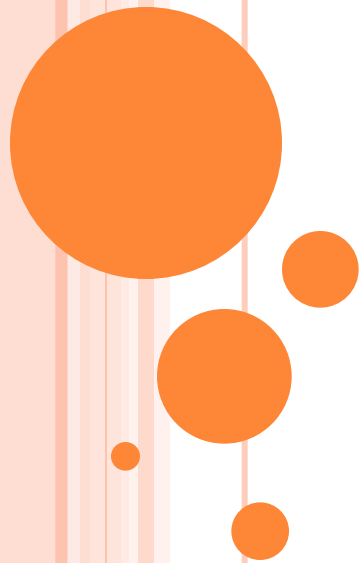


**DR. GARY MUMAUGH**



# **The Endocrine System**

# ENDOCRINE SYSTEM

- Endocrine system – the body's second great controlling system which influences metabolic activities of cells by means of hormones
- Endocrine glands – pituitary, thyroid, parathyroid, adrenal, pineal, and thymus
- The pancreas and gonads produce both hormones and exocrine products

# ENDOCRINE SYSTEM

- The hypothalamus has both neural functions and releases hormones
- Other tissues and organs that produce hormones – adipose cells, pockets of cells in the walls of the small intestine, stomach, kidneys, and heart

# MAJOR ENDOCRINE ORGANS

Pineal gland

Hypothalamus

Pituitary gland

Thyroid gland

Parathyroid glands  
(on dorsal aspect  
of thyroid gland)

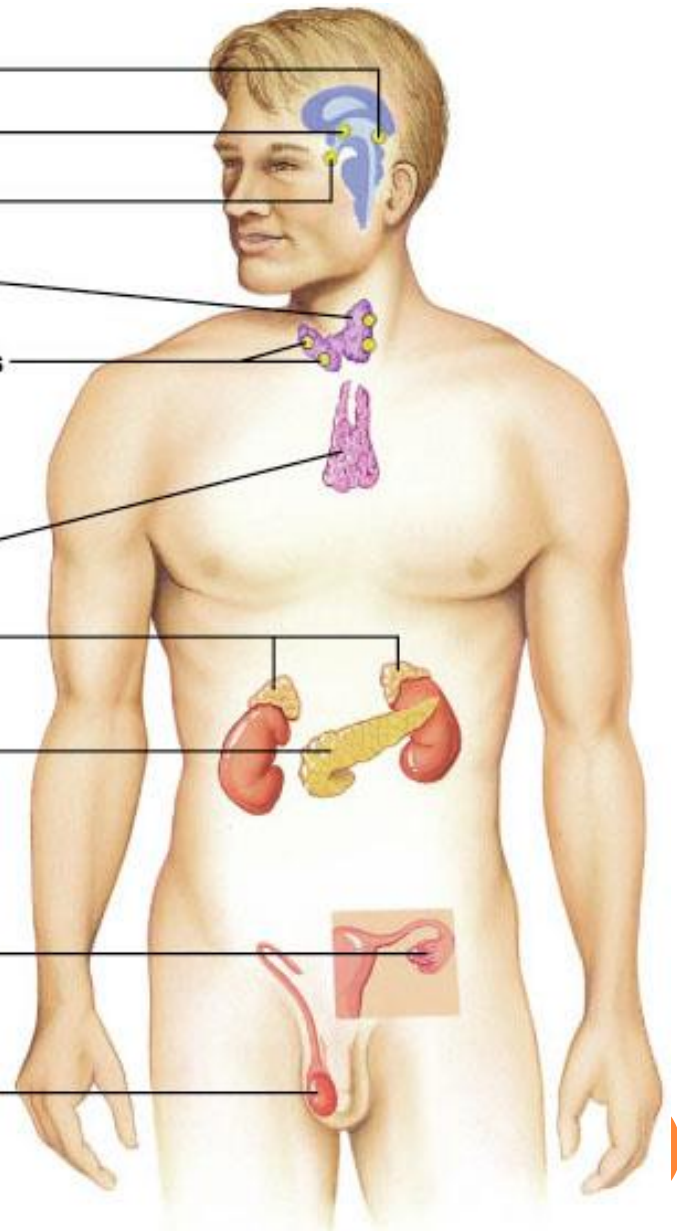
Thymus gland

Adrenal glands

Pancreas

Ovary  
(female)

