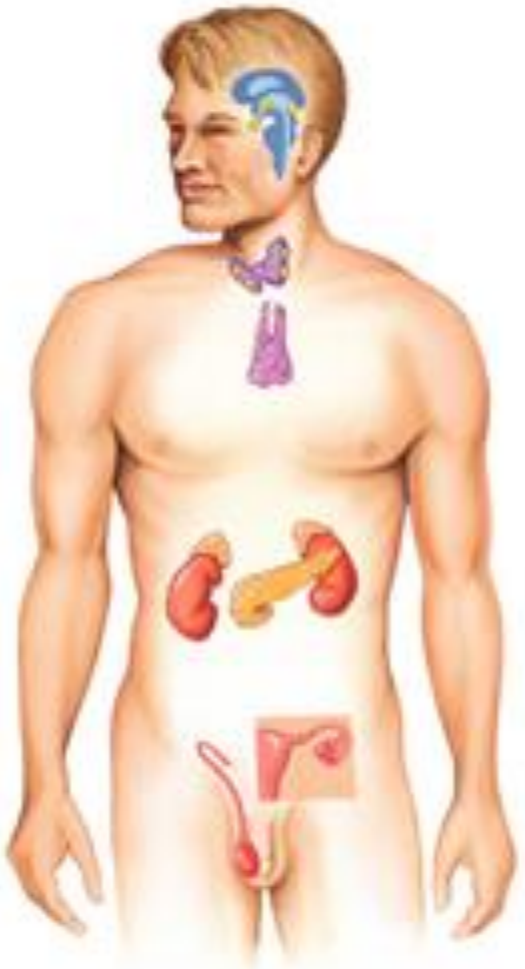
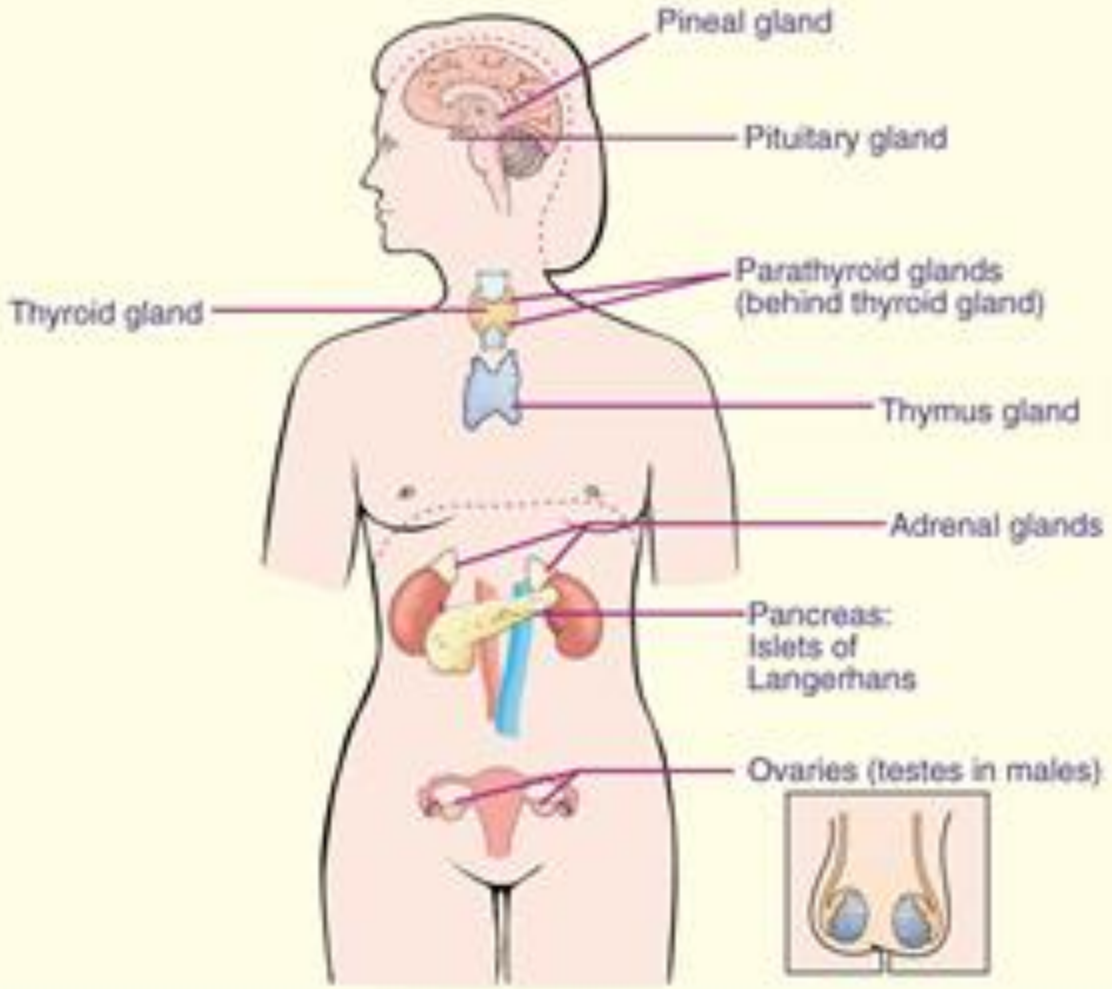
The Endocrine System



