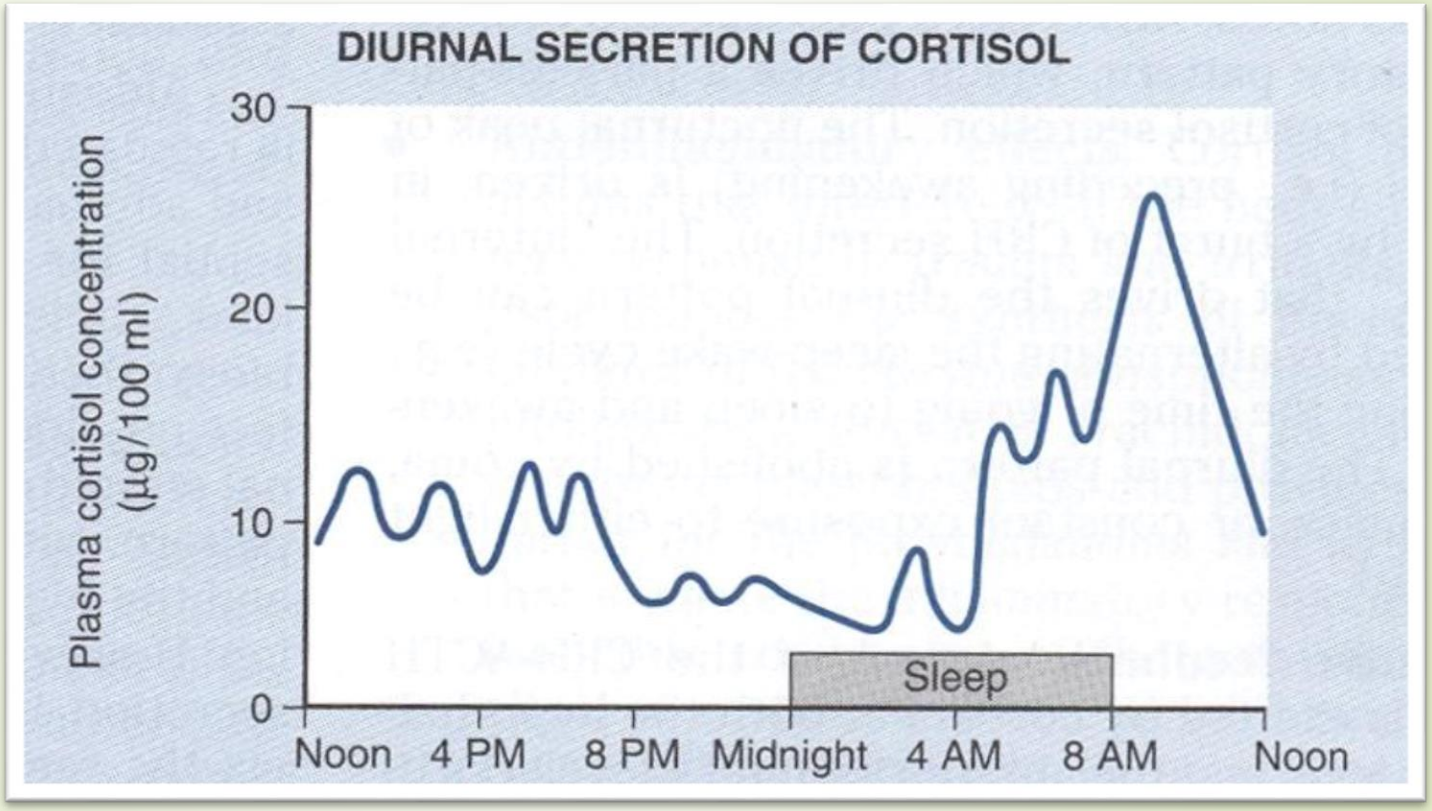
Hormone Clearance

- Metabolic breakdown in tissues
- Binding tissues
- Excretion via bile
- Urinary excretion

Diurnal Rhythms

- Mammalian circadian rhythm control:
  - Neural & endocrine
- Suprachiasmatic nuclie of hypothalamus
- Rhythms:
  - ACTH secretion
  - Melatonin secretion
  - Sleep – wake cycle
  - Body temperature
  - Locomotor activity templates

Cortisol Rhythm



Neuroendocrine Relation