ENDOCRINE SYSTEM

Mr. Sangale G.P.
Lecturer
Mula Education Society College of Pharmacy, Sonai.

THE ENDOCRINE SYSTEM

- Two body systems are responsible for sending and receiving sensory information and coordinating body responses. These are the *nervous system* and the *endocrine system*. Together, they are sometimes referred to as the **neuro-endocrine system**.

- The **endocrine system** regulates body activities by releasing **hormones** (chemical messengers) into the bloodstream, where they are carried throughout the entire body.

- Hormonal responses may be almost instantaneous (Sudden), or may occur days later. There is a wide variety of hormonal effects.

HORMONE FUNCTIONS

- Regulate the chemical composition and volume of the internal environment (extracellular fluid).
- Help regulate metabolism and energy balance.
- Help regulate contraction of smooth and cardiac muscle fibers and secretion by glands.
- Help maintain homeostasis, despite disruptions, such as infection, trauma, emotional stress, dehydration, starvation, hemorrhage, and temperature extremes.

- Regulate certain activities of the immune system.
- Play a role in the smooth, sequential integration of growth and development.
- Contribute to the basic processes of reproduction, including gamete production, fertilization, nourishment of the embryo and fetus, delivery, and nourishment of the newborn.

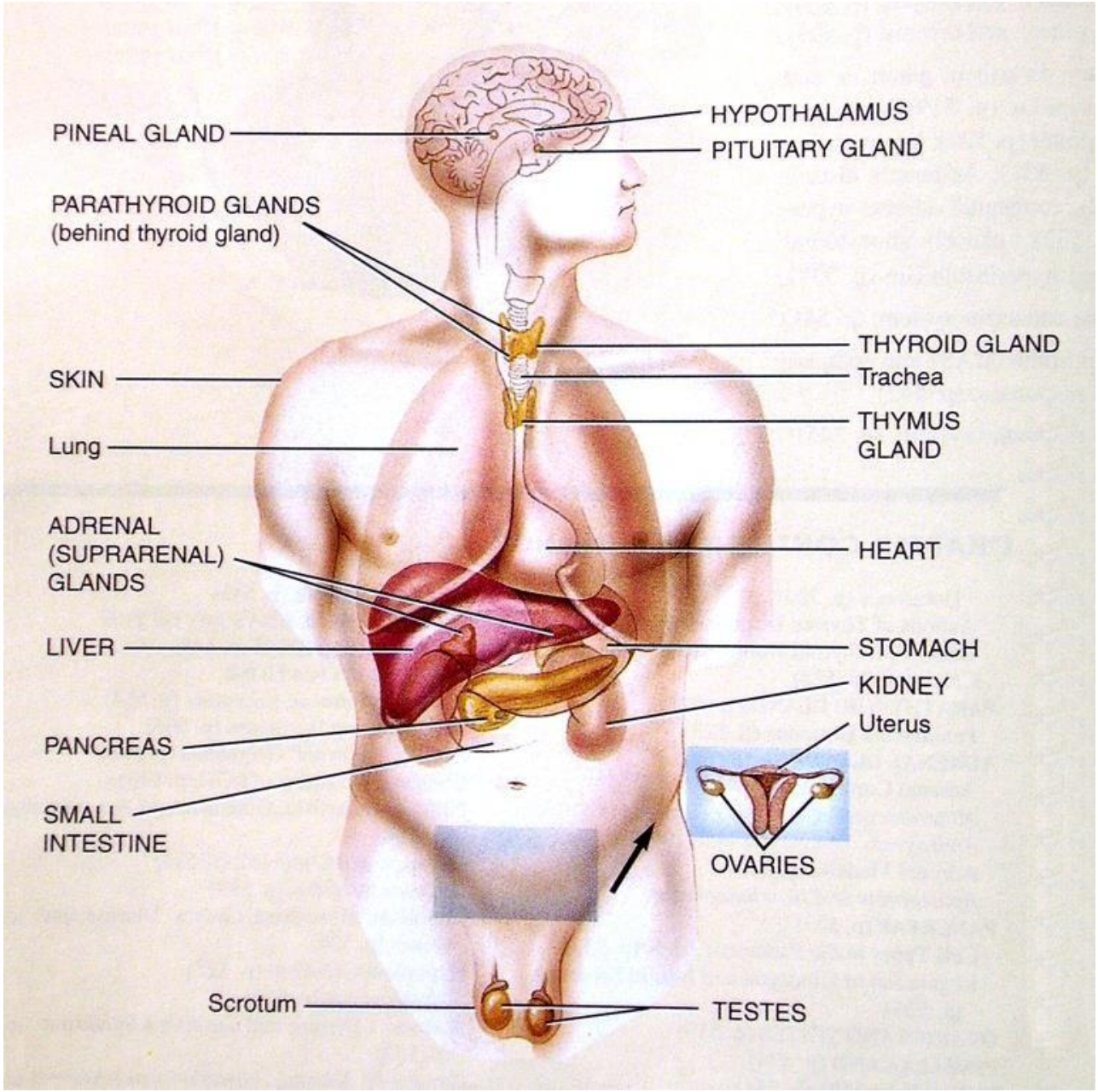
EXOCRINE & ENDOCRINE GLANDS

- The body contains two kinds of glands:
  - **Exocrine glands** secrete their products into body ducts, which carry the products into body cavities, the lumen of an organ, or the outer surface of the body.
    - Sudoriferous glands, sebaceous glands, mucous glands, and digestive glands.
  - **Endocrine glands** secrete their products (**hormones**) into the extracellular space around the secretory cells. The secretions diffuse into capillaries and are carried throughout the body by the circulatory system.

- The **endocrine system** is composed of the body's endocrine glands. These include:
  - The pituitary,
  - thyroid,
  - parathyroid,
  - adrenal
  - pineal glands
  - Pancreatic islets.

- There are also many organs that have cells which secrete hormones, but are not exclusively endocrine organs.
- These include:
  - The hypothalamus, thymus, pancreas, ovaries, testes, kidneys, stomach, liver, small intestine, skin, heart, and placenta.

ENDOCRINE SYSTEM



HORMONES

- Hormones are a chemical substances that are carried by a cell tissue and initiate specific action.

HORMONES

- Hormones can have very powerful effects, even when present in very low concentrations.
- There are approximately 50 different hormones produced in the human body.
- The specific cells which are affected by a hormone are called **target cells**.
- Hormones influence their target cells by binding to proteins or glycoproteins in the cell membrane called **receptors**.