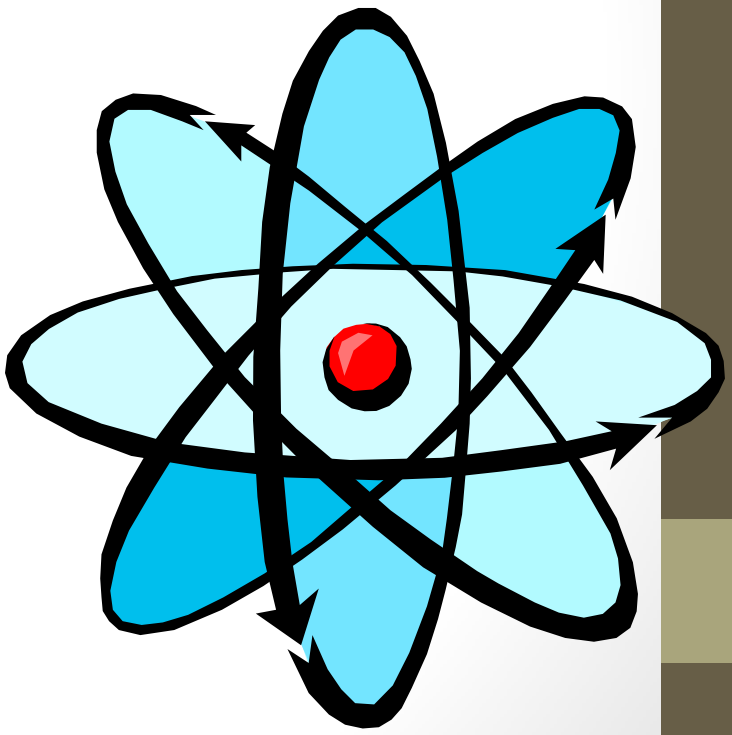
Major Endocrine Glands



Modified from Guyton and Hall, 1997

Functions of endocrine system

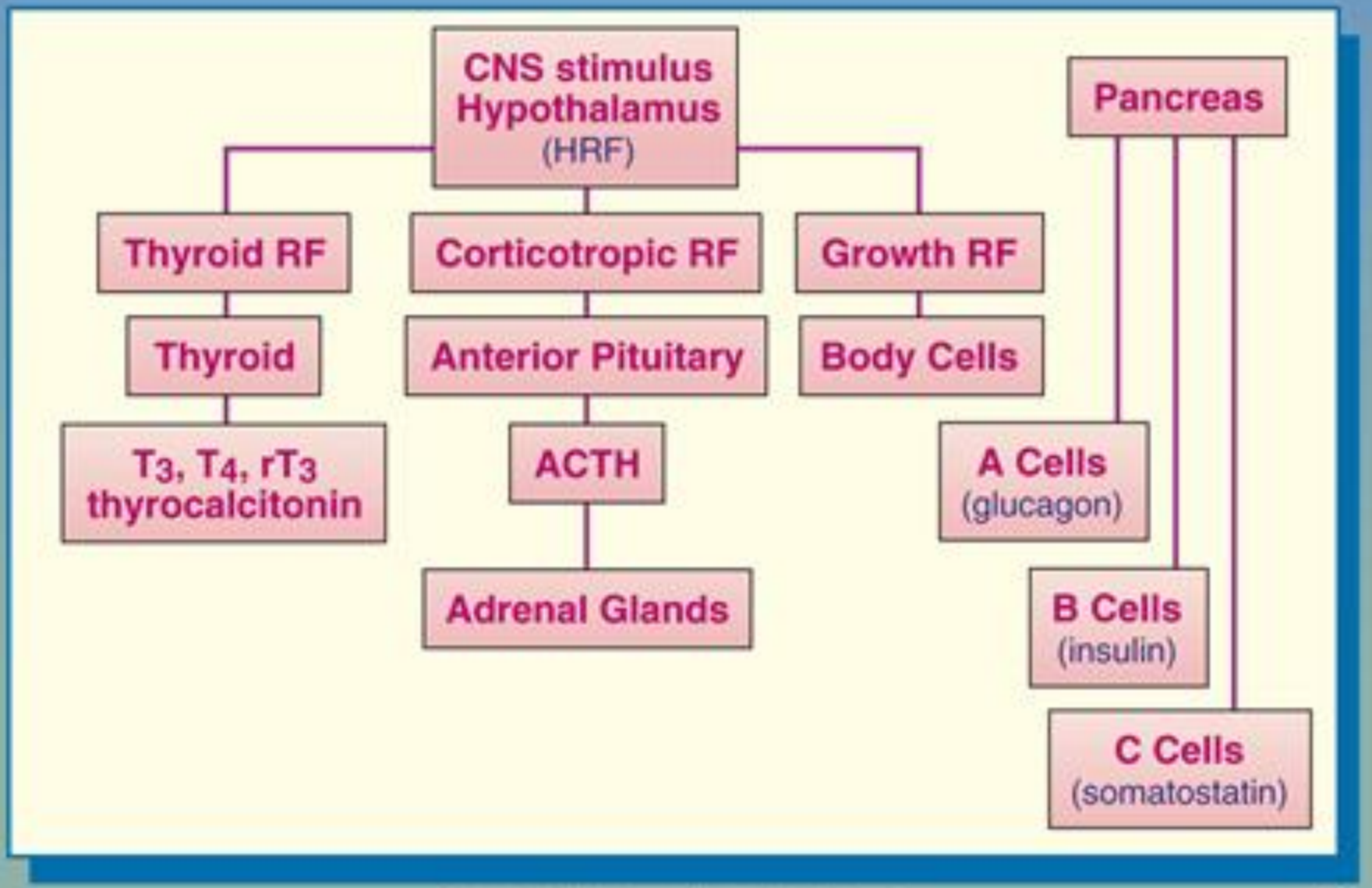
- Response to stress and injury.
- Growth and development.
- Reproduction.
- Homeostasis
- Energy metabolism.



