Faculty of Pharmacy
Biochemistry-2

Edited By:

Dr. Abdalkareem Maghmomeh

Lecturer of Biochemistry

Lecture

Hypothalamus

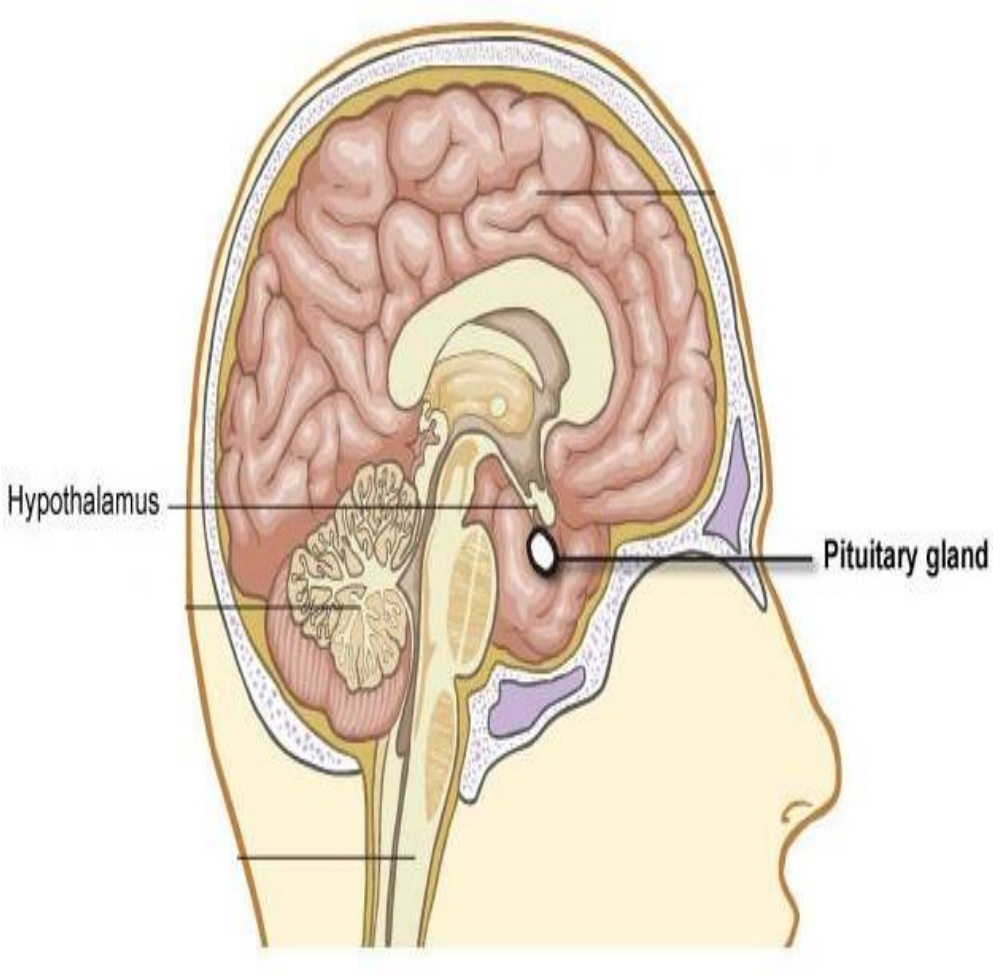
- The **hypothalamus**, an endocrine gland located in the brain, is actually part of both the nervous and the endocrine systems.

- Nerve signals from the hypothalamus control body temperature and feelings of sleep and hunger.

Hypothalamus

- Hormones from the hypothalamus control the body's water levels.
- Regulates primitive functions from water balance to sex drive
- Many functions carried out by pituitary gland

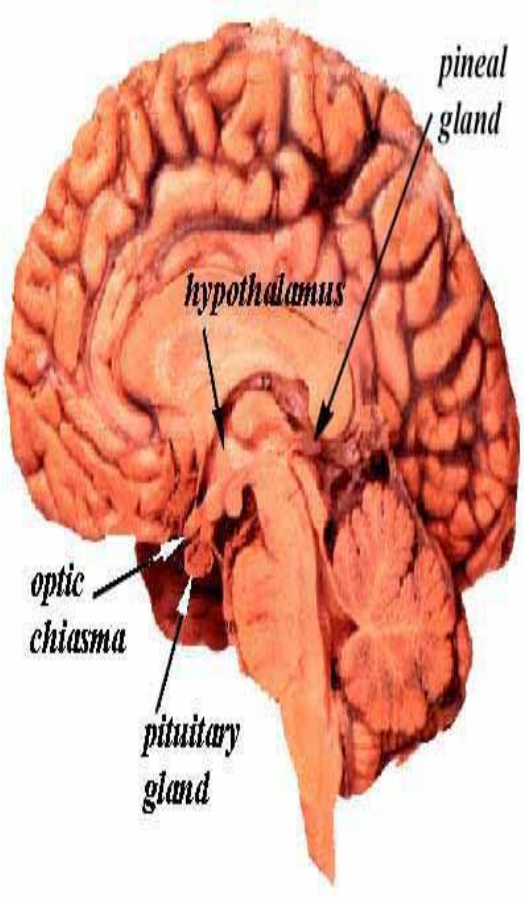
Location of pituitary gland



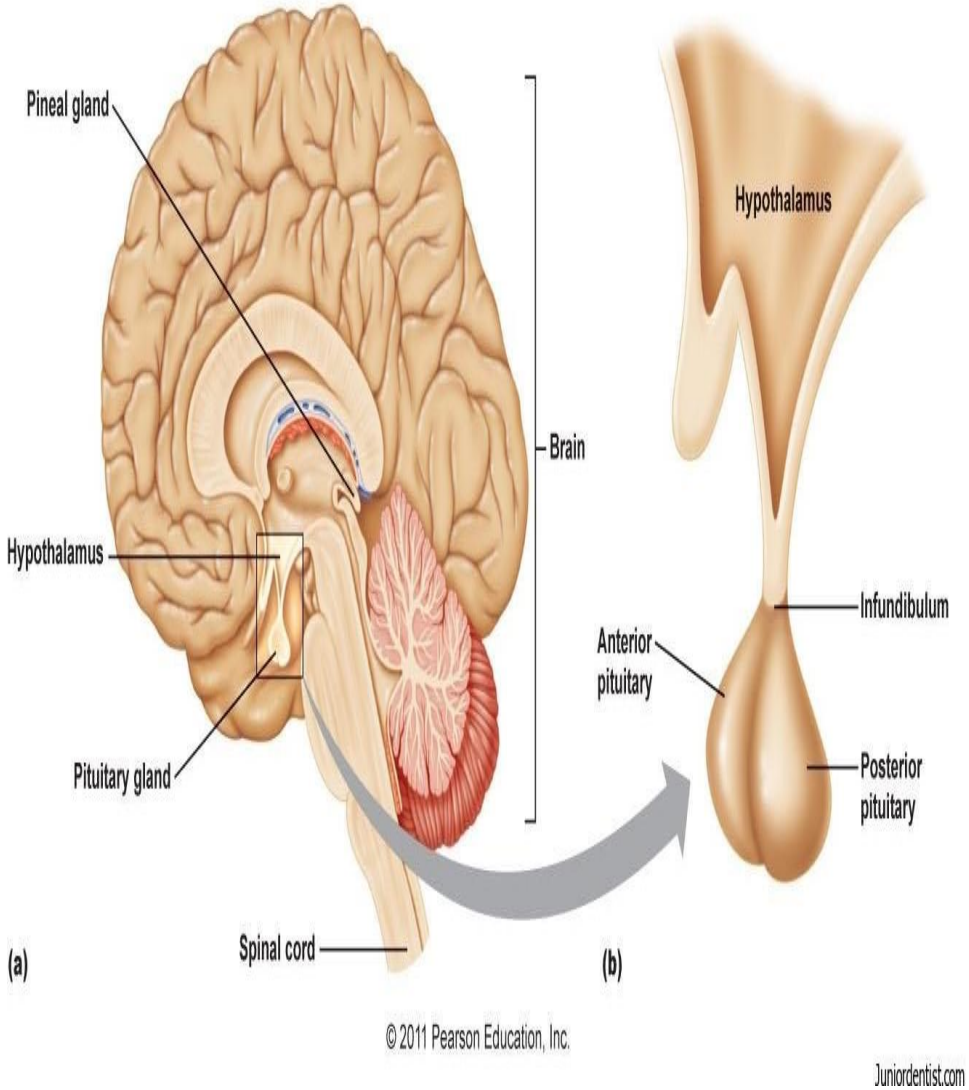
The pituitary gland lies beneath the hypothalamus, opposite to the nose