THE PITUITARY GLAND & hypothalamus

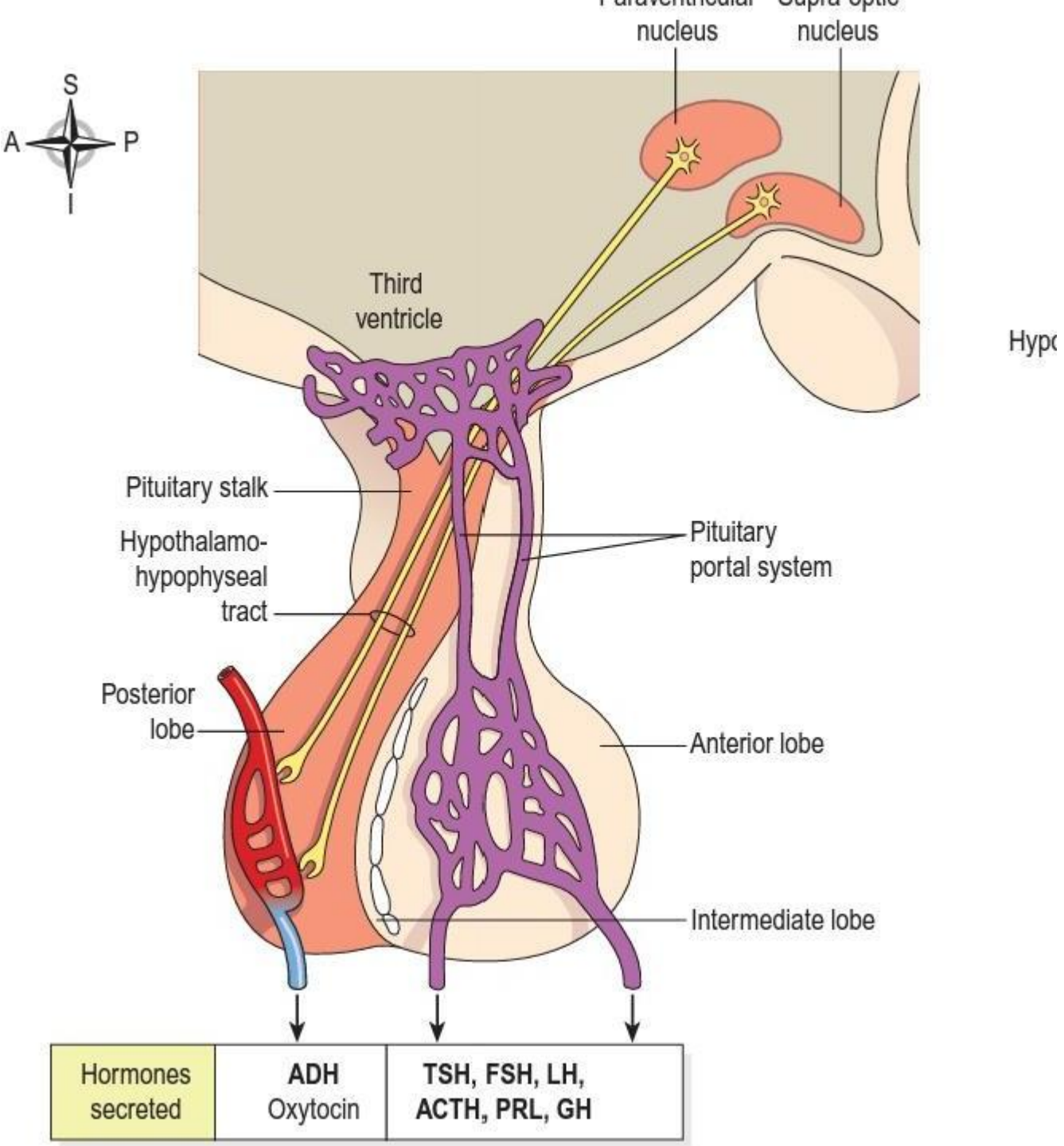
- The **pituitary gland** or **hypophysis** is attached to the **hypothalamus** at the base of the brain.
- The hypothalamus is the major integrating link between the nervous and endocrine systems.

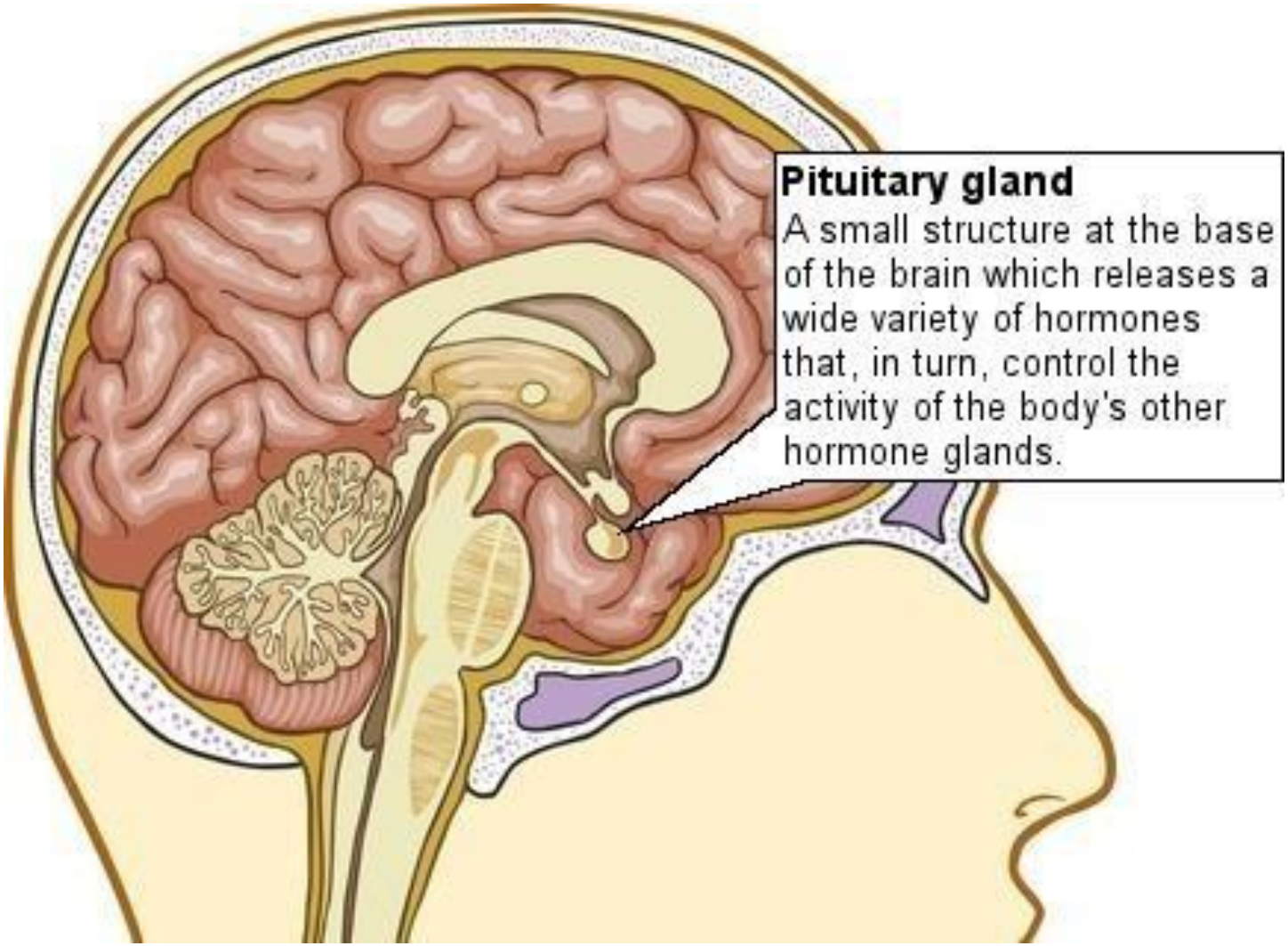
- Although the pituitary gland is sometimes called the "master" endocrine gland.
- Together, the hypothalamus and pituitary gland regulate virtually all aspects of growth, development, metabolism, and homeostasis.

- The pituitary gland can be divided into the **posterior pituitary** and **anterior pituitary**.

- It is the size of a pea, weighs about 500 mg and consists of two main parts that originate from different types of cells.
- The *anterior pituitary* (adenohypophysis) is an upgrowth of glandular epithelium from the pharynx and the *posterior pituitary* (neurohypophysis) a downgrowth of nervous tissue from the brain.

- There is a network of nerve fibres between the hypothalamus and the posterior pituitary.


S
A
P
I
nucleus
nucleus
Third
ventricle
Pituitary stalk
Hypothalamo-
hypophyseal
tract
Pituitary
portal system
Posterior
lobe
Anterior lobe
Intermediate lobe
Hormones
secreted
ADH
Oxytocin
TSH, FSH, LH,
ACTH, PRL, GH


Pituitary gland
A small structure at the base of the brain which releases a wide variety of hormones that, in turn, control the activity of the body's other hormone glands.

Blood supply

- **Arterial blood. This is from branches of the internal** carotid artery. The anterior lobe is supplied indirectlyby blood that has already passed through a capillary bed in the hypothalamus but the posterior lobe is supplied directly.

The influence of the hypothalamus on the pituitary gland

- The hypothalamus controls release of hormones from both the anterior and posterior pituitary but in different ways

- **<u>Hormones of the pituitary gland</u>**:

❑ Anterior pituitary = GH
TSH
ACTH
PRL
LH
FSH

❑ Posterior pituitary = Vassopressin or ADH
oxytocin

THE POSTERIOR PITUITARY

- The **posterior pituitary** works as a unit with the hypothalamus.