Endocrine glands

- Endocrine glands are specialized cluster of cells that secrete hormones.
  - Secreted hormones go directly into the blood stream (ductless gland) in respond to the nervous system stimulation.
  - Endocrine glands include :
    - The pituitary gland, thyroid gland,parathyroid glands, adrenals glands, ovaries and testes.

Endocrine System



Endocrine system

- Hormones are chemical messengers secreted by endocrine organs and transported throughout the body where they exert their action on specific cells called target cells.
- Hormones do not cause reactions but rather they are regulator of tissue responses.

Hormones

- Secreted in minimum amount in respond to need.
- Either travel through the blood stream to the target organ or are secreted locally to produce an effect.

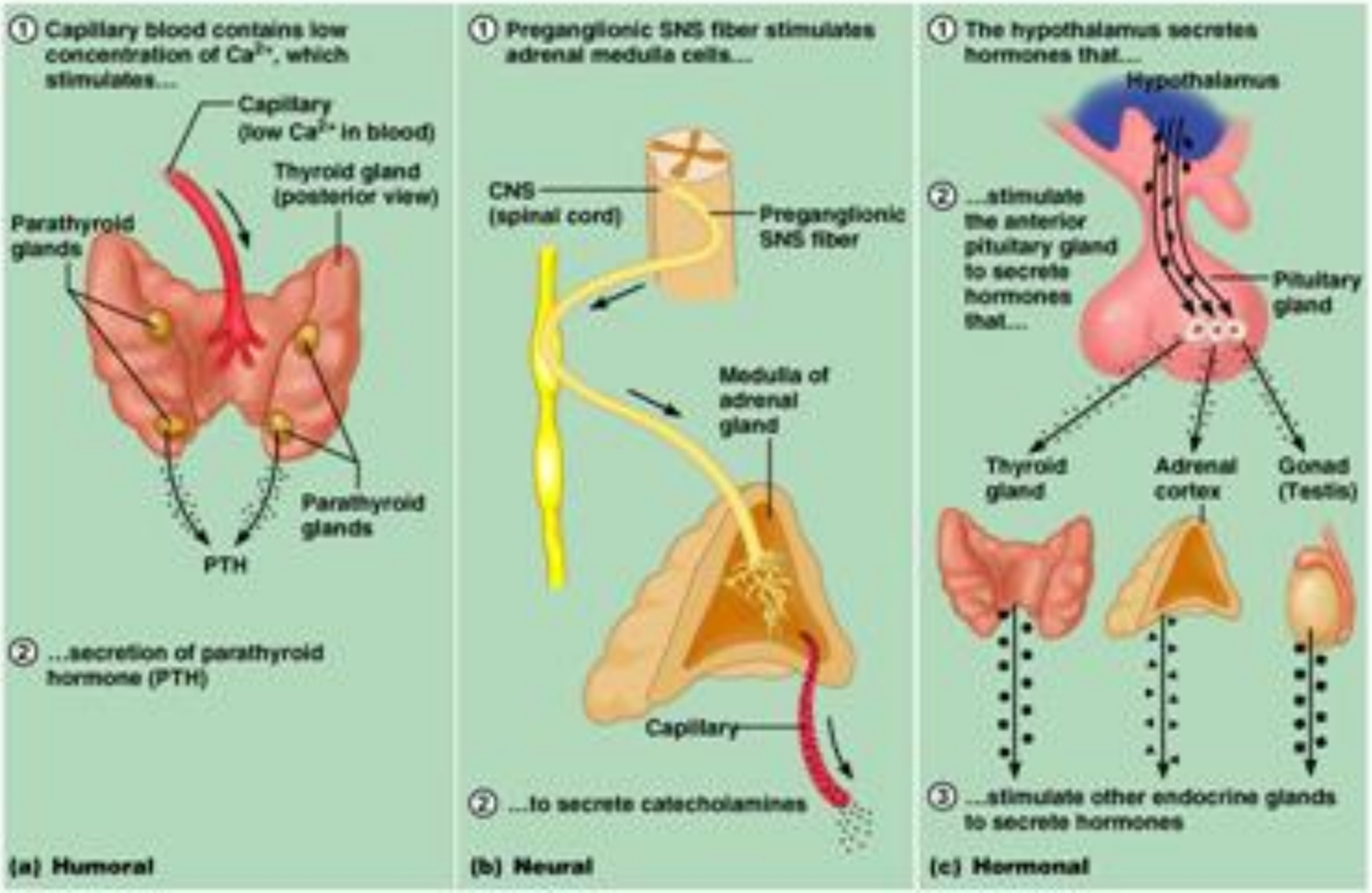
- Transportation of the hormones
  - Bounded to plasma proteins such thyroid and steroid (they serve as a reserve for acute changes)
  - Some are transported free in the blood only free hormones are biological active.

Mechanisms of hormone release

(a) **Humoral**: in response to changing levels of ions or nutrients in the blood

(b) **Neural**: stimulation by nerves

(c) **Hormonal**: stimulation received from other hormones



Hormone structure and function

- Chemically hormones are of three basic types:
  - Steroid/products of cholesterol breakdown such as glucorticoids and mineral corticoids.
- Monoacids analog-derivated from amino acid tyrosine (T3 and T4)
- Peptides either a large proteins or a chain of proteins such ACTH, TSH or ADH.

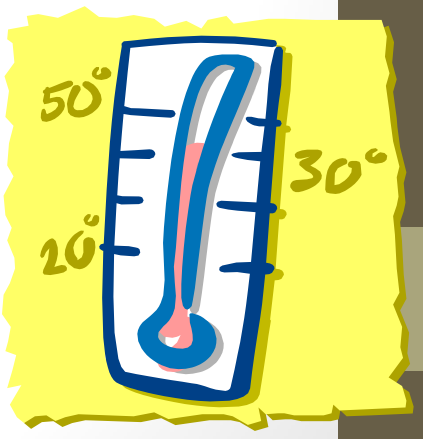
Hormones

- Maintain homeostatic balance utilizing a feedback mechanism that involves other hormones, blood or chemicals, and the nervous system.