Testis  
(male)



# HORMONES

- Hormones – chemical substances secreted by cells into the extracellular fluids
  - Regulate the metabolic function of other cells
  - Have lag times ranging from seconds to hours
  - Tend to have prolonged effects
- Hormones circulate to all tissues but only activate cells referred to as target cells
- In general, hormones regulate body growth, the use of foods and energy, resistance to stress, fluid balance and reproduction

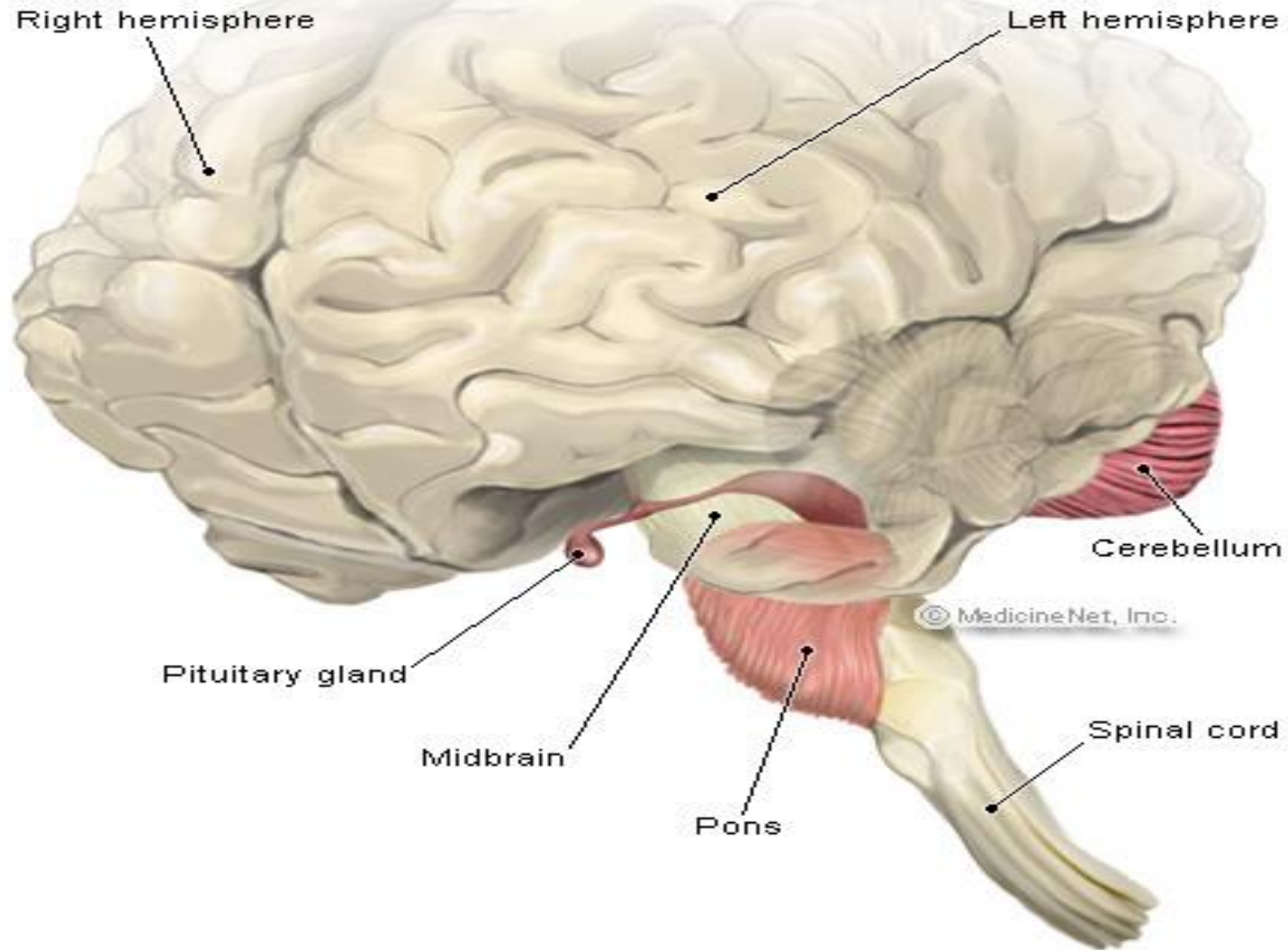
# CONTROL OF HORMONE RELEASE

- Blood levels of hormones are controlled by negative feedback systems
- Hormone secretions are triggered by internal and external stimuli
- As hormone levels rise, they cause target organ effects and inhibit further hormone release