Pituitary

- **Pituitary gland** is a round organ about the size of a pea (~1 cm in diameter)
- Secretes 9 different hormones, which affect many different areas of the body, including:
  - **Growth**
  - **Blood pressure**
  - Regulation of Pregnancy
  - Breast milk production
  - Sex organ functions in both men and women
  - Thyroid gland function
  - **Metabolism**
  - Water regulation in the body (kidneys)
  - Temperature regulation



Pituitary gland structure



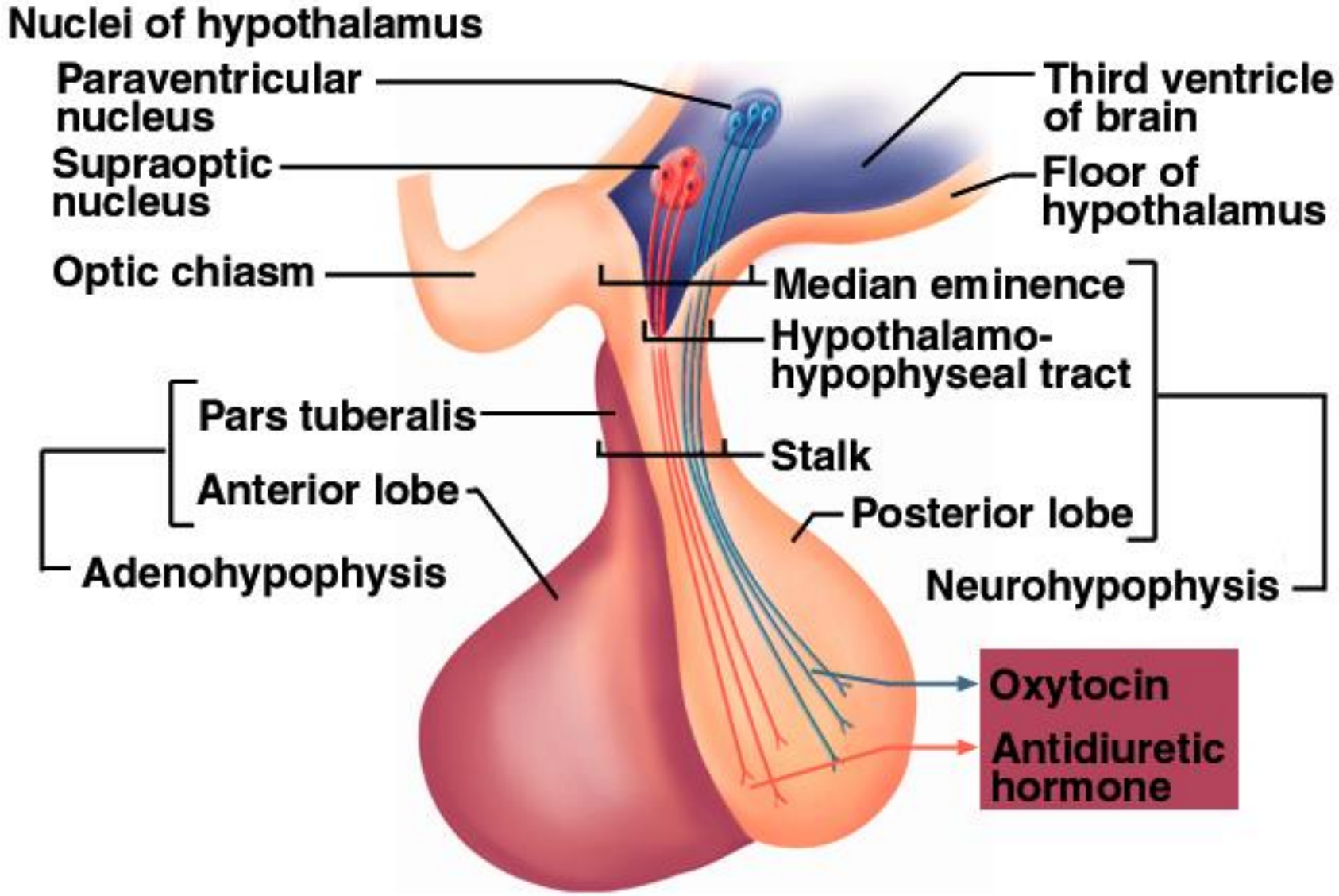
The normal adult pituitary has two lobes:

1- The anterior lobe

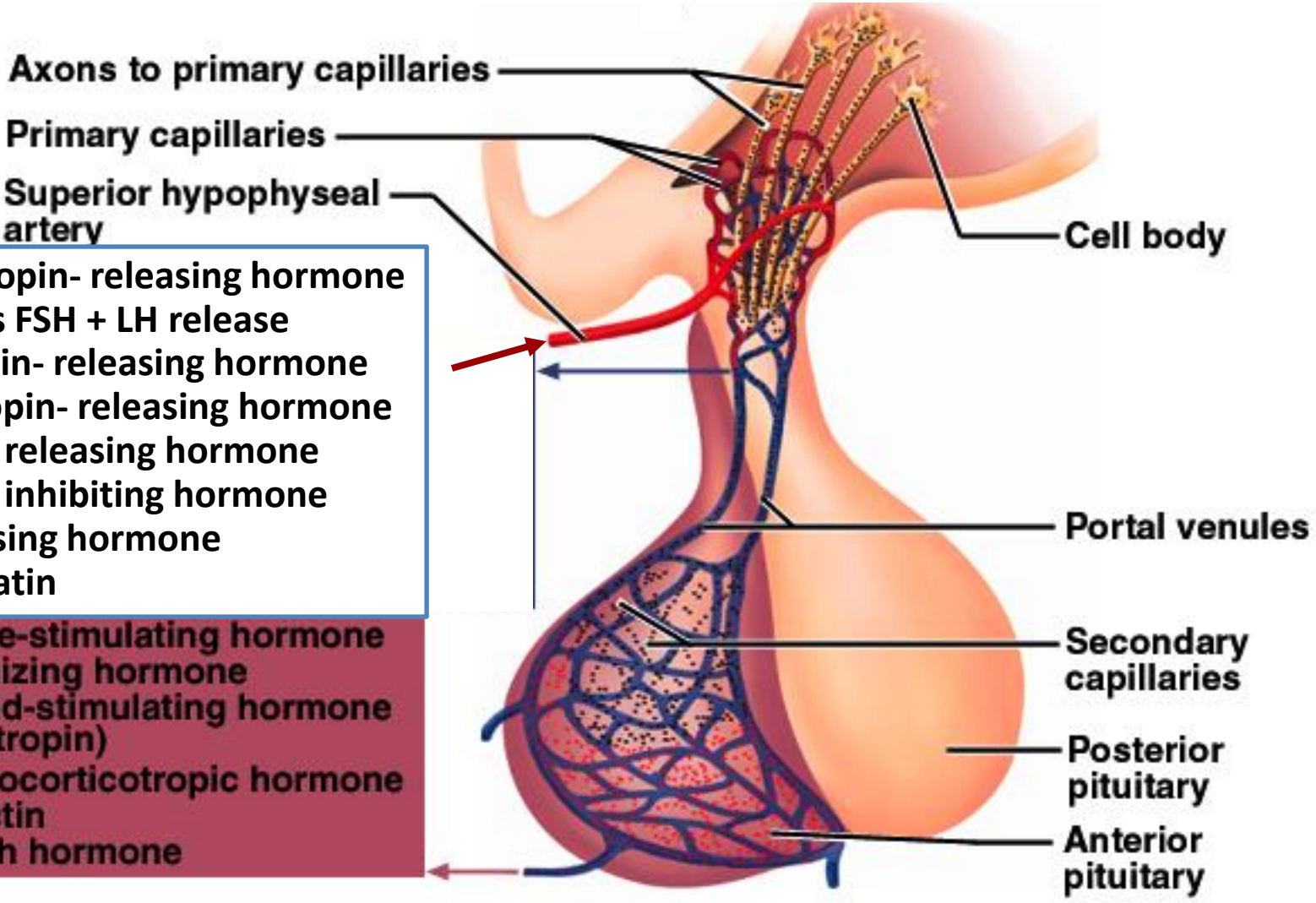
-2The posterior lobe

Pituitary gland is called the master endocrine organ as **it produces hormones that control other glands.**