Feedback loop mechanism.

- Sensors in the endocrine system detect changes in the hormonal levels.

- Hormones are adjusted to maintain normal body levels.

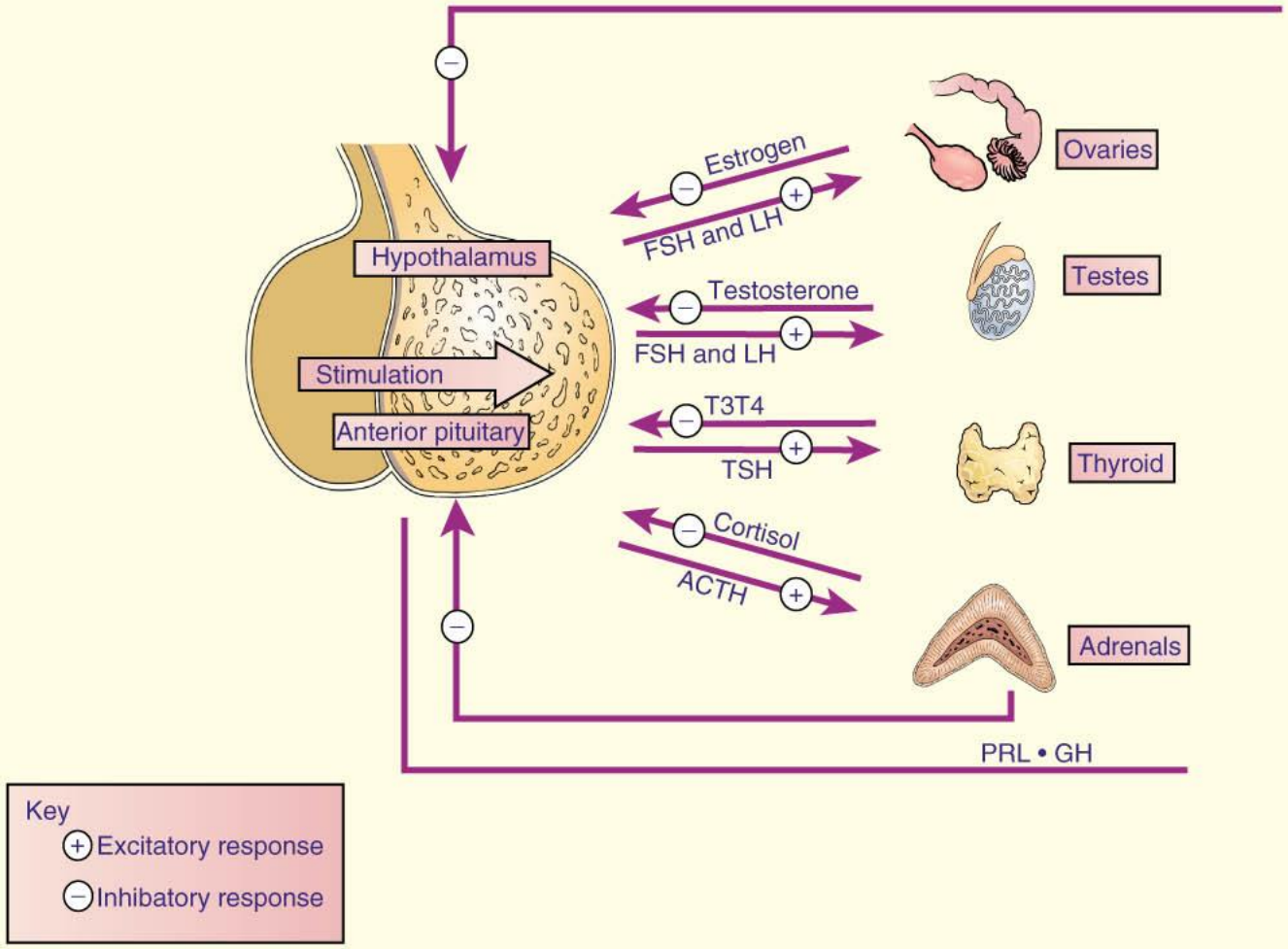


Feedback loop mechanism.

- When the sensor detect a decreased in hormone levels. They began to act to cause at increased in hormonal level.

- When the hormonal levels rise above normal, the sensors cause a decreased in hormonal production.

Feedback System



From Ignatavicius et al., 1999

The Pituitary

Sits in hypophyseal fossa: depression in sella turcica of sphenoid bone

Pituitary secretes 9 hormones

Two divisions:

- Anterior pituitary (adenohypophysis)

1. TSH
2. ACTH
3. FSH
4. LH

---

5. GH
6. PRL
7. MSH

The first four are "tropic" hormones, they regulate the function of other hormones

---

- Posterior pituitary (neurohypophysis)

8. ADH (antidiuretic hormone), or vasopressin
9. Oxytocin

Hypothalamus controls anterior pituitary hormone release

- **Releasing hormones (releasing factors)**
  - Secreted like neurotransmitters from neuronal axons into capillaries and veins to anterior pituitary (adenohypophysis)
  - **TRH**-----turns on TSH
  - **CRH**-----turns on ACTH
  - **GnRH** (=LHRH)---turns on FSH and LH
  - **PRF**-----turns on PRL
  - **GHRH**----turns on GH
- **Inhibiting hormones**
  - **PIF**-----turns off PRL
  - **GH inhibiting hormone** ---turns off GH