# MAJOR ENDOCRINE ORGANS

- The Pituitary Gland (Hypophysis)
  - Posterior Pituitary Gland
  - Anterior Pituitary Gland
- Thyroid Gland
- Parathyroid Gland
- Adrenal Glands
- Pineal Gland

# Pituitary Gland





# PITUITARY GLAND (HYPOPHYSIS)

- Sits in the sella turcica of the sphenoid
- Pituitary gland – two-lobed organ that secretes nine major hormones
- Posterior pituitary – is primarily neural tissue
  - Receives, stores, and releases hormones from the hypothalamus
- Anterior pituitary – is primarily glandular tissue
  - Synthesizes and secretes a number of hormones

# THE POSTERIOR PITUITARY HORMONES

- Posterior pituitary – made of axons of hypothalamic neurons, stores antidiuretic hormone (ADH) and oxytocin
- ADH and oxytocin are synthesized in the hypothalamus
- ADH influences water balance
- Oxytocin stimulates smooth muscle contraction in breasts and uterus

# ANTIDIURETIC HORMONE (ADH)

- ADH helps to avoid dehydration or water overload
  - Prevents urine formation
- The stimulus for ADH secretion is decreased water content of the body
  - Any type of dehydration stimulates the secretion of ADH
  - Excessive sweating and diarrhea
  - Severe hemorrhage
- Large amounts of ADH will cause vasoconstriction, which helps maintain blood pressure
  - ADH also called vasopressin because of this
- Alcohol inhibits ADH release and causes copious urine output

# DIABETES INSIPIDUS

- Caused by ADH deficiency
- Marked by:
  - Polyuria – excessive urine output
  - Polydipsia – excessive thirst
- Insulin deficiency causes large amounts of blood glucose in the urine
  - In the past, urine was tasted dx insipidus vs mellitus
- Can be caused by head trauma damaging the pituitary or after meningitis in children, or after some medications or anesthesia

# OXYTOCIN

- Oxytocin is a strong stimulant of uterine contraction
- This leads to increased intensity of uterine contractions, ending in birth
- Oxytocin triggers milk ejection (“letdown” reflex) in women producing milk
- Oxytocic drugs used to induce or hasten labor

# ANTERIOR PITUITARY HORMONES

- Often called the “master endocrine gland”
- The six hormones of the anterior pituitary:
  - Regulate the activity of other endocrine glands
  - Are abbreviated as GH, TSH, ACTH, FSH, LH, and PRL
    - Growth hormone
    - Thyroid stimulating hormone
    - Adrenocorticotrophic hormone
    - Follicle stimulating hormone
    - Luteinizing hormone
    - Prolactin

# GROWTH HORMONE (GH)

- Stimulate most cells, but target bone and skeletal muscle
- Promote protein synthesis and encourage the use of fats for fuel
- Most effects are mediated indirectly by growth promoting proteins produced by the liver, skeletal muscle, bone and other tissues

# HYPERSECRETION AND HYPOSECRETION OF GH

## ○ Hypersecretion – Gigantism

- Abnormally large with normal body proportions
- Acromegaly – large extremities and head
- Hypersecretion is normally caused by a tumor



## ○ Hyposecretion – Pituitary dwarfism

- Usually less than 4 feet with normal proportions





# THYROID STIMULATING HORMONE (TSH)

- Stimulates the normal development and secretory activity of the thyroid gland
- Rising blood levels of thyroid hormones act on the pituitary and hypothalamus to block the release of TSH

# ADRENOCORTICOTROPIC HORMONE (ACTH)

- Stimulates the adrenal cortex to release cortisol and other hormones by the adrenal cortex
- Internal and external factors such as fever, hypoglycemia, and stressors can trigger the release of CRH
  - Corticotropin-releasing hormone