- Although the posterior pituitary does not synthesize its own hormones, it does store and release **oxytocin (OT)** and **antidiuretic hormone (ADH)** produced in the hypothalamus.

  – OT controls uterine contractions during delivery and milk ejection during breastfeeeding.

  – ADH causes retention of body water, controlling the body's water-balancing mechanism

THE ANTERIOR PITUITARY

- The anterior pituitary secretes hormones that control a wide range of bodily activities.

- The hypothalamus regulates the anterior pituitary by producing **releasing hormones**
- that stimulate release of anterior pituitary gland hormones and **inhibiting hormones** that suppress release of anterior pituitary gland hormones.

- The Anterior pituitary has five princple types of cells which secrete seven major hormones.

ANTERIOR PITUITARY HORMONES

- **GH :** which stimulates general body growth and regulates certain aspects of metabolism.

- **thyroid stimulating hormone (TSH)**, which controls secretions and other activities of the thyroid gland.

- **follicle-stimulating hormone (FSH)** and **luteinizing hormone (LH)**. Together FSH and LH stimulate the secretion of estrogen and progesterone and the maturation of oocytes in the ovaries and the secretion of testosterone and sperm production in the testes.

- **prolactin (PRL),** which initiates milk production in the mammary glands.

- **adrenocorticotropic hormone (ACTH)** and **melanocyte-stimulating hormone (MSH).** ACTH stimulates the adrenal cortex to secrete glucocorticoids. MSH affects skin pigmentation.

Table 9.2 Summary of the hormones secreted by the anterior pituitary gland and their functions

Hormone	Function
Growth hormone (GH)	Regulates metabolism, promotes tissue growth especially of bones and muscles
Thyroid stimulating hormone (TSH)	Stimulates growth and activity of thyroid gland and secretion of T_3 and T_4
Adrenocorticotrophic hormone (ACTH)	Stimulates the adrenal cortex to secrete glucocorticoids
Prolactin (PRL)	Stimulates growth of breast tissue and milk production
Follicle stimulating hormone (FSH)	Stimulates production of sperm in the testes, stimulates secretion of oestrogen by the ovaries, maturation of ovarian follicles, ovulation
Luteinising hormone (LH)	Stimulates secretion of testosterone by the testes, stimulates secretion of progesterone by the corpus luteum

GH: Growth hormone:

- This is the most abundant hormone synthesised by the anterior pituitary.
- It stimulates growth and division of most body cells but especially those in the bones and skeletal muscles.
- Body growth in response to the secretion of GH is evident during childhood and adolescence, and thereafter secretion of GH maintains the mass of bones and skeletal muscles.

- It also regulates aspects of metabolism in many organs, e.g. liver, intestines and pancreas.

- Its release is stimulated by *growth hormone releasing hormone (GHRH) and suppressed by growth hormone release inhibiting hormone (GHRIH), also known as somatostatin,* both of which are secreted by the hypothalamus.

- Secretion of GH is greater at night during sleep and is also stimulated by hypoglycaemia (low blood sugar), exercise and anxiety. Secretion peaks in adolescence and then declines with age.

Thyroid stimulating hormone (TSH)

- The release of this hormone is stimulated by *thyrotrophin releasing hormone (TRH) from the hypothalamus.*

- *It stimulates* growth and activity of the thyroid gland, which secretes the hormones *thyroxine (T4) and tri-iodothyronine* (T3).

- Release is lowest in the early evening and highest during the night.

Adrenocorticotrophic hormone (ACTH, corticotrophin)

- *Corticotrophin releasing hormone (CRH) from the hypothalamus* promotes the synthesis and release of ACTH by the anterior pituitary.

- This increases the concentration of cholesterol and steroids within the adrenal cortex

- ACTH levels are highest at about 8 a.m. and fall to their lowest about midnight,

Prolactin

- This hormone is secreted during pregnancy to prepare the breasts for *lactation (milk production) after childbirth.*

- The blood level of prolactin is stimulated by *prolactin releasing hormone (PRH)* released from the hypothalamus and it is lowered by *prolactin inhibiting hormone (PIH, dopamine)* and by an increased blood level of prolactin.

Gonadotrophins

- Just before puberty two gonadotrophins (sex hormones) are secreted in gradually increasing amounts by the anterior pituitary in response to *luteinising hormone releasing hormone (LHRH), also known as gonadotrophin releasing hormone (GnRH).*

- Rising levels of these hormones at puberty promotes mature functioning of the reproductive organs. In both males and females the hormones responsible
- are:
    - follicle stimulating hormone (FSH)
    - luteinising hormone (LH).

- **Follicle-stimulating hormone (FSH)**
- In female : regulates the development of sex organs in female, development of immature ovarian follicle from the ovary.
- Secretes oestrogen & progesterone during menstrual cycle.
- In male: initiation of spermatogenesis.
- **LH:**
- In females: ovulation, maintaining of corpus luteum and secretion of progesterone.
- In males: testosterone secretion.

THE THYROID GLAND

- The thyroid gland is situated in the neck in front of the larynx and trachea at the level of the 5th, 6th and 7th cervical and 1st thoracic vertebrae.

- It is a highly vascular gland that weighs about 25 g and is surrounded by a fibrous capsule.

- It resembles a butterfly in shape, consisting of two lobes, one on either side of the thyroid cartilage and upper cartilaginous rings of the trachea.

- The lobes are joined by a narrow *isthmus, lying in front of the* trachea.

- The lobes are roughly cone shaped, about 5 cm long and 3 cm wide.

- The *arterial blood supply to the gland is through the* superior and inferior thyroid arteries. The superior thyroid artery is a branch of the external carotid artery and the inferior thyroid artery is a branch of the subclavian artery.

- The *venous return is by the thyroid veins, which drain* into the internal jugular veins.

- The gland is composed of largely spherical follicles formed from cuboidal epithelium.
- These secrete and store *colloid, a thick sticky protein material. Between* the follicles are other cells found singly or in small groups: *parafollicular cells, also called C-cells, which secrete then* hormone *calcitonin.*