- Releasing hormones (releasing factors) of hypothalamus
  - Secreted like neurotransmitters from neuronal axons into capillaries and veins to anterior pituitary (adenohypophysis)
  - TRH (thyroid releasing hormone) -----turns on* TSH
  - CRH (corticotropin releasing hormone) -----turns on ACTH
  - GnRH (gonadotropin releasing hormone) ---turns on FSH and LH
  - PRF (prolactin releasing hormone) -----turns on PRL
  - GHRH (growth hormone releasing hormone) ----turns on GH

- Inhibiting hormones of hypothalamus
  - PIF (prolactin inhibiting factor) -----turns off PRL
  - GH (growth hormone) inhibiting hormone ---turns off GH

The hypothalamus controls secretion of hormones which in their turn control the secretion of hormones by the thyroid gland, the adrenal cortex and gonads: in this way the brain controls these endocrine glands

So what do the pituitary hormones do?

The four tropic ones regulate the function of other hormones:

- TSH stimulates the thyroid to produce thyroid hormone
- ACTH stimulates the adrenal cortex to produce corticosteroids: aldosterone and cortisol
- FSH stimulates follicle growth and ovarian estrogen production; stimulates sperm production and androgen-binding protein
- LH has a role in ovulation and the growth of the corpus luteum; stimulates androgen secretion by interstitial cells in testes

The others from the anterior pituitary…

- GH (aka somatrotropic hormone) stimulates growth of skeletal epiphyseal plates and body to synthesize protein
- PRL stimulates mammary glands in breast to make milk
- MSH stimulates melanocytes; may increase mental alertness

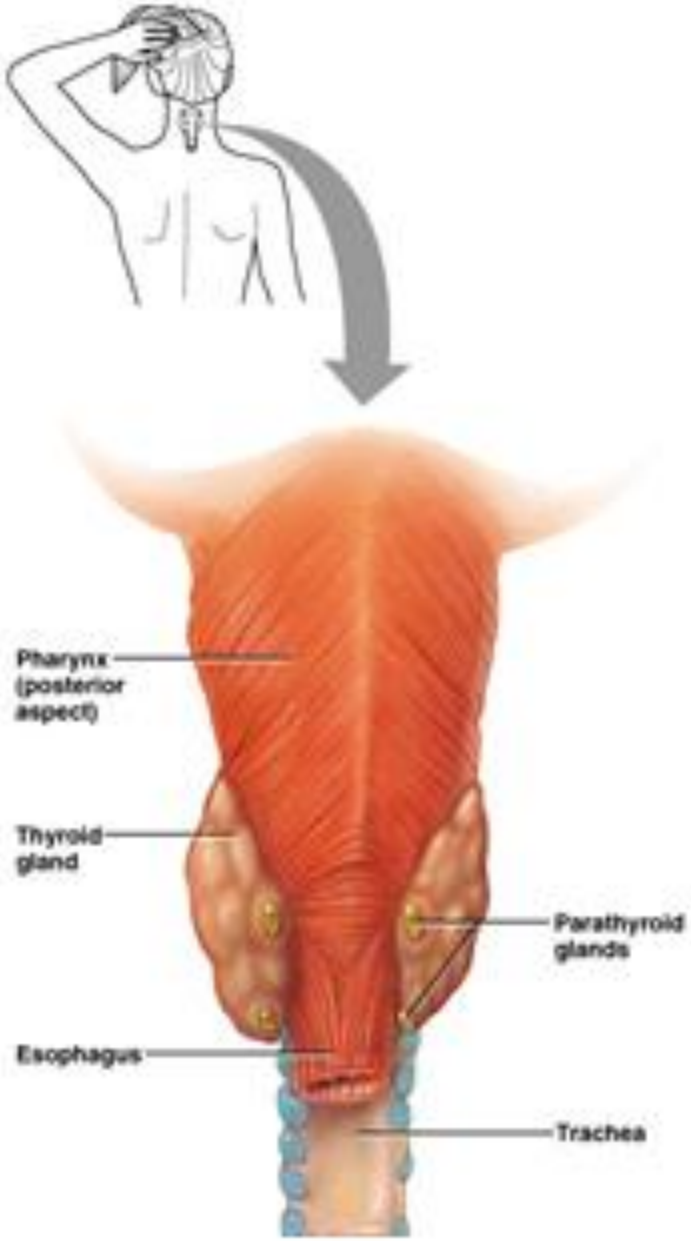
From the posterior pituitary (neurohypophysis)
structurally part of the brain

- ADH (antidiuretic hormone AKA vasopressin) stimulates the kidneys to reclaim more water from the urine, raises blood pressure
- Oxytocin prompts contraction of smooth muscle in reproductive tracts, in females initiating labor and ejection of milk from breasts

The Parathyroid Glands

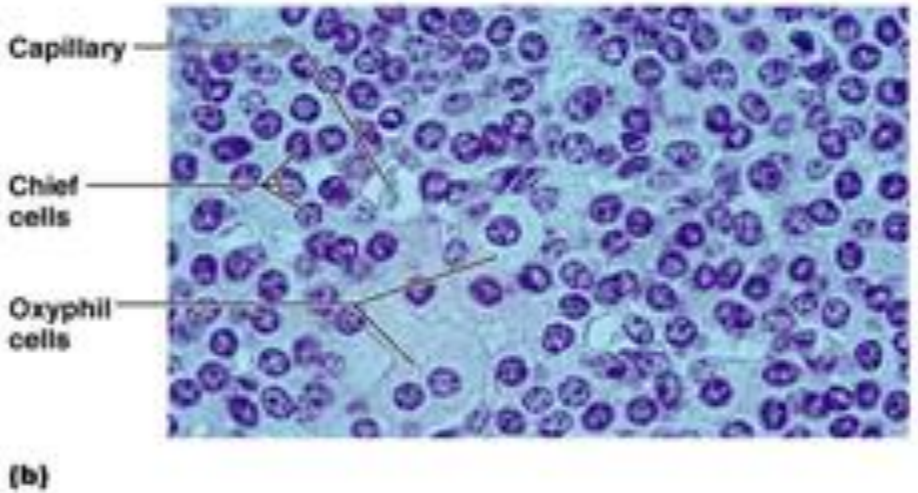
- Most people have four
- On posterior surface of thyroid gland