Pituitary Gland Anatomy and Hormones of the Neurohypophysis



Hypothalamo-Hypophyseal Portal System

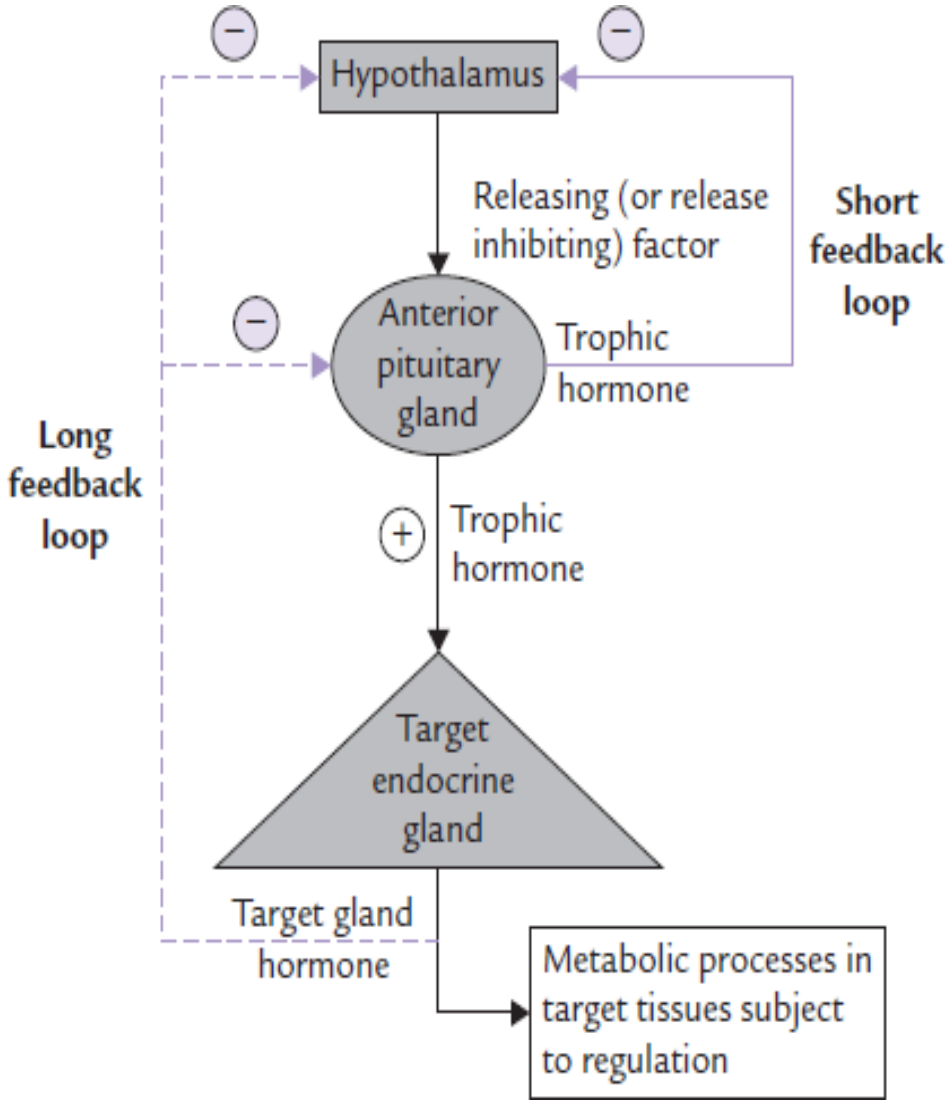


Gonadotropin- releasing hormone
controls FSH + LH release
Thyrotropin- releasing hormone
Corticotropin- releasing hormone
Prolactin- releasing hormone
Prolactin- inhibiting hormone
GH- releasing hormone
Somatostatin

Follicle-stimulating hormone
Luteinizing hormone
Thyroid-stimulating hormone (thyrotropin)
Adrenocorticotropic hormone
Prolactin
Growth hormone

- Hormones secreted by hypothalamus, travel in portal system to anterior pituitary
- Hormones (red box)secreted by anterior pituitary (under control of hypothalamic releasers and inhibitors)

Hormones of HPA

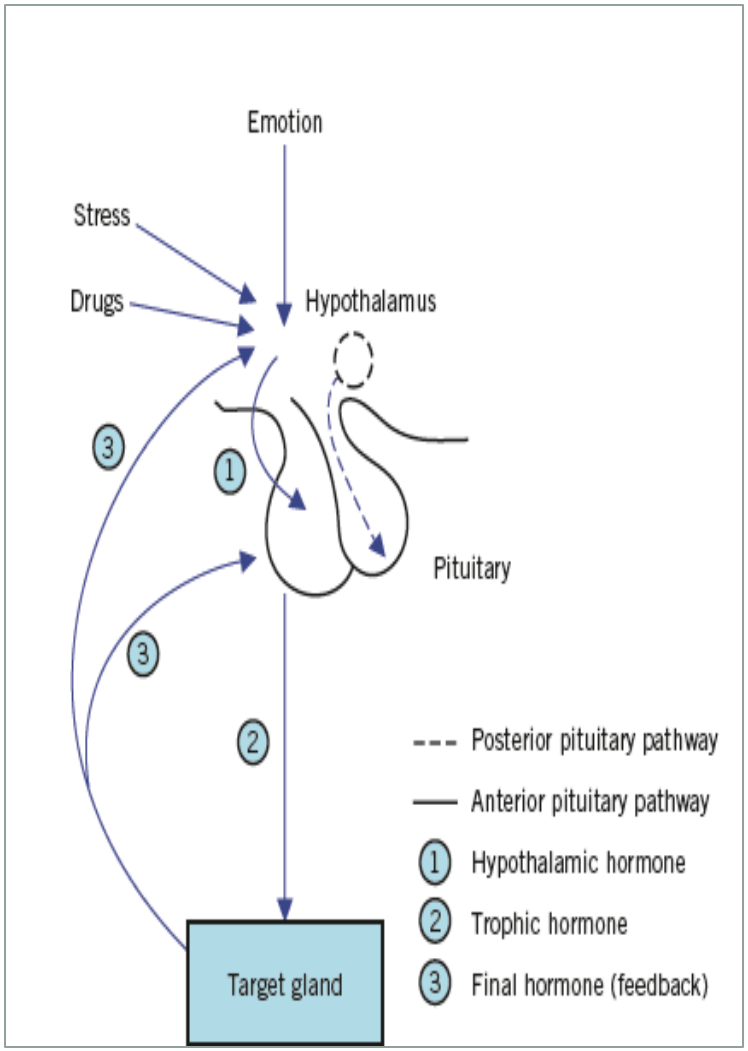


- Hypothalamus releases regulatory hormones (RH) that is transported to pituitary gland producing another hormone (trophic hormone) that stimulate third hormone in another target gland

Regulation of pituitary gland hormones secretion

1.Neural control: The releasing hormones (RH) from the **hypothalamus,** have a stimulatory effect on the anterior pituitary gland and inhibitory hormones (IH) that have a suppressive effect.

2.Feedback control: The hormones released by the target glands, decrease the secretion of the RH and or trophic hormone (negative feedback), or increase the IH (positive feedback)