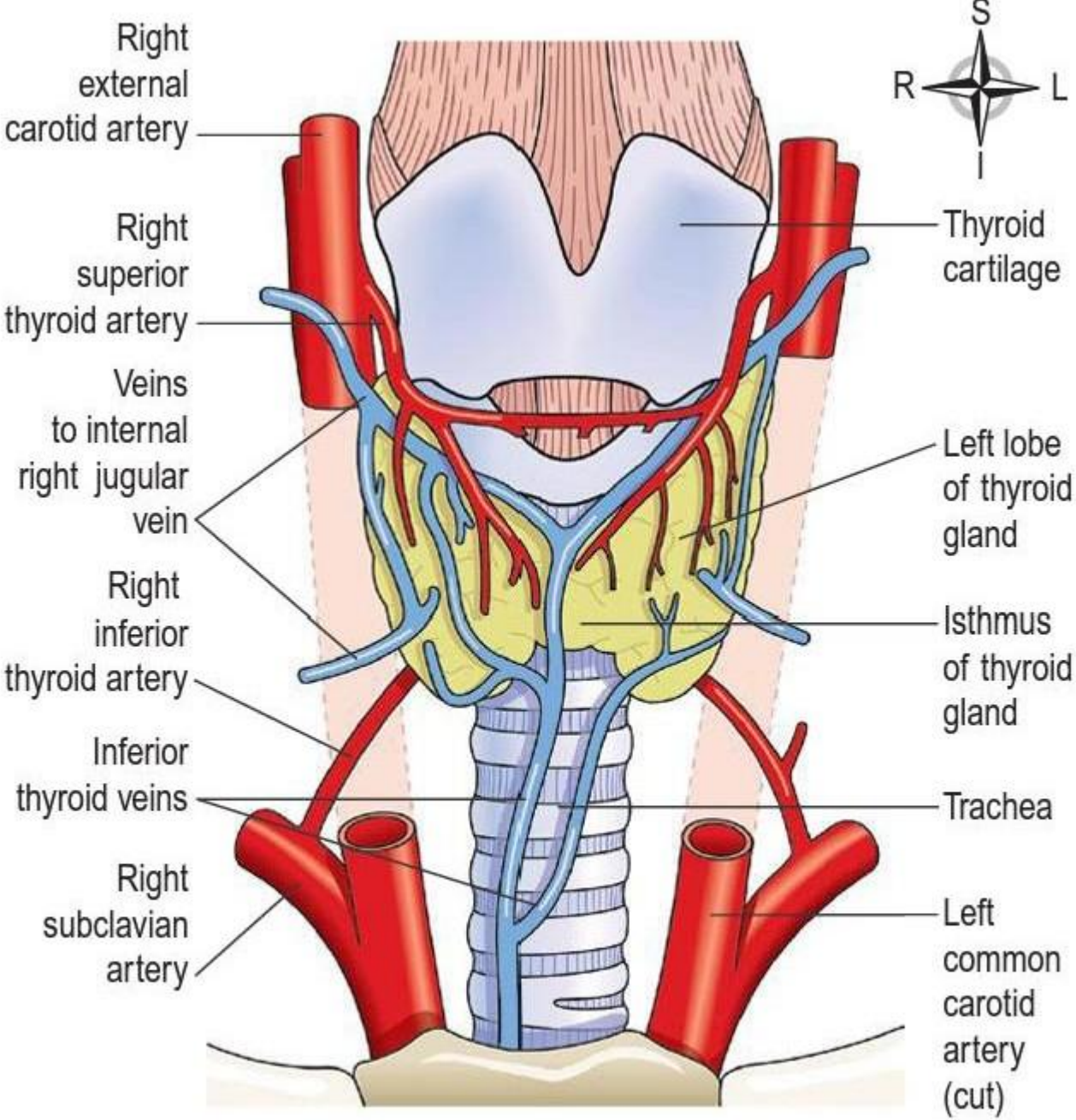
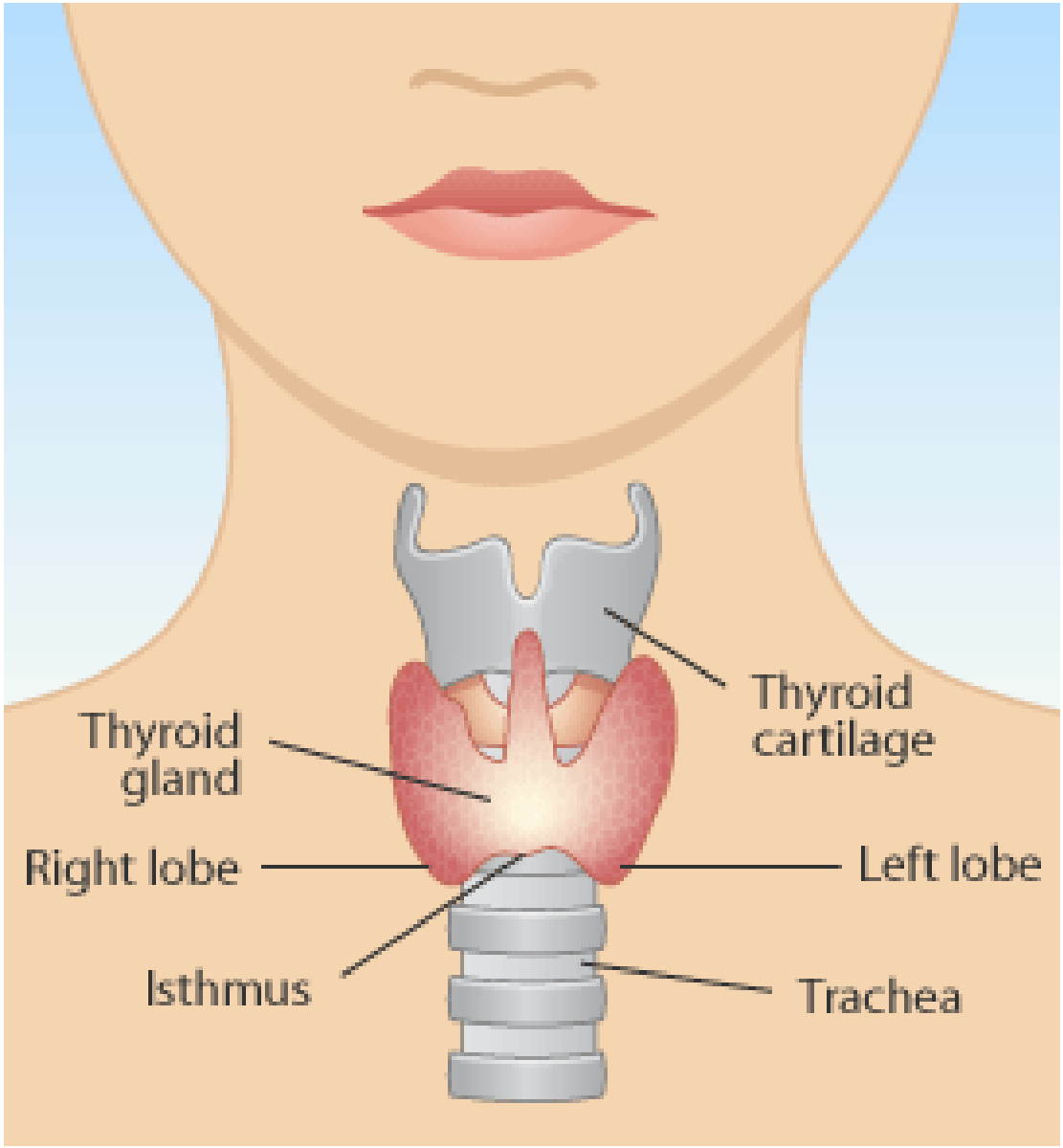


Figure 9.7 The position of the thyroid gland and its associated structures. Anterior view.


Thyroid cartilage
Thyroid gland
Right lobe
Left lobe
Isthmus
Trachea

Thyroid hormones

- **<u>Thyroxine and tri-iodothyronine</u>**
- Iodine is essential for the formation of the thyroid hormones, thyroxine (T4) and tri-iodothyronine (T3),

- The thyroid gland selectively takes up iodine from the blood, a process called *iodine trapping.*

- The release of T3 and T4 into the blood is stimulated by *thyroid stimulating hormone (TSH) from the anterior* pituitary.

- Secretion of TSH is stimulated by *thyrotrophin releasing hormone (TRH) from the hypothalamus and secretion of* TRH is stimulated by exercise, stress, malnutrition, low plasma glucose levels and sleep.

- **Function of T3 & T4:**
- T3 and T4 are essential for normal growth and development, especially of the skeleton and nervous system.
- Most other organs and systems are also influenced by thyroid hormones. Physiological effects of T3 and T4 on the heart, skeletal muscles, skin, digestive and reproductive systems are more evident when there is underactivity or overactivity of the thyroid gland and can be profound in childhood