(sometimes embedded)

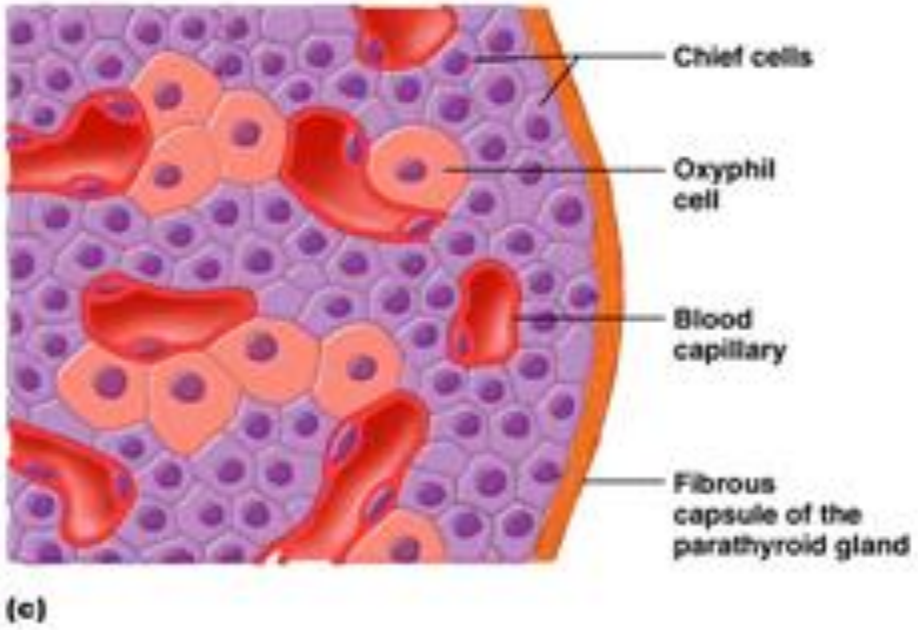


Parathyroids (two types of cells)

- Rare chief cells
- Abundant oxyphil cells (unknown function)



- Chief cells produce PTH
  - Parathyroid hormone, or parathormone
  - A small protein hormone