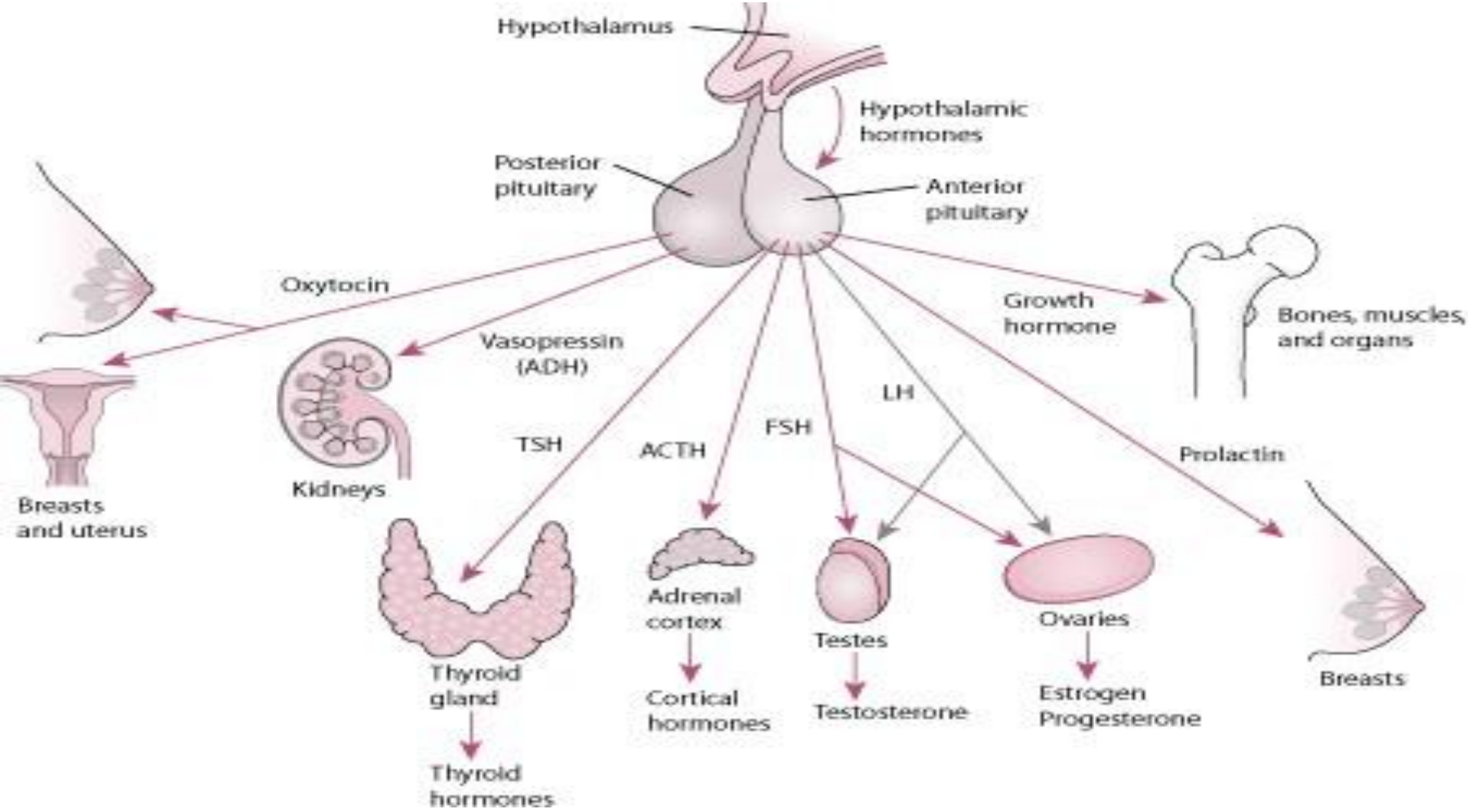
Hormones of the Anterior Pituitary

Six anterior pituitary hormones

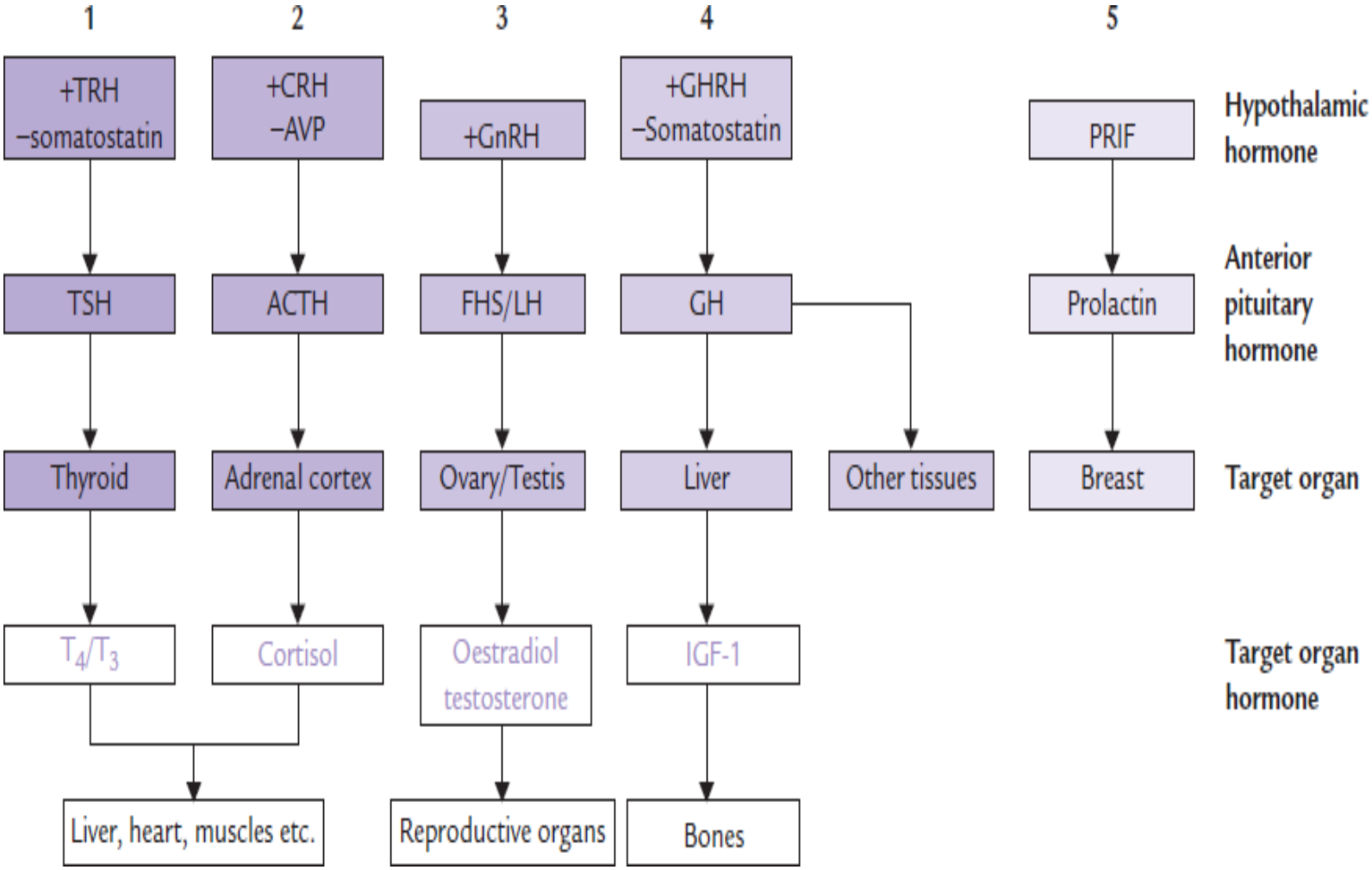
- Two affect non-endocrine targets
- Four stimulate other endocrine glands (tropic hormones)

- Characteristics of all anterior pituitary hormones
  - Proteins (or peptides)
  - Act through second-messenger systems
  - Regulated by hormonal stimuli, mostly negative feedback

Pituitary gland hormones and target organs/ glands



Hypothalamus-anterior pituitary target organ hormones



Hormones in HPAsystem

Releasing hormones (-RH)	Pituitary hormones	Target organ or gland	Effect
-1**GH**RH	Growth hormone (GH)	Liver	IGF production
.2**P**RH	Prolactin (PRL)	breast	Milk production
.3**C**RH	Adrenocortico-trophic hormone (ACTH)	Adrenal gland	Cortisol production
.4**T**RH	Thyroid stimulatory hormone (TSH)	Thyroid gland	T3, T4 production
.5Gonadotrophin releasing hormone (**Gn**RH	Leutinizing hormone (LH) Follicle stimulating hormone (FSH)	Testis/ Ovary	Testosterone/ Oestradiol production

Disorders of anterior pituitary hormone

Pituitary hormones	Excess	Deficiency
Growth hormone (GH)	Acromegaly or Gigantism	Dwarfism
Prolactin (PRL)	Infertility, Galactorrhoea, Osteopenia	Lactation failure
Adrenocorticotrophic hormone (ACTH)	Cushing's disease	**Secondary** adrenal insufficiency
Thyroid stimulatory hormone (TSH)	hyperthyroidism	Secondary hypothyroidism
Leutinizing hormone (LH) Follicle stimulating hormone (FSH)	Precocious puberty	Secondary hypogonadism, Infertility

Functions of Anterior Pituitary Hormones

- Prolactin (PRL)
  - Stimulates and maintains milk production following childbirth
  - Function in males is unknown
- Adrenocorticotropic hormone (ACTH)
  - Regulates endocrine activity of the adrenal cortex
- Thyroid-stimulating hormone (TSH)
  - Influences growth and activity of the thyroid

Functions of Anterior Pituitary Hormones

- Gonadotropic hormones
  - Regulate hormonal activity of the gonads
    - Follicle-stimulating hormone (FSH)
      - Stimulates follicle development in ovaries
      - Stimulates sperm development in testes

Functions of Anterior Pituitary Hormones

- Gonadotropic hormones
- Luteinizing hormone (LH)
    - Triggers ovulation
    - Causes ruptured follicle to become the corpus luteum
    - Stimulates testosterone production in males

Growth Hormone (GH)

- General metabolic hormone
- Major effects are directed to growth of skeletal muscles and long bones
- Causes amino acids to be built into proteins
- Causes fats to be broken down for a source of energy

Hormones of the Posterior Pituitary

- Oxytocin
  - Stimulates contractions of the uterus during labor
  - Causes milk ejection
- Antidiuretic hormone (ADH)
  - Can inhibit urine production
  - In large amounts, causes vasoconstriction leading to increased blood pressure (vasopressin)