Calcitonin

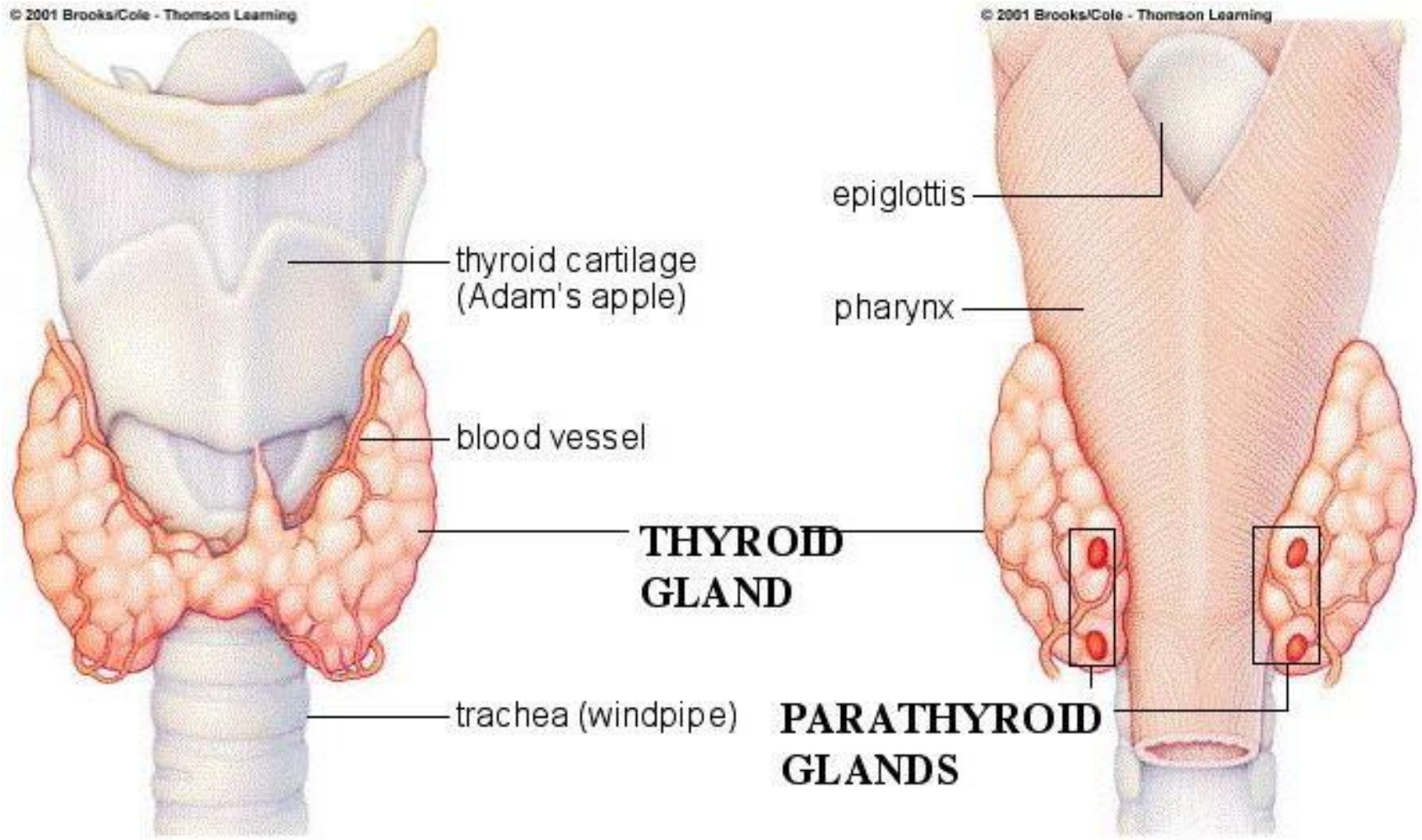
- This hormone is secreted by the parafollicular or C-cells in the thyroid gland.
- Calcitonin lowers raised blood calcium (Ca2+) levels.
- It does this by acting on:
  - bone cells promoting their storage of calcium
  - kidney tubules inhibiting the reabsorption of calcium.

- Release of calcitonin is stimulated by increased blood calcium levels.

THE PARATHYROID GLANDS

- There are four small parathyroid glands, each weighing around 50 g, two embedded in the posterior surface of each lobe of the thyroid gland.

- They are surrounded by fine connective tissue capsules that contain spherical cells arranged in columns with sinusoids containing blood in between them.


© 2001 Brooks/Cole - Thomson Learning
thyroid cartilage
(Adam's apple)
blood vessel
THYROID
GLAND
trachea (windpipe)
© 2001 Brooks/Cole - Thomson Learning
epiglottis
pharynx
PARATHYROID
GLANDS

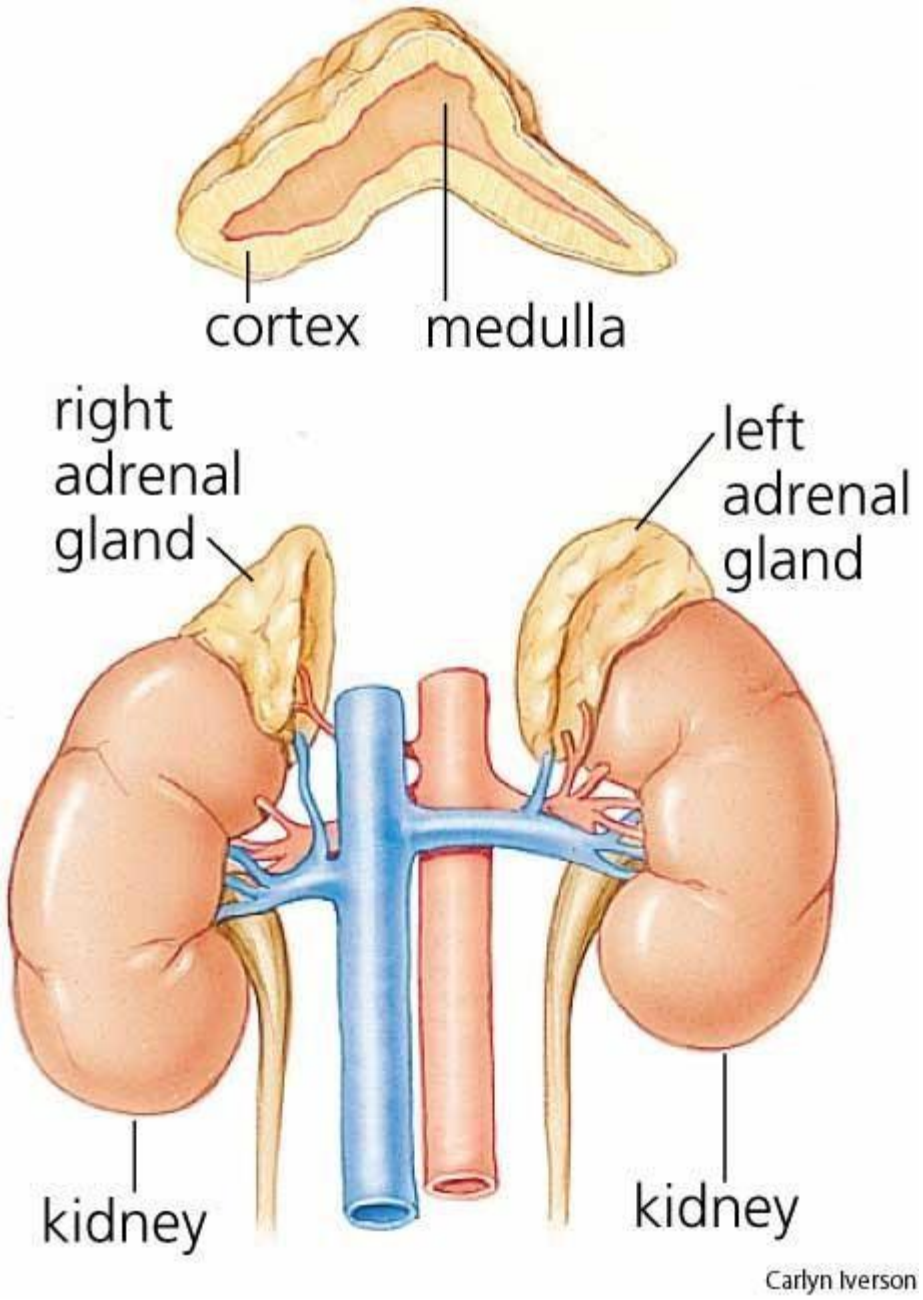
Function

- These glands secrete *parathyroid hormone (PTH, parathormone).* Secretion is regulated by blood calcium levels.

- The main function of PTH is to increase blood calcium levels. This is achieved by increasing the calcium absorption from the small intestine and reabsorption from the renal tubules.