# GONADOTROPINS

- Gonadotropins – follicle-stimulating hormone (FSH) and luteinizing hormone (LH)
  - Regulate the function of the ovaries and testes
  - FSH stimulates gamete egg and sperm production
  - Absent from the blood in prepubertal boys and girls

# FUNCTIONS OF GONADOTROPINS

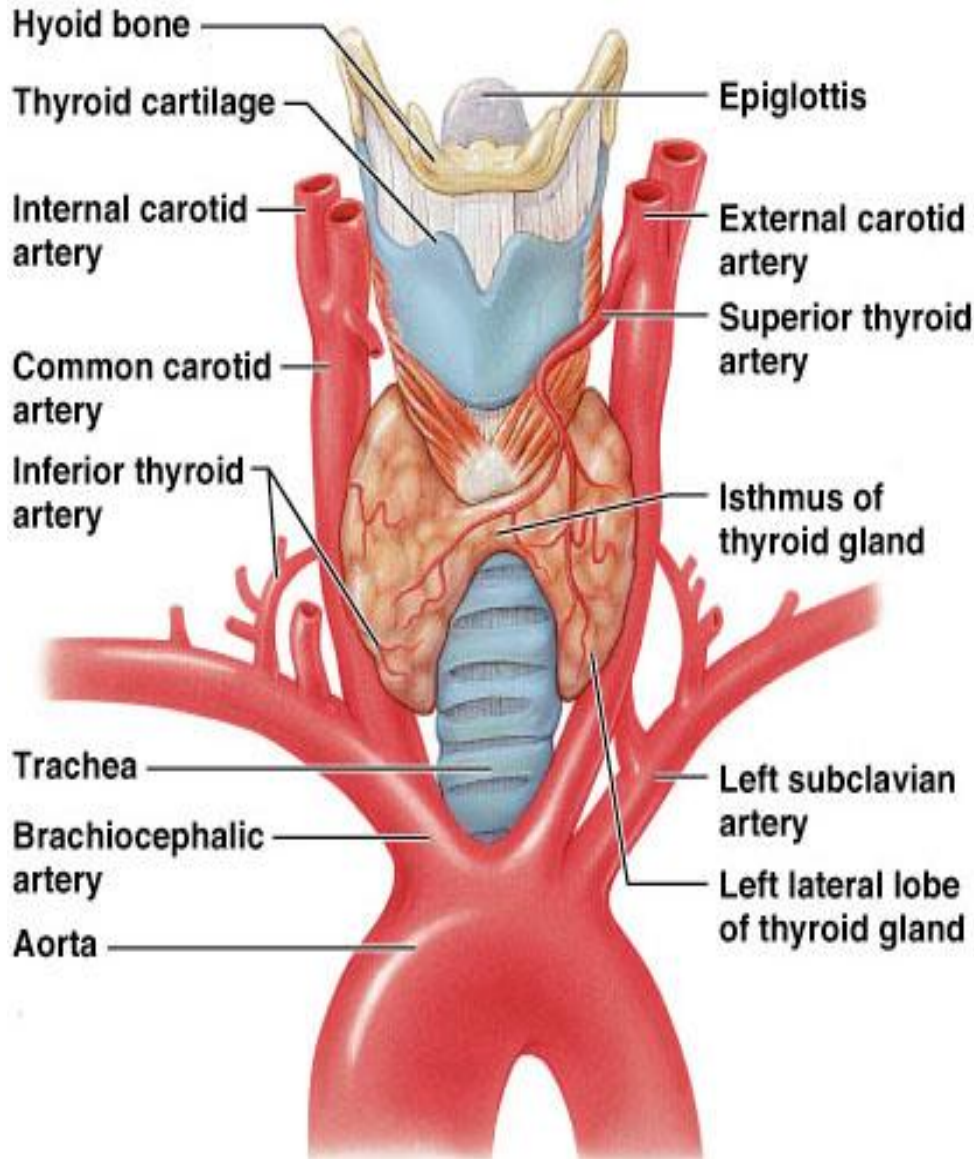
## ○ In females

- LH works with FSH to cause maturation of the ovarian follicle
- LH works alone to trigger ovulation
- LH promotes synthesis and release of estrogens and progesterone

## ○ In males

- LH stimulates interstitial cells of the testes to produce testosterone

# THYROID GLAND



The largest endocrine gland, located in the anterior neck, consists of two lateral lobes connected by a median tissue mass called the isthmus