Hormones of the Posterior Pituitary

- ADH
  - targets kidneys to ↑ water retention, reduce urine
  - also functions as neurotransmitter
- Oxytocin
  - labor contractions, lactation
  - possible role sperm transport

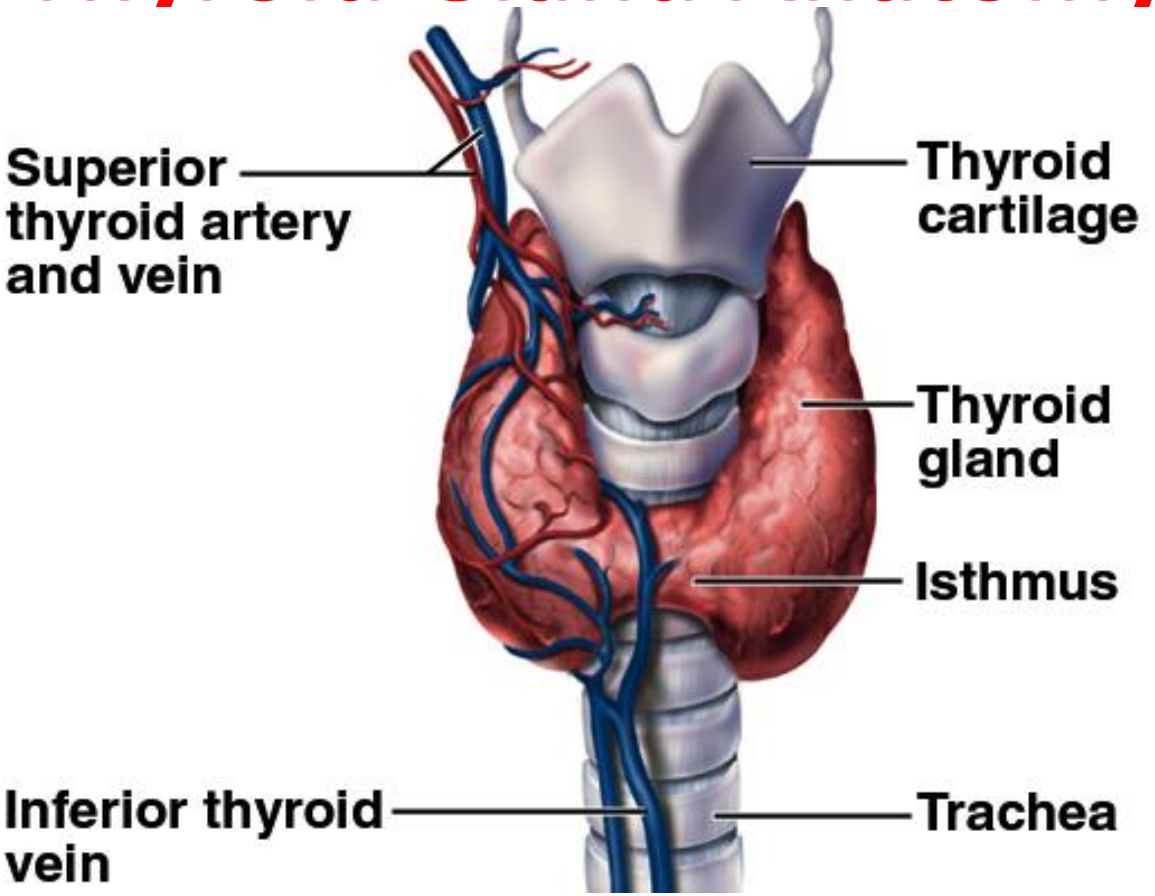
The hypothalamus-pituitary regulatory system.

- The posterior pituitary hormones are synthesized in nuclei of hypothalamus
- The posterior pituitary hormones are transported (from hypothalamus) along nerve fibers to posterior pituitary.
- Hormones are produced as larger precursors: pre provasopressin and pre-prooxytocin

Hormones in posterior pituitary gland

Posterior Pituitary hormones	Target organ or gland	Effect
Arginine vasopressin (AVP, ADH) hormone	Kidney	Control water hemostasis
Oxytocin	Uterus and Breast	1. Stimulates contraction of **uterus (womb)** during child birth 2.Stimulates contraction of **mammary** glands to cause milk ejection (lactation)

Thyroid Gland Anatomy



- Largest endocrine gland with high rate of blood flow
- Anterior and lateral sides of trachea
- 2 large lobes connected by isthmus

Thyroid Gland

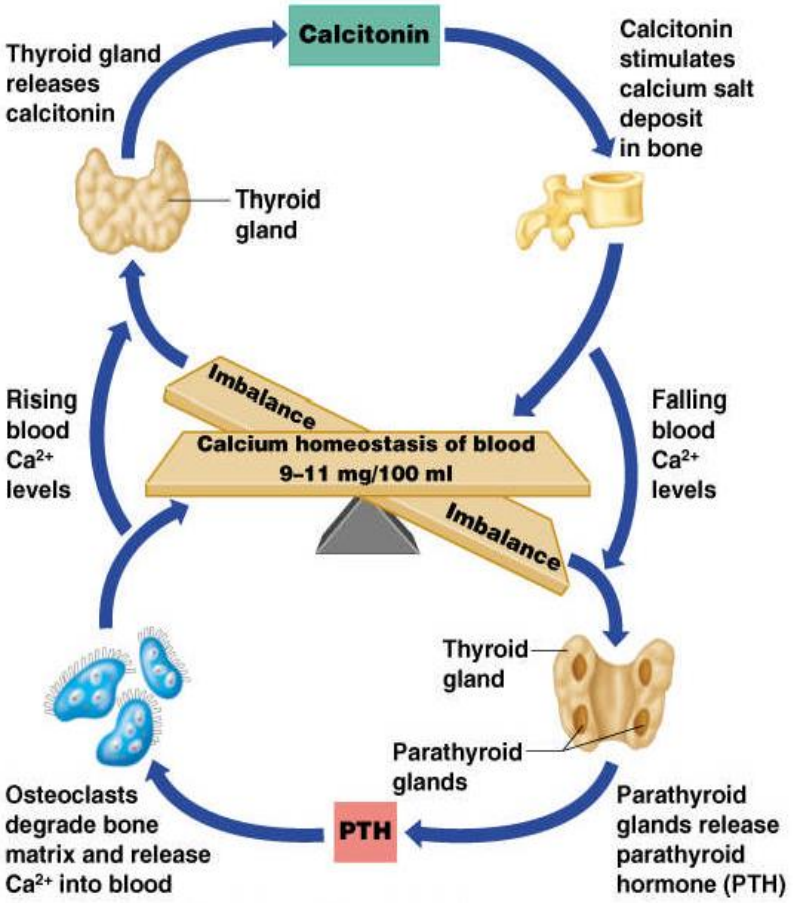
- Produces two hormones
  - Thyroid hormone
  - Calcitonin

Thyroid Hormone

- Major metabolic hormone
- Composed of two active iodine- containing hormones
  - Thyroxine (T_4)
  - Triiodothyronine (T_3) – conversion of T_4 at target tissues

Calcitonin

- Decreases blood calcium levels by causing its deposition on bone
- Antagonistic to parathyroid hormone



Thyroid Gland

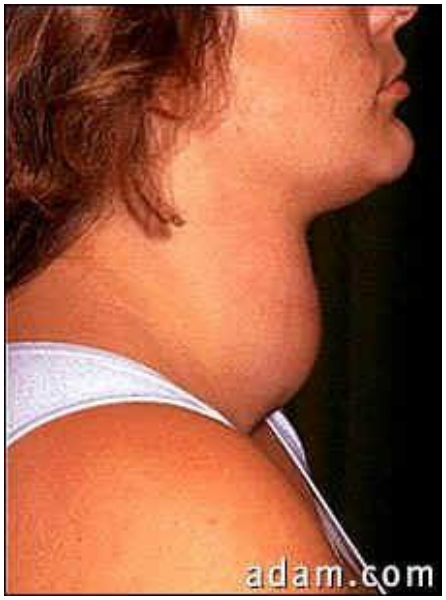
- That secretes 2 hormones, T_3+T_4
  - Thyroid hormone
    - ↑ body's metabolic rate and O_2 consumption
    - calorigenic effect - ↑ heat production
    - ↑ heart rate and contraction strength
    - ↑ respiratory rate
    - stimulates appetite and breakdown CHO, lipids & proteins
- C (calcitonin) produce calcitonin that ↓ blood Ca^{+2}, promotes Ca^{+2} deposition and bone formation especially in children