THE ADRENAL GLANDS

- The paired **adrenal (suprarenal) glands** lie superior to the kidneys enclosed within the renal fascia.
- They are about 4 cm long and 3 cm thick.
- The adrenal glands are composed of the outer **adrenal cortex** and the inner **adrenal medulla**.
- The adrenal cortex produces a total of about 40 different hormones which are collectively known as **corticosteroids**.
- The complete loss of adrenocorticol hormones leads to death within a few days to a week, due to dehydration and electrolyte imballances.


cortex
medulla
right adrenal gland
left adrenal gland
kidney
kidney
Carlyn Iverson

- The glands are composed of two parts which have different structures and functions.
- The outer part is the *cortex* and the inner part the *medulla.*
- *The adrenal cortex is essential* to life but the medulla is not.

- **Hormones of the adrenal gland**:
- Adrenal cortex: cortisol
- corticosterone
- cortisone
- aldosterone
- androgens

- Adrenal medulla: epinephrine
- Nor- epinephrine

Adrenal cortex

- The adrenal cortex produces three groups of steroid hormones from cholesterol. They are collectively called
- *adrenocorticocoids (corticosteroids).*
- *The groups are:*
  - glucocorticoids
  - mineralocorticoids
  - sex hormones (androgens).

- The hormones in each group have different characteristic actions but as they are structurally similar their actions may overlap.

Glucocorticoids

- *Cortisol* (hydrocortisone) is the main glucocorticoid but small amounts of *corticosterone* and *cortisone* are also produced. Commonly these are collectively known as „steroids", they are essential for life, regulating metabolism and responses to stress.
- It is stimulated by ACTH from the anterior pituitary and by stress
- Glucocorticosteroids having a anti-inflammatory actions.

Mineralocorticoids (aldosterone)

- Aldosterone is the main mineralocorticoid. It is involved in maintaining water and electrolyte balance. Through a negative feedback system it stimulates the reabsorption of sodium (Na+) by the renal tubules and excretion of potassium (K+) in the urine.

- Sodium reabsorption is also accompanied by retention of water and therefore aldosterone is involved in the regulation of blood volume and blood pressure too.

- Blood potassium levels regulate aldosterone secretion by the adrenal cortex. When blood potassium levels rise, more aldosterone is secreted.
- Low blood potassium has the opposite effect. *Angiotensin* (see below) also stimulates the release of aldosterone.

Renin–angiotensin–aldosterone system.

- When renal blood flow is reduced or blood sodium levels fall, the enzyme *renin* is secreted by kidney cells.

- Renin converts the plasma protein *angiotensinogen*, produced by the liver, to *angiotensin 1*.
- *Angiotensin converting enzyme* (ACE), formed in small quantities in the lungs, proximal kidney tubules and other tissues, converts angiotensin 1 to *angiotensin 2*, which stimulates secretion of aldosterone.

- Angiotensin 2 causes vasoconstriction and increases blood pressure closing the negative feedback loop

Sex hormones

- Sex hormones secreted by the adrenal cortex are mainly *androgens* (male sex hormones) although the amounts produced are insignificant compared with those secreted by the testes and ovaries in late puberty and adulthood

Adrenal medulla

- The medulla is completely surrounded by the adrenal cortex. It develops from nervous tissue in the embryo and is part of the sympathetic nervous system.

- When stimulated by extensive sympathetic nerve supply, the glands release the hormones ***adrenaline (epinephrine, 80%) and noradrenaline (norepinephrine, 20%).***

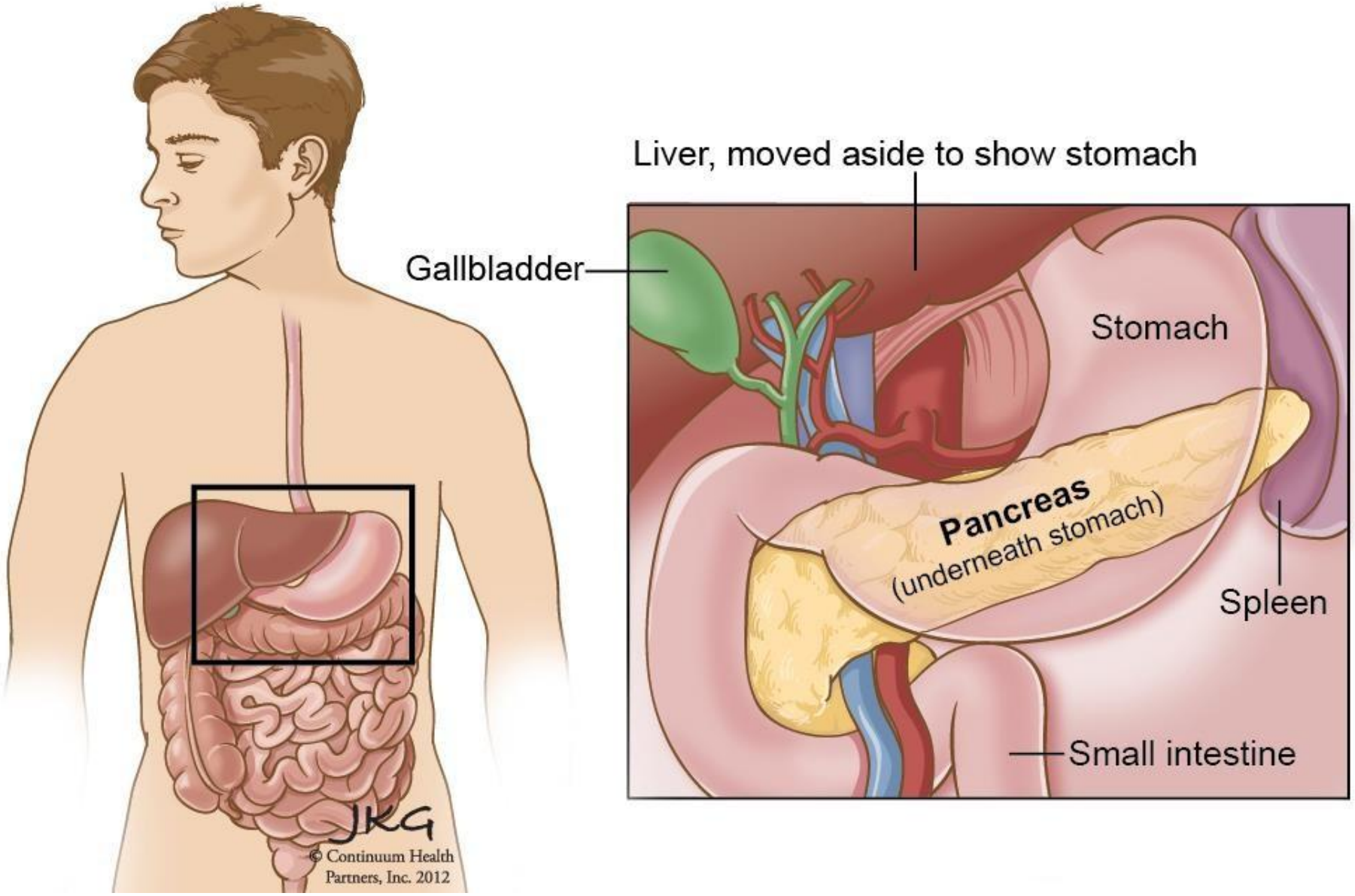
Adrenaline (epinephrine) and noradrenaline (norepinephrine)

- Noradrenaline is the postganglionic neurotransmitter of the sympathetic division of the autonomic nervous system
- Adrenaline and some noradrenalineare released into the blood from the adrenal medulla during stimulation of the sympathetic nervous system.
- The action of these hormones prolongs and augments stimulation of the sympathetic nervous system.

THE PANCREAS

- Since the **pancreas** is classified as both and endocrine organ and an exocrine organ, it will also be discussed again with the digestive system.