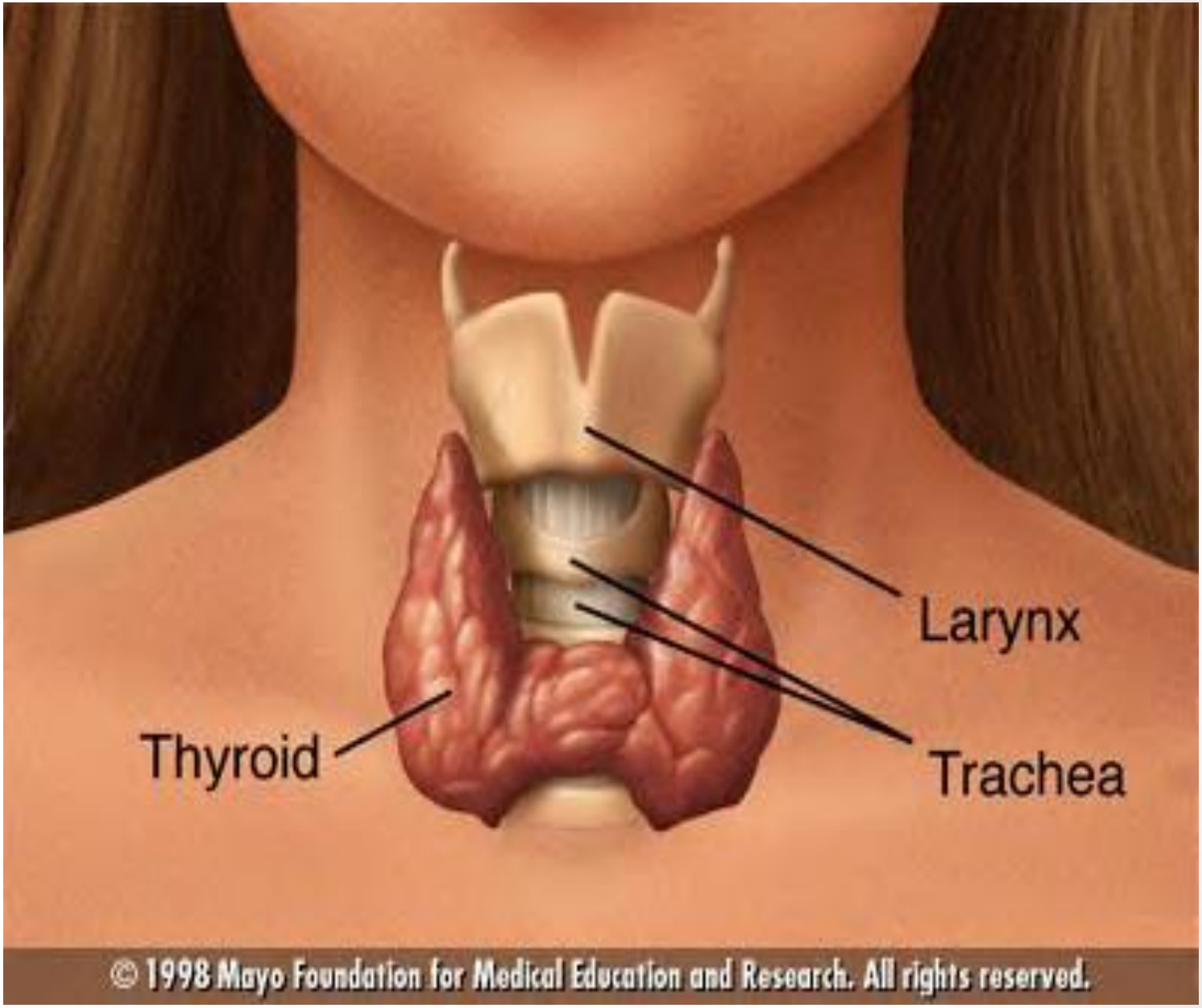
Function of PTH

(parathyroid hormone or "parathormone")

- ***Increases blood Ca++ (calcium) concentration when it gets too low***
- Mechanism of raising blood calcium
  1. Stimulates osteoclasts to release more Ca++ from bone
  2. Decreases secretion of Ca++ by kidney
  3. Activates Vitamin D, which stimulates the uptake of Ca++ from the intestine
- Unwitting removal during thyroidectomy was lethal
- ***Has opposite effect on calcium as calcitonin (which lowers Ca++ levels)***

Thyroid gland

- A small gland shaped like a butterfly located below the larynx; it weights 15-20g.
- Needs iodine to produce hormones
- It produces these two hormone **thyroxine** and **triiodothyronine.**


Larynx
Thyroid
Trachea
© 1998 Mayo Foundation for Medical Education and Research. All rights reserved.

Thyroid hormones

- The glands contain two types of cells
  - Follicular cells which produce T3 and T4
  - Parafocicullar cells which secrete thyrocalcitonin
- T3=9% of the hormone secreted is in active form.
- T4=90% of the hormone secreted is bounded to protein as a storage form; this form is inactive until converted to T3.

Thyroid Hormones: Regulation

- **Hormones:** T_3, T_4, rT_3, thyrocalcitonin
- **Regulation**
  - Hypothalamus → thyroid releasing hormone
  - TRH → anterior pituitary → thyroid stimulating hormone (TSH) → thyroid gland
  - Thyroid gland → hormones → body cells

Functions of thyroid hormones.

- They act on most body systems usually stimulating them

  - Metabolism=Controls and increased the basic metabolic rate (BMR) increasing oxygen consumption and heat production.

  - Carbohydrate metabolism= stimulates cellular glucose uptake, glycolysis,gluconeogenesis, GI absorption and insulin secretion.