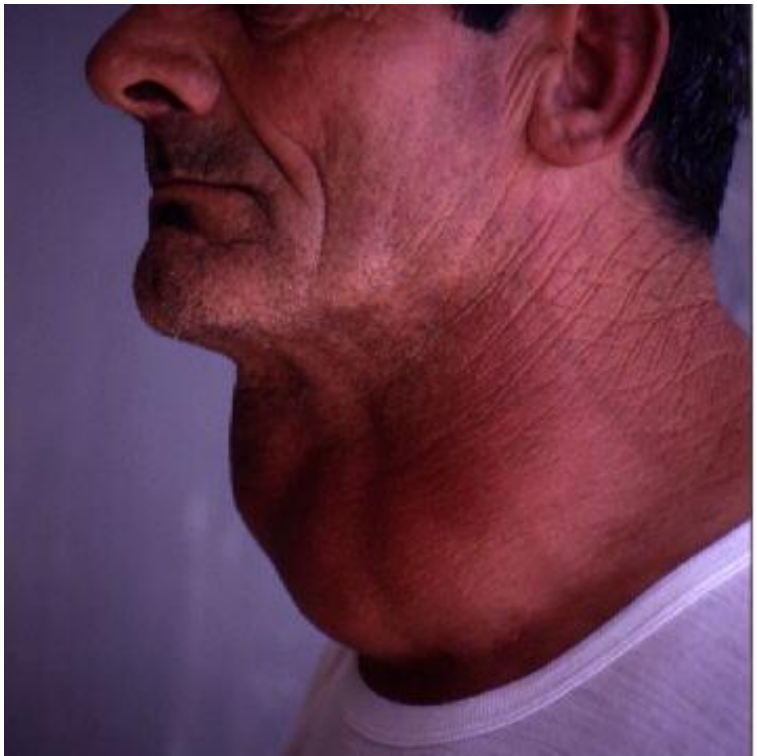
Thyroid Gland

- Oversecretion of thyroxin:
  - Results in nervousness and weight loss
- Undersecretion of thyroxin:
  - Results in cretinism (mental retardation, small size) in children

Thyroid

- **Iodine** deficiency in your diet results in **goiter** (enlargement of thyroid gland)





Parathyroid Glands

Function is to control **metabolism of calcium**

- Necessary for normal nerve and muscle function, blood clotting, healthy bones and teeth

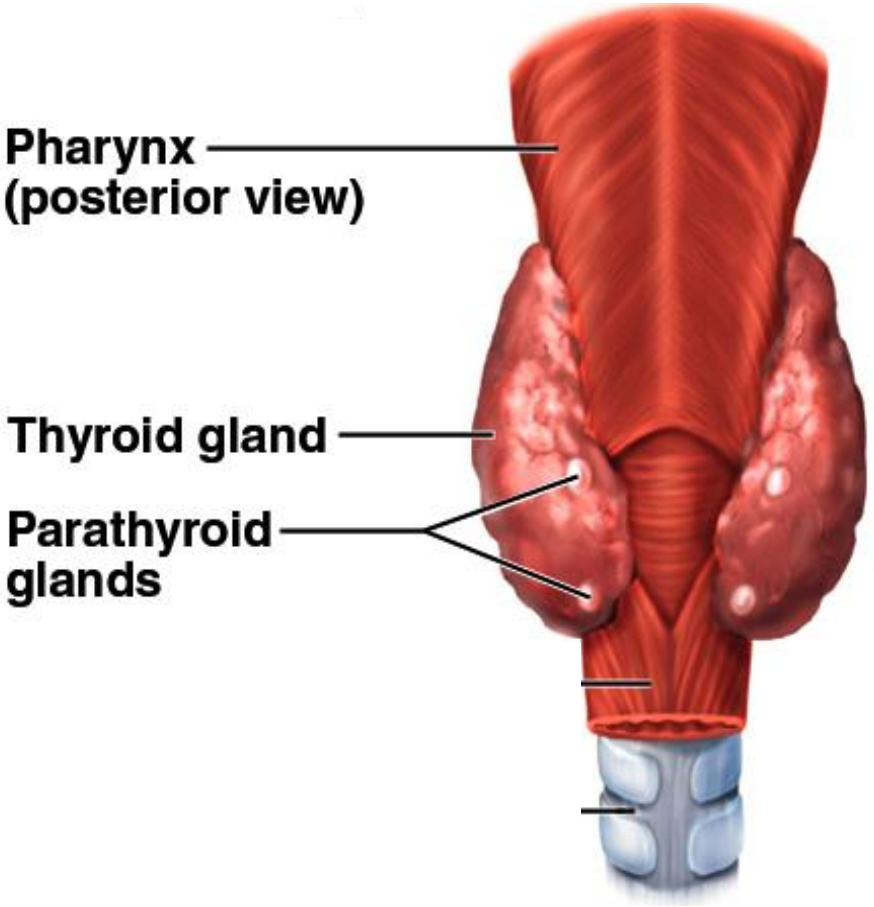
- Located in back of thyroid gland (in neck)
- Undersecretion of parathyroid hormone results in nerve disorders, brittle bones and clotting problems

Parathyroid Glands

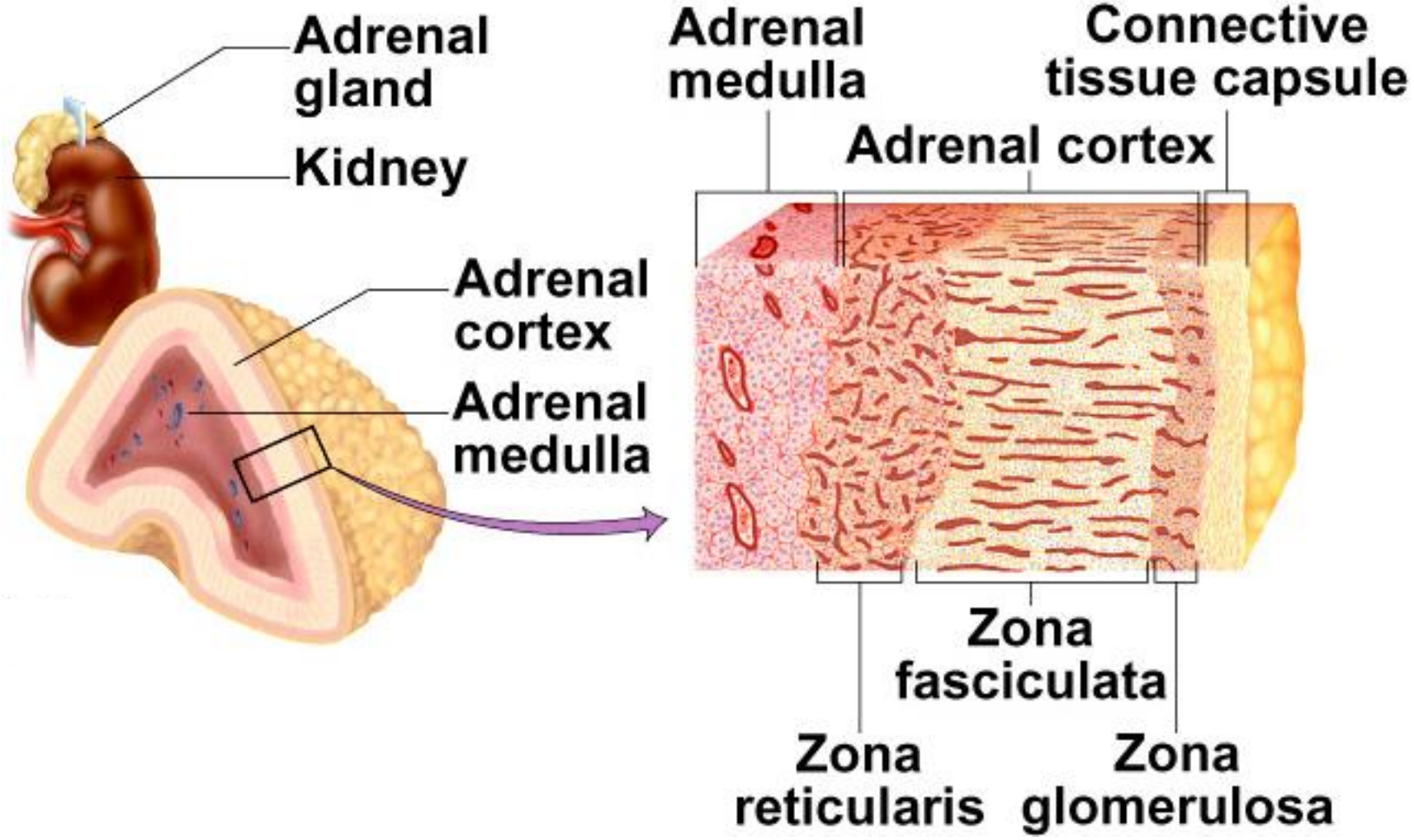
- Secrete parathyroid hormone
  - Stimulate osteoclasts to remove calcium from bone and release it into the blood
  - Stimulate the kidneys and intestine to absorb more calcium
  - Raises calcium levels in the blood