# THYROID HORMONE

- The body's major metabolic hormone
- Causes a calorogenic effect
  
- TH is concerned with:
  - Glucose oxidation
  - Increasing metabolic rate
  - Heat production
  
- TH plays a role in:
  - Maintaining blood pressure
  - Regulating tissue growth
  - Developing skeletal and nervous systems
  - Maturation and reproductive capabilities

# THYROID UNDERACTIVITY

- Hypothyroidism
  - Results from thyroid gland defect or inadequate TSH or TRH release
  - Also from low dietary iodine or removal of thyroid
- Myxedema
  - Low metabolic rate, chilled, constipation, thick dry skin, edema, lethargy, mental sluggishness
  - Goiter is myxedema from lack of iodine
- Cretinism
  - Infant hypothyroidism





# CALCITONIN

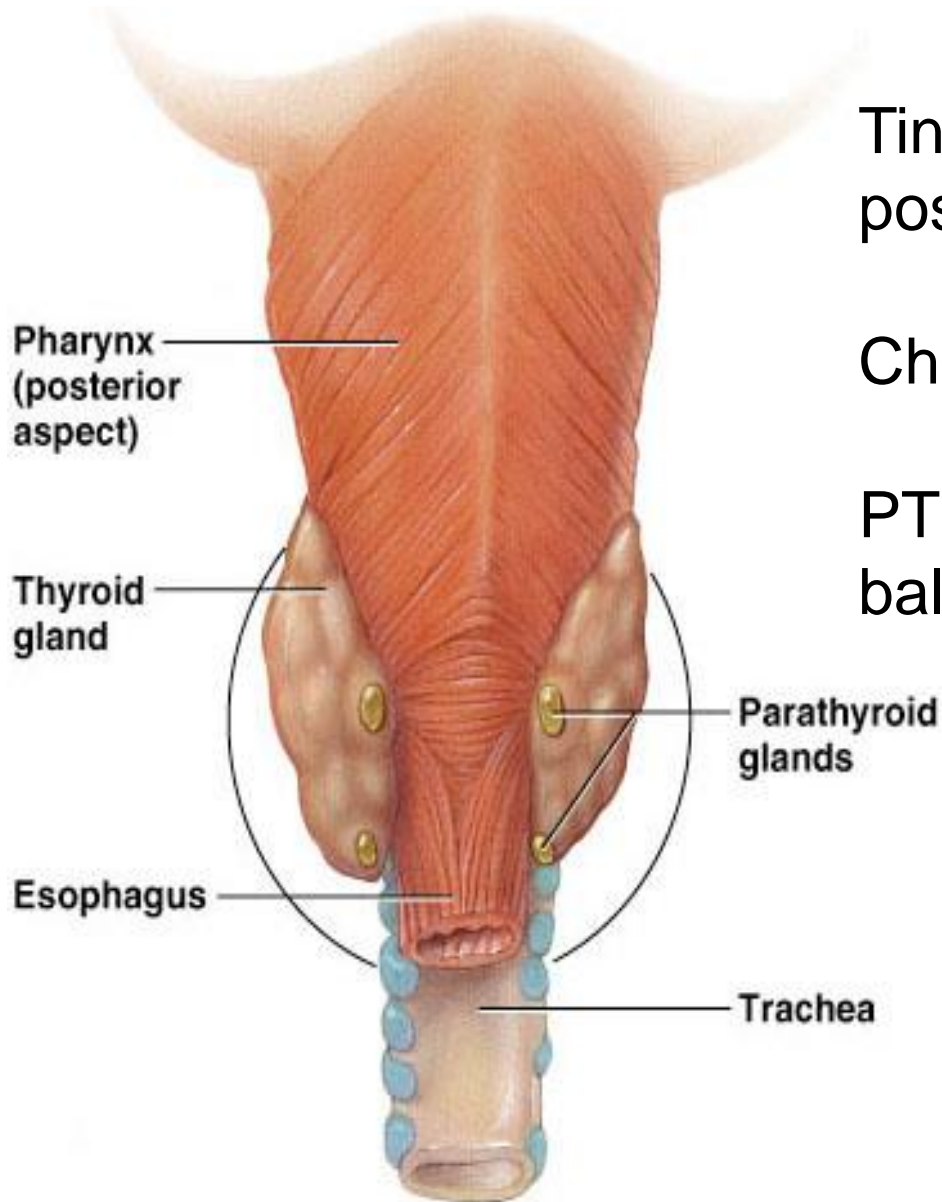
- Helps maintain normal blood levels of calcium and phosphate and helps to maintain a strong bone matrix
- Lowers blood calcium levels in children, when bones are growing
- The stimulus for secretion of calcitonin is hypercalcemia
- Antagonist to parathyroid hormone (PTH)