- There are three main types of cells in the pancreatic islets:
    - (alpha) cells, which secrete *glucagon*
    - (beta) cells, which are the most numerous, secrete *insulin*
    - (delta) cells, which secrete *somatostatin* (GHRIH,


Liver, moved aside to show stomach
Gallbladder
Stomach
Pancreas
(underneath stomach)
Spleen
Small intestine
JKG
© Continuum Health Partners, Inc. 2012

- The normal blood glucose level is between 3.5 and 8 mmol/litre (63 to 144 mg/100 mL).
- Blood glucose levels are controlled mainly by the opposing actions of insulin and glucagon:

  - **glucagon increases blood glucose levels**

  - **insulin reduces blood glucose levels.**

Insulin

- Its main function is to lower raised blood nutrient levels, not only glucose but also amino acids and fatty acids.

- These effects are described as anabolic, i.e. they promote storage of nutrients. When nutrients, especially glucose, are in excess of immediate needs insulin promotes their storage by:

- **<u>Mechanism by which insulin lowers the blood glucose level:</u>**
- acting on cell membranes and stimulating uptake and use of glucose by muscle and connective tissue cells

- increasing conversion of glucose to glycogen (*glycogenesis*), especially in the liver and skeletal muscles

- accelerating uptake of amino acids by cells, and the synthesis of protein

- promoting synthesis of fatty acids and storage of fat in adipose tissue (*lipogenesis*)

- decreasing *glycogenolysis* (breakdown of glycogen into glucose)

Glucagon

Glucagon increases blood glucose levels by stimulating:

• conversion of glycogen to glucose in the liver and skeletal muscles (glycogenolysis)

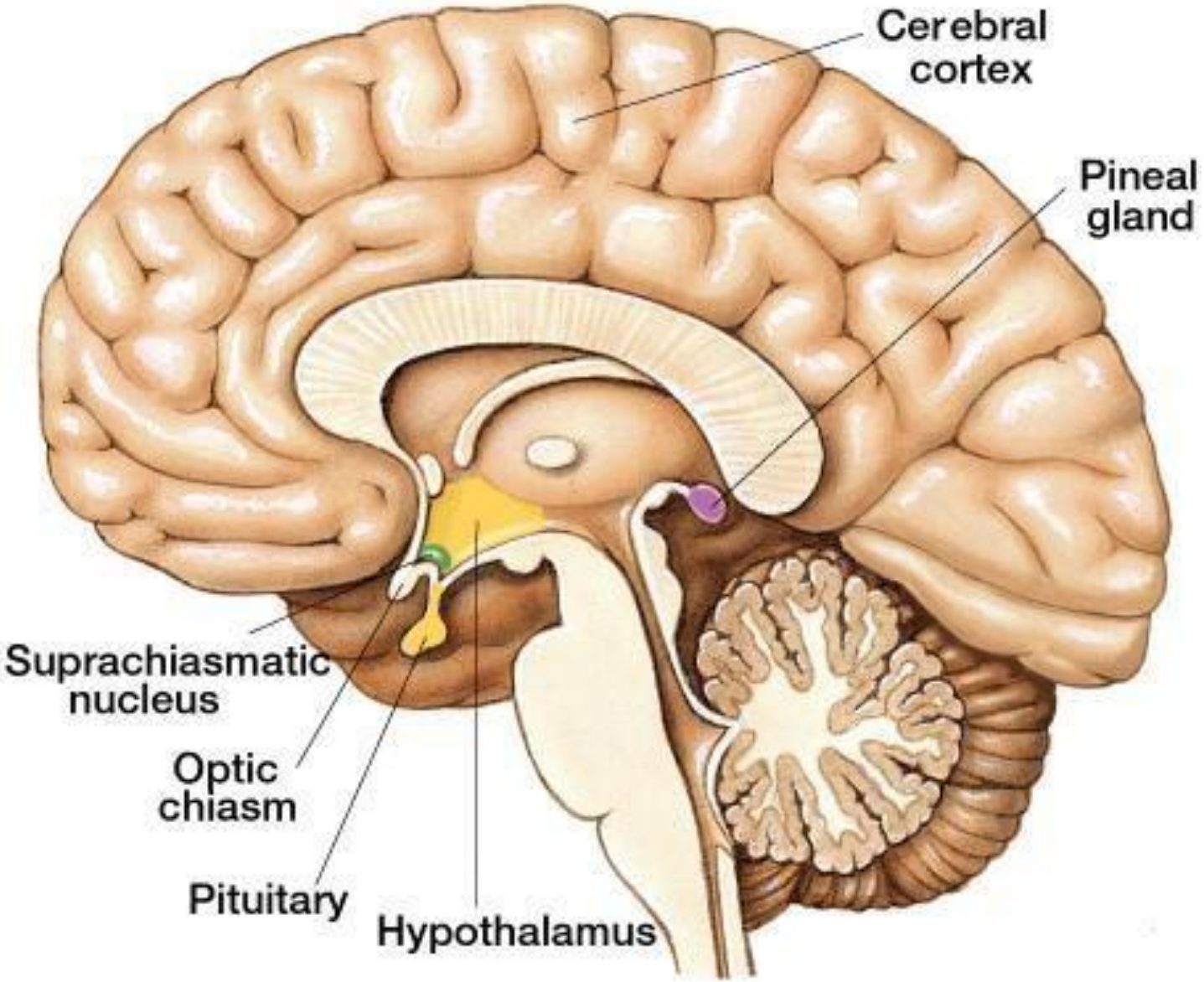
- Secretion of glucagon is stimulated by low blood glucose levels and exercise, and decreased by somatostatin and insulin.

Somatostatin (GHRIH)

- This hormone, also produced by the hypothalamus, inhibits the secretion of both insulin and glucagon in addition to inhibiting the secretion of GH from the anterior pituitary

Pineal gland

- The pineal gland is a small body attached to the roof of the third ventricle and is connected to it by a short stalk containing nerves, many of which terminate in the hypothalamus. The pineal gland is about 10 mm long, reddish brown in colour and surrounded by a capsule. The gland tends to atrophy after puberty and may become calcified in later life.


Cerebral cortex
Pineal gland
Suprachiasmatic nucleus
Optic chiasm
Pituitary
Hypothalamus

Function

- The physiological role of the pineal gland remains unclear.

- The pineal gland secretes **melatonin**, which is thought to promote sleepiness and help regulate the body's biological clock. In animals that breed during specific seasons, melatonin apparently alters their capacity for reproduction, but it has not been shown to have a similar effect on humans.

THE OVARIES AND TESTES

- The **ovaries** and **testes** are paired oval organs referred to as **gonads**.
- The ovaries are the female gonads, located in the pelvic cavity. They secrete **estrogens** and **progesterone**, which are responsible for the development and maintenance of female sexual characteristics, as well regulating the female reproductive system [in conjunction with gonadotropic hormones from the pituitary gland]). The ovaries also produce **relaxin**, which soften connective tissues in preparation for childbirth.
- The testes are the male gonads, located in the scrotum. They secrete **testosterone**, which is responsible for male sexual characteristics, and **inhibin**, which controls sperm production by inhibiting follicle stimulating hormone.