Parathyroid Glands

- PTH release
  - ↑ blood Ca^{+2} levels
  - promotes synthesis of calcitriol
    - ↑ absorption of Ca^{+2}
    - ↓ urinary excretion
    - ↑ bone resorption



Adrenal Gland



Adrenal Glands

- Two glands
  - Cortex –three layers
  - Medulla – inner region
- Sits on top of the kidneys

Hormones of the Adrenal Cortex

- Mineralocorticoids (mainly aldosterone)
  - Produced in outer adrenal cortex
  - Regulate mineral content in blood, water, and electrolyte balance
  - Target organ is the kidney
  - Production stimulated by renin and aldosterone
  - Production inhibited by atrial natriuretic peptide

Hormones of the Adrenal Cortex

- Glucocorticoids (including cortisone and cortisol)
  - Produced in the middle layer of the adrenal cortex
  - Promote normal cell metabolism
  - Help resist long-term stressors
  - Released in response to increased blood levels of ACTH

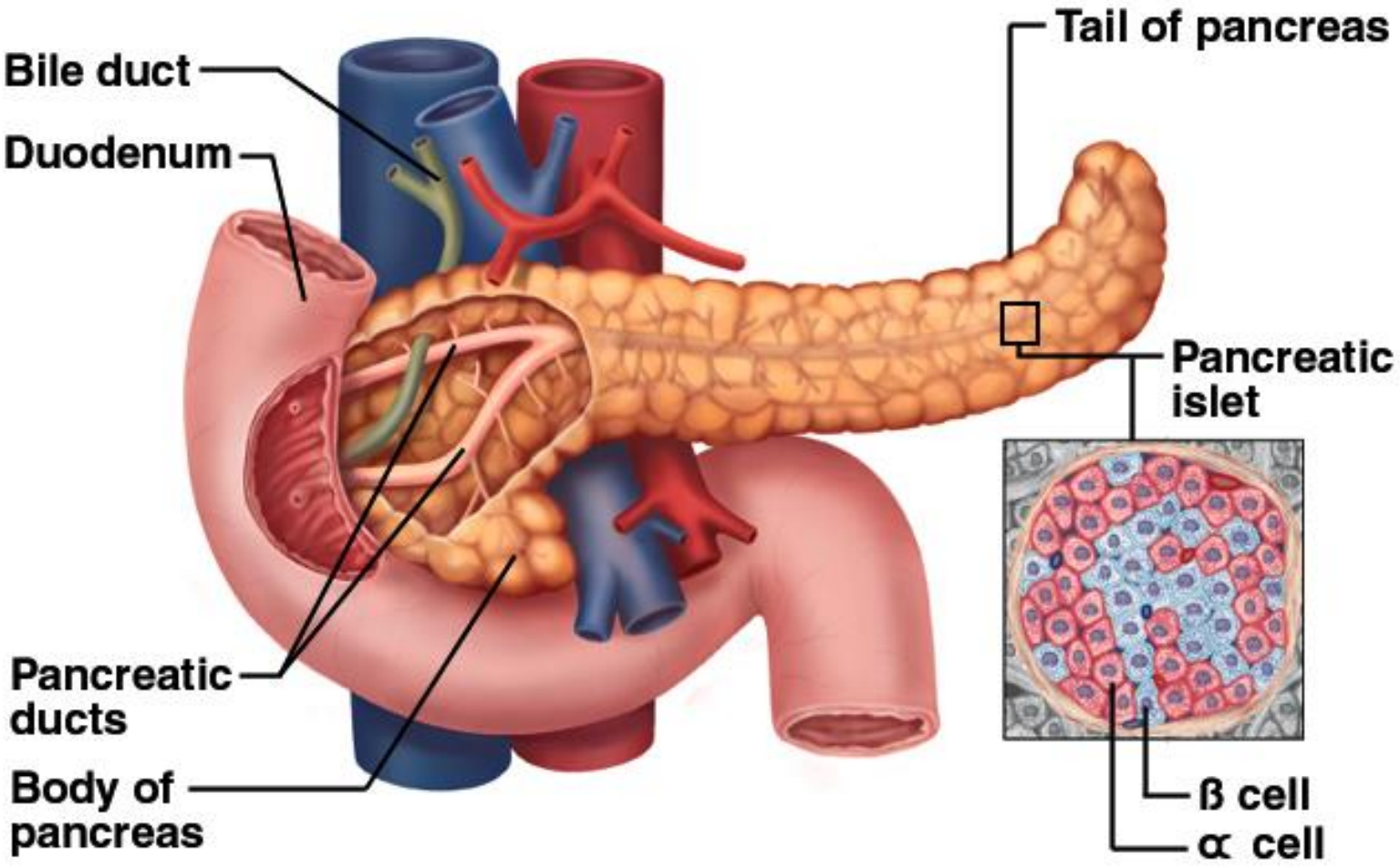
Hormones of the Adrenal Cortex

- Sex hormones
  - Produced in the inner layer of the adrenal cortex
  - Androgens (male) and some estrogen (female)

Hormones of the Adrenal Medulla

- Produces two similar hormones (catecholamines)
  - Epinephrine
  - Norepinephrine
- These hormones prepare the body to deal with short-term stress

Pancreas

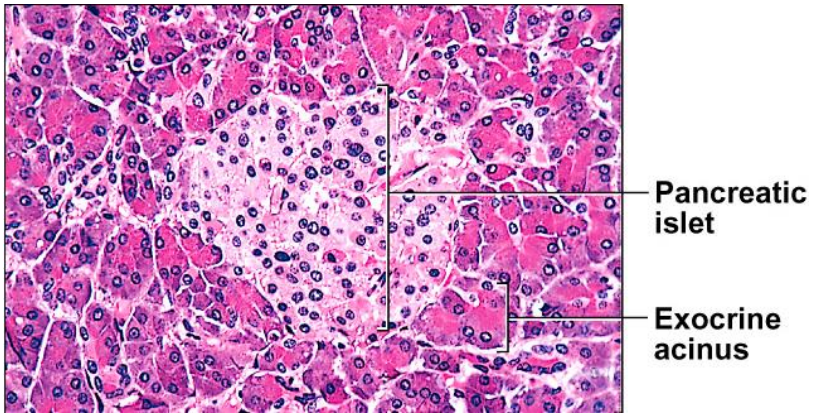

Bile duct
Duodenum
Tail of pancreas
Pancreatic islet
Pancreatic ducts
Body of pancreas
ß cell
α cell

Pancreatic Islets

- The pancreas is a mixed gland
- The islets of the pancreas produce hormones
  - Insulin – allows glucose to cross plasma membranes into cells from beta cells
  - Glucagon – allows glucose to enter the blood from alpha cells
  - These hormones are antagonists that maintain blood sugar homeostasis