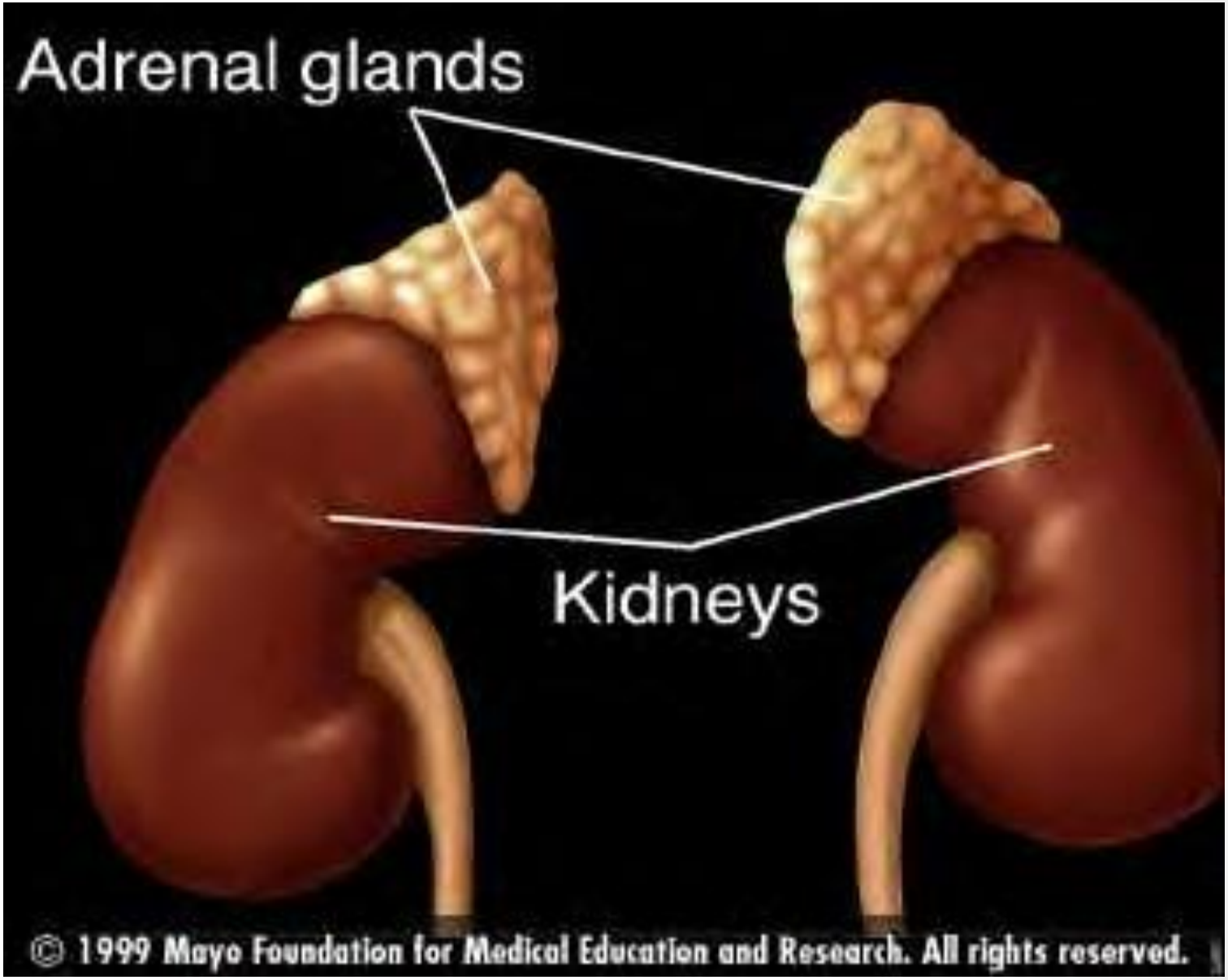
Thyroid Hormones: Functions

- Body tissues
- Metabolism: BMR
- CHO metabolism
- Fat metabolism
- Protein metabolism
- Body weight
- Body growth
- Cardiovascular function
- Pulmonary function
- Gastrointestinal function
- CNS
- Thyrocalcitonin: Bone Ca++

The adrenal glands

- The adrenal glands are bilaterally located above each kidney and consist of two tissues in one gland:

- Cortex -outer layer
- Medulla-inner portion


Adrenal glands
Kidneys
© 1999 Mayo Foundation for Medical Education and Research. All rights reserved.

Adrenal medulla produces

- Medulla
  - Makes up 15% of the gland
  - mimic sympathetic nervous system stimulation.
- Catecholamines
  - Epinephrine
  - Norepinephrine

Adrenal Medullary Hormones

- **Epinephrine**
  - Fight or flight response
  - Increased HR, BP
  - Gluconeogenesis
  - Lipolysis
- **Norepinephrine**
  - Increased HR, BP
  - Neurotransmitter
- **Dopamine**
  - Increased BP

Adrenal cortex functions.

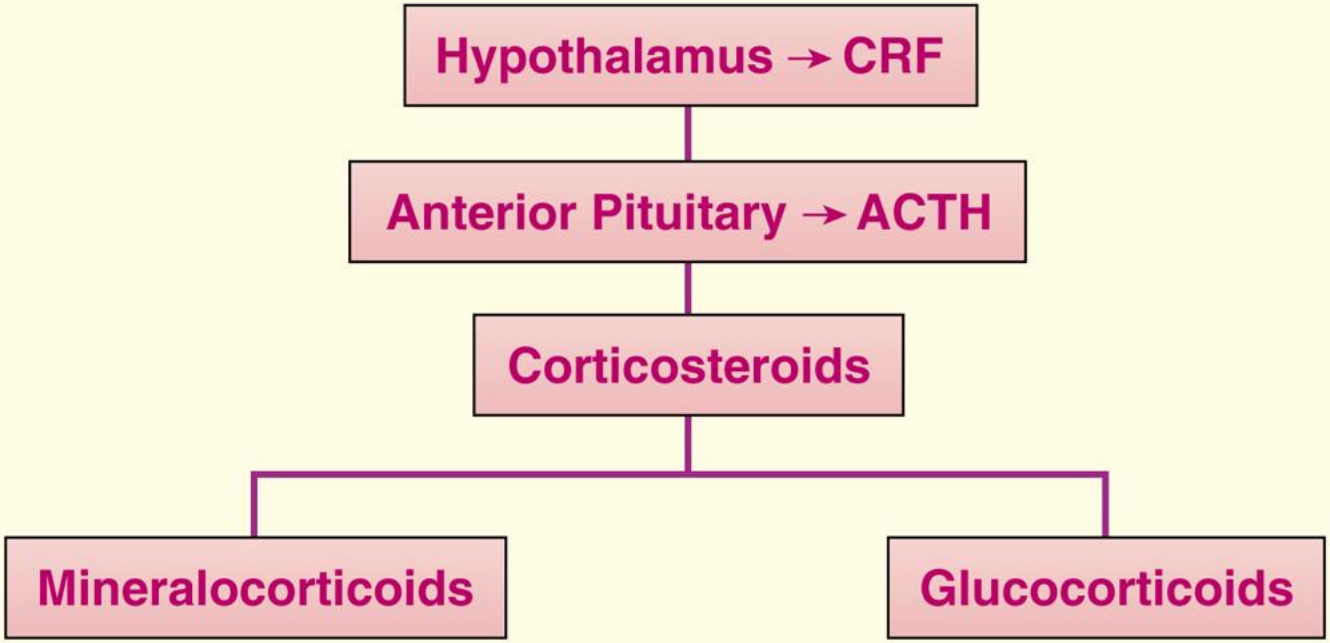
- **Adrenal steroid hormones**
- Glucortocosteroids
- Mineralcorticosteroids
- Androgens

Disorders of the adrenal cortex.

- **Cushing's Syndrome**
  - Caused by excess of cortisol production or by excessive use of cortisol or other similar steroid (glucorticoid)

- **Addison's Disease**
  - Addison's disease is a severe or total deficiency of the hormones made in the adrenal cortex, cause by a destruction of the adrenal cortex.

Regulation of Adrenal Cortical Hormones



Glucocorticoids and Mineralocorticoids

- **Glucocorticoids:** cortisol
  - Kidney: fluid and electrolyte balance
  - Body cells: protein breakdown
  - Glucose metabolism: ↑ gluconeogenesis, ↓ uptake
  - Fat: enhances deposition
  - Immune response: suppresses
- **Mineralocorticoids:** aldosterone
  - Kidney: ↑ Na^+ and H_2O retention