# PARATHYROID GLANDS

Tiny glands embedded in the posterior aspect of the thyroid

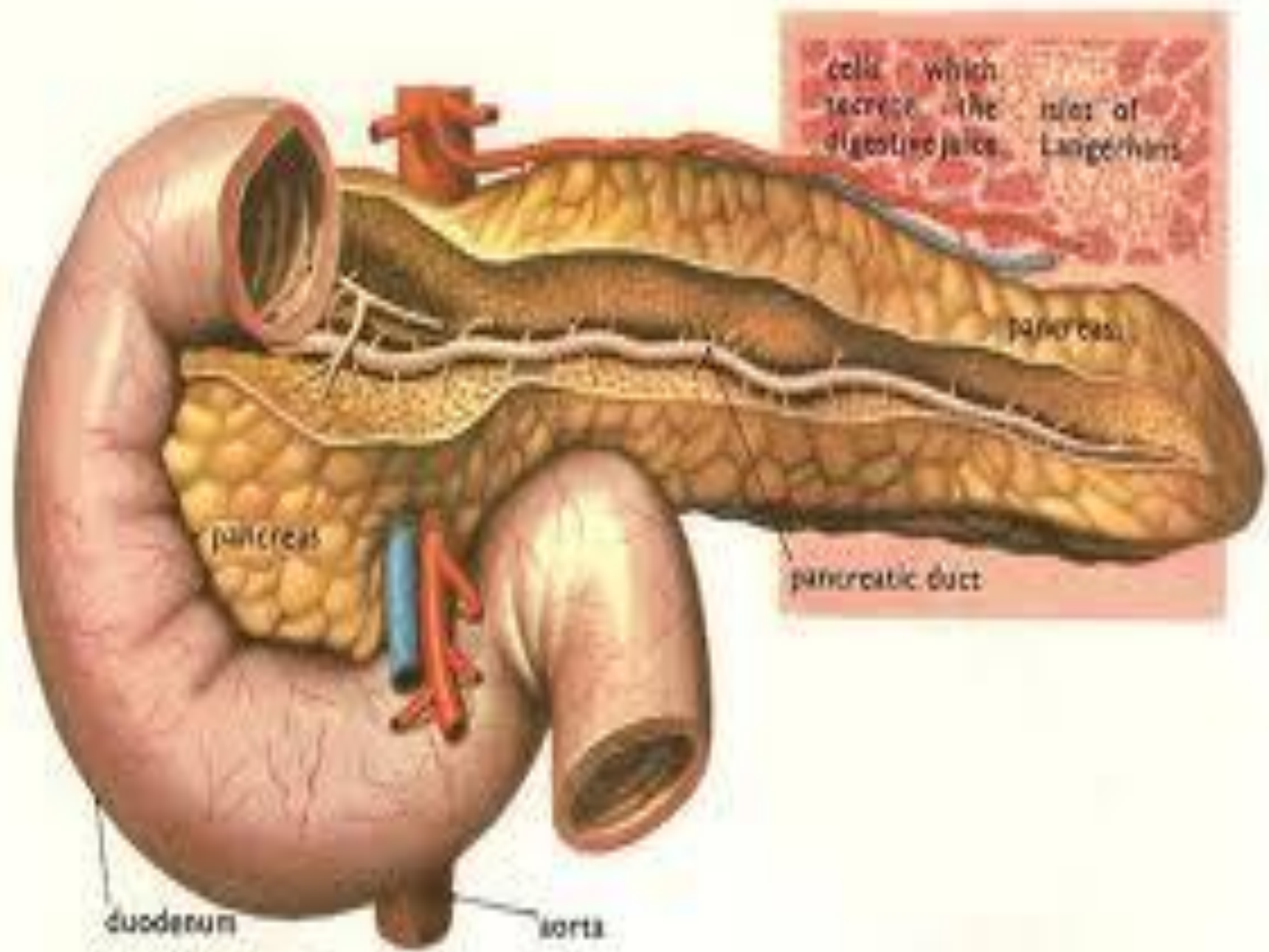
Chief cells secrete PTH

PTH regulates calcium balance in the blood



# PANCREAS

- A triangular gland, which has both exocrine and endocrine cells, located behind the stomach
- Cells produce an enzyme-rich juice used for digestion (exocrine product)
- Pancreatic islets (islets of Langerhans) produce hormones (endocrine products)