Pancreatic Hormones

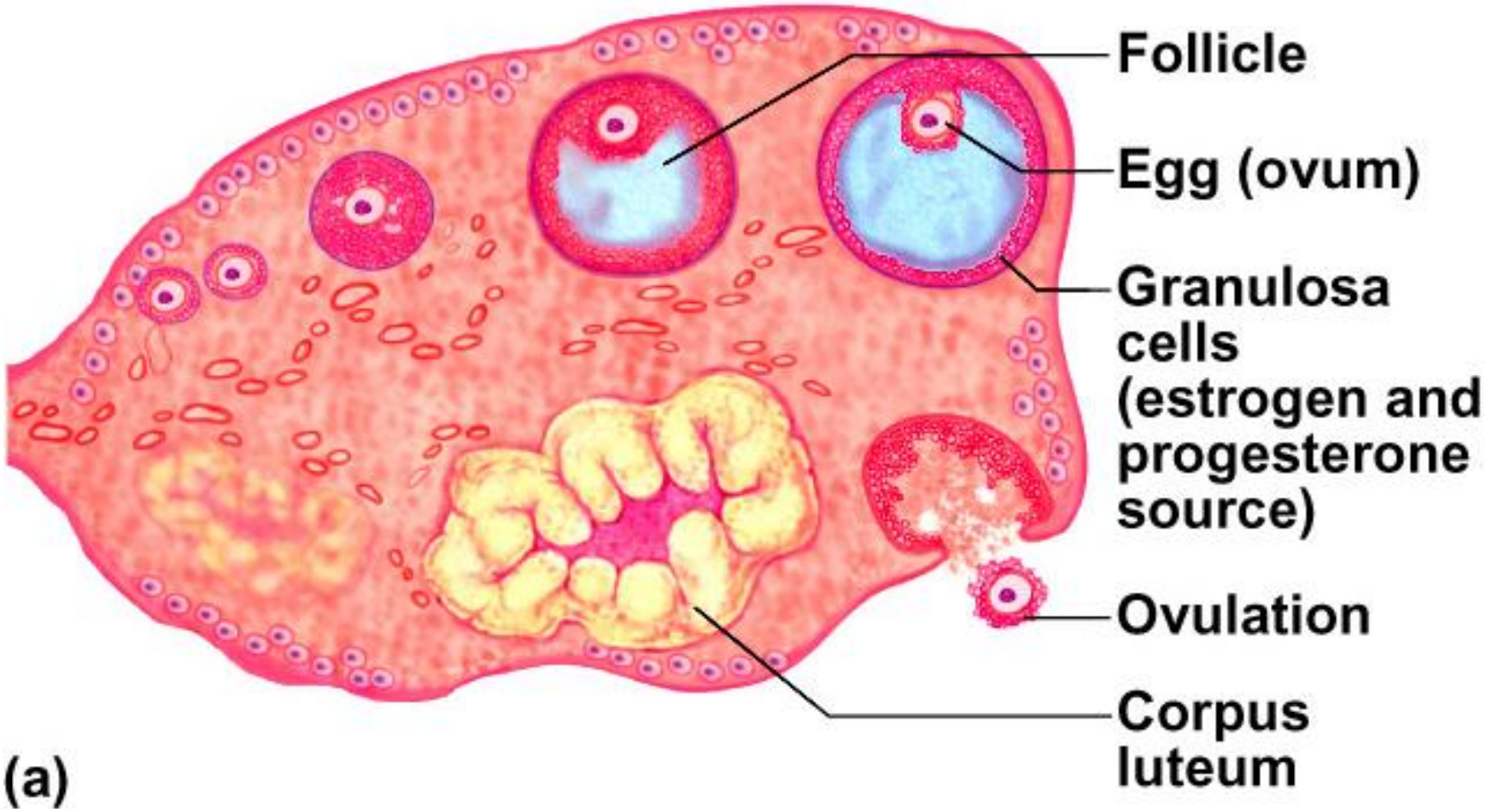
- 1-2 Million pancreatic islets producing hormones
  - 98% of organ produces digestive enzymes (exocrine)
- **Insulin (from β cells)**
  - secreted after meal with carbohydrates raises glucose blood levels
  - stimulates glucose and amino acid uptake
  - nutrient storage effect (stimulates glycogen, fat and protein synthesis
  - antagonizes glucagon



Pancreatic Hormones

- **Glucagon (from α cells)**
  - secreted in very low carbohydrate and high protein diet or fasting
  - stimulates glycogenolysis, fat catabolism (release of FFA's) and promotes absorption of amino acids for gluconeogenesis

Histology of Ovary



Follicles = egg surrounded by granulosa cells

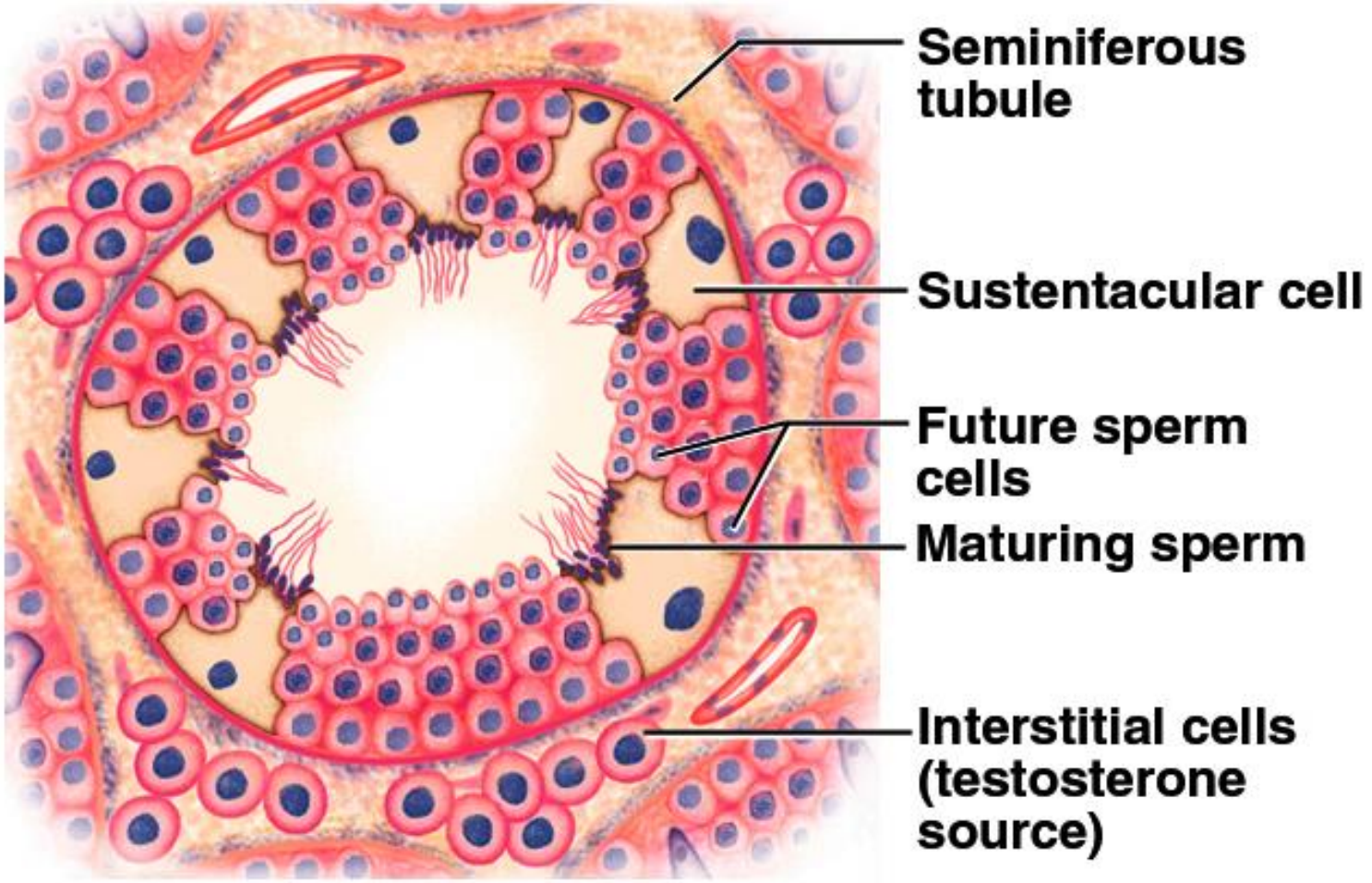
Hormones of the Ovaries

- Estrogens
  - Produced ovaries or the placenta
  - Stimulates the development of secondary female characteristics
  - Matures female reproductive organs
  - Helps prepare the uterus to receive a fertilized egg
  - Helps maintain pregnancy
  - Prepares the breasts to produce milk

Hormones of the Ovaries

- Progesterone
  - Produced by the corpus luteum
  - Acts with estrogen to bring about the menstrual cycle
  - Helps in the implantation of an embryo in the uterus

Histology of Testis



Seminiferous tubules produce sperm.

Hormones of the Testes

- Produce several androgens
- Testosterone is the most important androgen
  - Responsible for adult male secondary sex characteristics
  - Promotes growth and maturation of male reproductive system
  - Required for sperm cell production

Endocrine Functions of Other Organs

- Heart –
  - atrial natriuretic peptide released with an increase in BP
  - ↓ blood volume + ↓ BP by ↑ Na^+ and H_2O loss by kidneys
- Skin
  - keratinocytes help produce D3, first step in synthesis
- Liver
  - converts vitamin D3 to calcidiol
  - source of IGF-I that works with GH
  - secretes about 15% of erythropoietin
  - secretes angiotensinogen (a prohormone)
    - precursor of angiotensin II, a vasoconstrictor

Endocrine Functions of Other Organs

- Kidneys
  - converts calcidiol to calcitriol (active form of vitamin D)
  - produces 85% of erythropoietin –
    - stimulates bone marrow to produce RBC's
  - convert angiotensinogen to angiotensin I
- Stomach and small intestines (10 enteric hormones)
  - coordinate digestive motility and secretion
- Placenta
  - secretes estrogen, progesterone and others
    - regulate pregnancy, stimulate development of fetus and mammary glands

Endocrine Function of the Placenta

- Produces hormones that maintain the pregnancy
- Some hormones play a part in the delivery of the baby
- Produces human chorionic gonadotropin (HCG) in addition to estrogen, progesterone, and other hormones

Developmental Aspects of the Endocrine System

- Most endocrine organs operate smoothly until old age
  - Menopause is brought about by lack of efficiency of the ovaries
  - Problems associated with reduced estrogen are common – osteoporosis
  - Growth hormone production declines with age
  - Many endocrine glands decrease output with age