Uterus

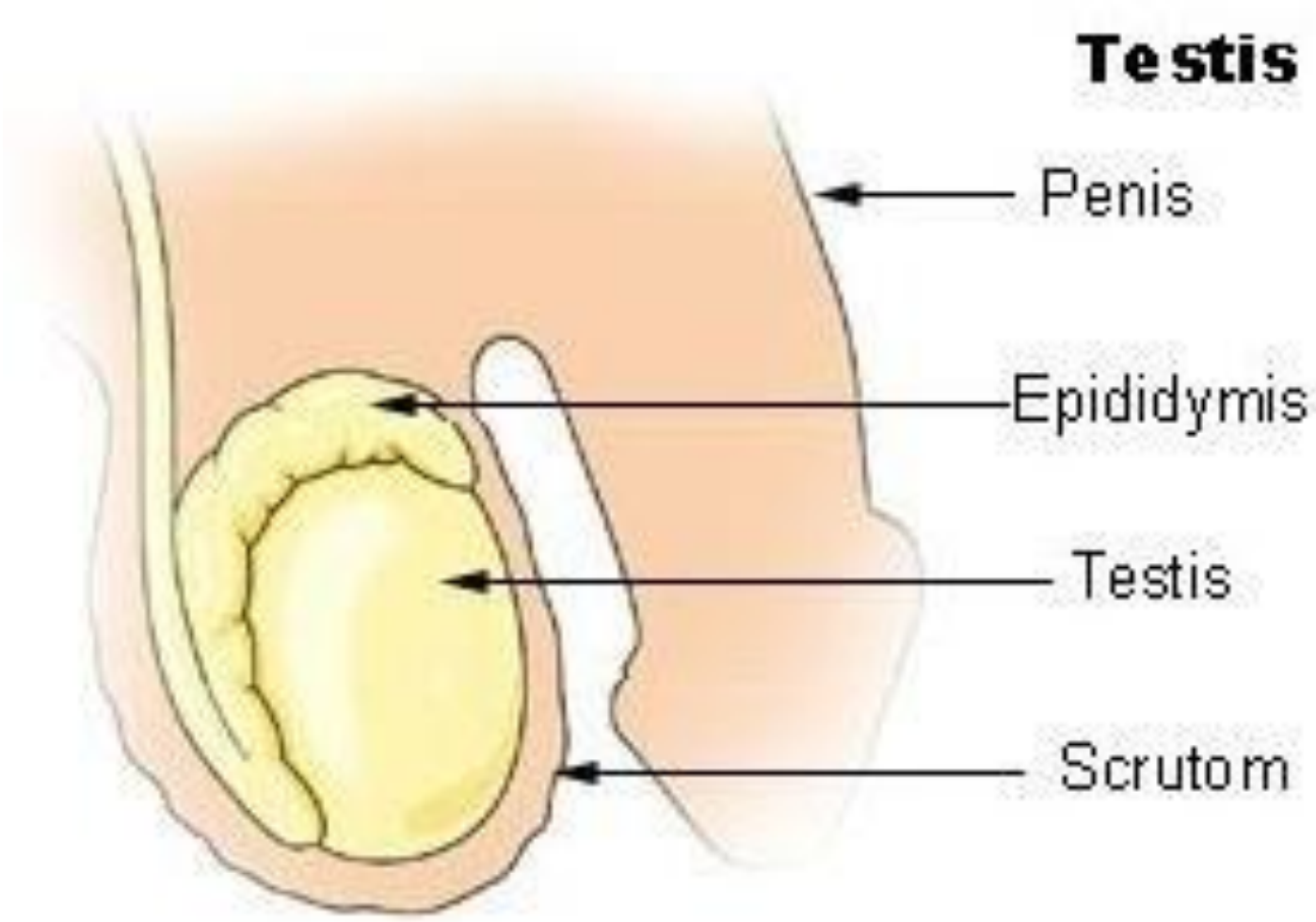
Fallopian tube

Ovary

Cervix

Vagina

A.D.A.M.

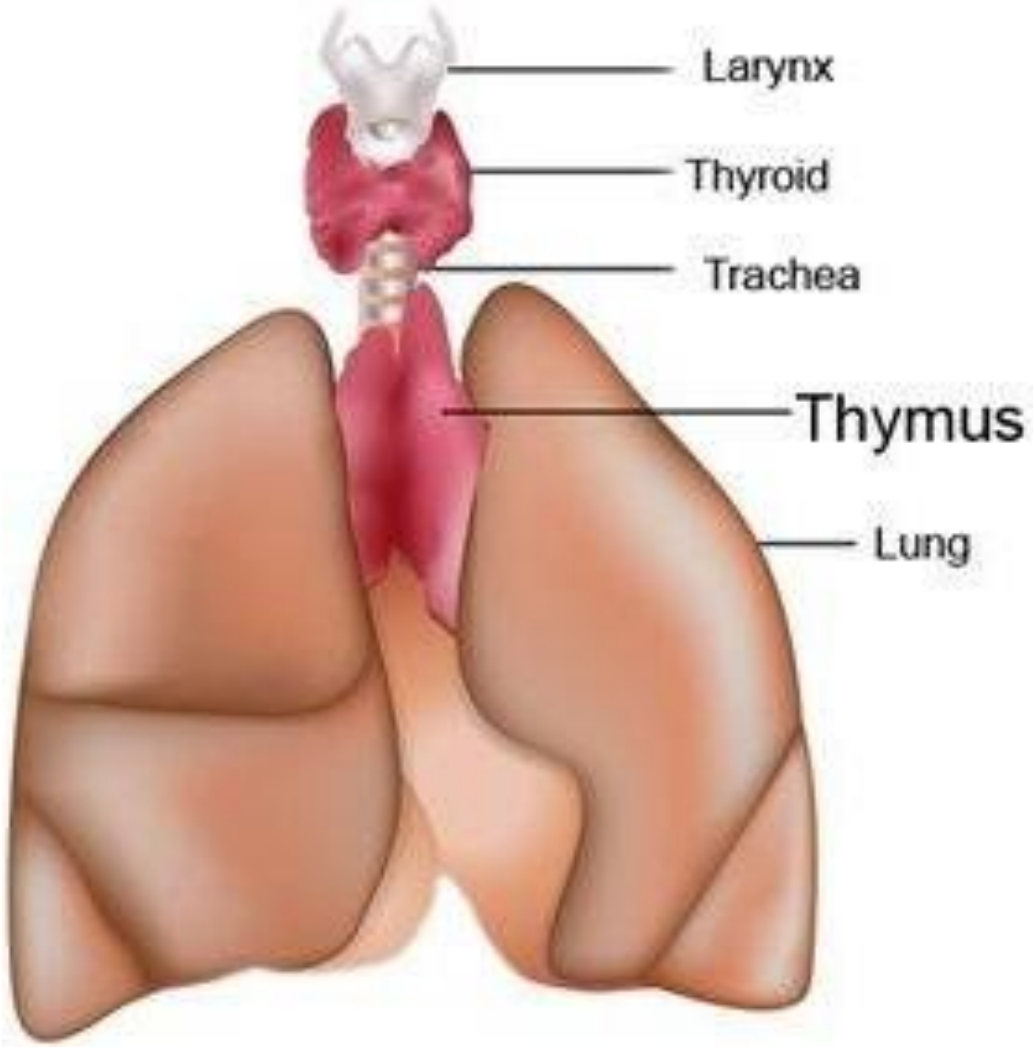

Testis
Penis
Epididymis
Testis
Scrutom

THE THYMUS

- The **thymus gland** was previously discussed in the lymphatic system lesson.

- Hormones produced by the thymus gland are **thymosin**= These hormones promote the proliferation and maturation of T cells (white blood cells which destroy microbes and foreign substances).

-
- Thymic hormones may also help to retard the aging process.


Larynx
Thyroid
Trachea
Thymus
Lung

Local hormones

- **Histamine**
- This is synthesised and stored by mast cells in the tissues and basophils in blood. It is released as part of the inflammatory responses, especially when caused by allergy

- **Serotonin (5-hydroxytryptamine, 5-HT)**
- This is present in platelets, in the brain and in the intestinal wall. It causes intestinal secretion and contraction of smooth muscle and its role in haemostasis (blood clotting)
- It is a neurotransmitter in the CNS and is known to influence mood.

- **Prostaglandins (PGs)**
- These are lipid substances found in most tissues. They act on neighbouring cells but their actions are short-lived as they are quickly metabolized. Prostaglandins have potent and wide-ranging physiological effects in:
- • the inflammatory response
- • potentiating pain
- • fever
- • regulating blood pressure
- • blood clotting
- • uterine contractions during labour.

Question

- Hormones of anterior pituitary gland
- Hormones of posterior pituitary gland
- Master gland of our body
- T4-
- T3-
- Function of prolactine
- Which hormone lowers the raised blood calcium level
- Which hormone raise the blood calcium level
- Hormones of adrenal cortex
- Hormones of adrenal medulla
- Function of FSH & LH
- Hormone of parathyroid gland
- Hormone of thymus gland
- Hormone of pineal gland
- Sex hormones of male & female


Thank
you