cells which secrete the digestive juices

islets of Langerhans

pancreas

pancreas

pancreatic duct

duodenum

aorta

# GLUCAGON

- Its major target is the liver, where it promotes:
  - Glycogenolysis
    - The breakdown of glycogen to glucose
  - Gluconeogenesis
    - Conversion of excess amino acids into simple carbohydrates
- Hypoglycemia stimulate the secretion glucagon

# INSULIN

- Insulin:
  - Lowers blood glucose levels
  - Enhances transport of glucose into body cells
  - Counters metabolic activity that would enhance blood glucose levels

# DIABETES MELLITUS (DM)

- Results from hyposecretion or hypoactivity of insulin
- The three cardinal signs of DM are:
  - Polyuria – huge urine output
  - Polydipsia – excessive thirst
  - Polyphagia – excessive hunger and food consumption
- Hyperinsulinism – excessive insulin secretion, resulting in hypoglycemia

# DIABETES MELLITUS

- Other symptoms include fatigue, diarrhea, visceral symptoms, dizziness and headaches
- Bear in mind that severe consequences of diabetes (especially untreated) is retinopathy and blindness, CAD, renal failure, peripheral neuropathy and vasculopathy resulting in chronic ulceration, gangrene and amputation



# ADRENAL GLANDS

- Adrenal glands – paired, pyramid-shaped organs atop the kidneys
- Also called Suprarenal Glands
- Structurally and functionally, they are two glands in one
  - Adrenal medulla – nervous tissue
  - Adrenal cortex – glandular tissue

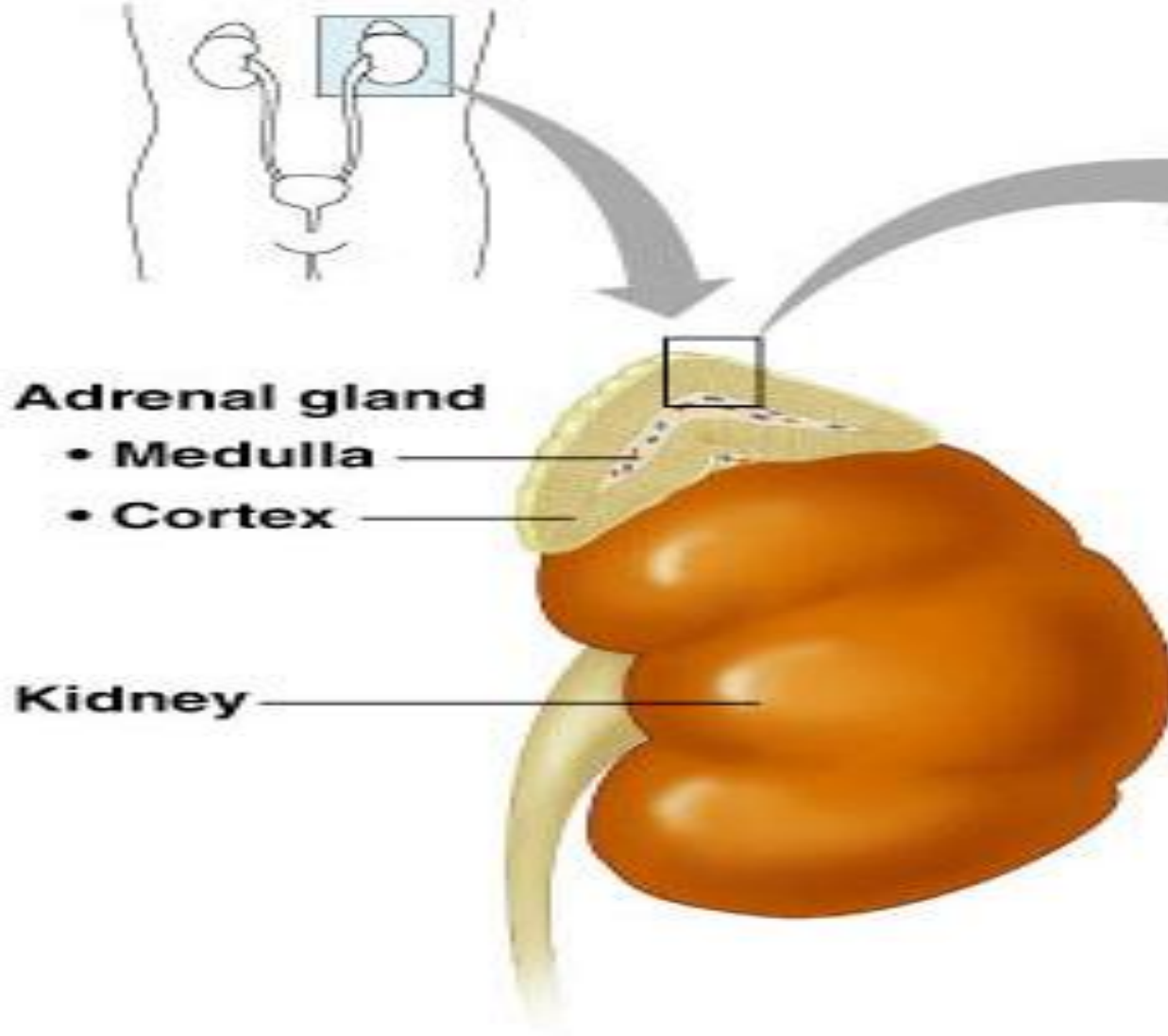
# ADRENAL MEDULLA

- Secretes epinephrine and norepinephrine
  - Epinephrine is the more potent stimulator of the heart and metabolic activities
  - Norepinephrine is more influential on peripheral vasoconstriction and blood pressure
- Secretion of these hormones causes:
  - Blood glucose levels to rise
  - Blood vessels to constrict
  - The heart to beat faster
  - Blood to be diverted to the brain, heart, and skeletal muscle

# ADRENAL CORTEX

- Synthesizes and releases steroid hormones called corticosteroids
- Different corticosteroids are produced in all three layers
  - Mineralocorticoids (chiefly aldosterone)
  - Glucocorticoids (chiefly cortisol)
  - Gonadocorticoids (chiefly androgens)

# ADRENAL CORTEX



# MINERALOCORTICIDS

- Regulate the electrolyte concentrations of extracellular fluids
- Aldosterone – most important mineralocorticoid
  - Maintains Na<sup>+</sup> balance by reducing excretion of sodium from the body
  - Restricts water loss at kidneys, sweat glands, GI tract, and salivary glands

# GLUCOCORTICOIDS (CORTISOL)

- Help the body resist stress by:
  - Keeping blood sugar levels relatively constant
  - Maintaining blood volume and preventing water shift into tissue
- Cortisol provokes:
  - Gluconeogenesis (formation of glucose from noncarbohydrates)
  - Rises in blood glucose, fatty acids, and amino acids



## CUSHING'S DISEASE



- May be caused by a pituitary tumor or by ACTH releasing malignancy of the lungs, pancreas, or kidneys
- Also caused by glucocorticoid drugs
- Characterized by persistent hyperglycemia, loss of bone and muscle protein, water and salt retention, hypertension and edema
- Cushing signs include moon face, fat redistribution on abdomen and neck

# GONADOCORTICOIDS (SEX HORMONES)

- Most gonadocorticoids (male sex hormones), are secreted are androgens
  - The most important one is testosterone
- Androgens contribute to:
  - The onset of puberty
  - The appearance of secondary sex characteristics
  - Sex drive in females
- Androgens can be converted into estrogens after menopause



# GONADS: FEMALE

- Paired ovaries in the abdominopelvic cavity produce estrogens and progesterone
- They are responsible for:
  - Maturation of the reproductive organs
  - Appearance of secondary sexual characteristics
  - Breast development and cyclic changes in the uterine mucosa

# GONADS: MALE

- Testes located in an extra-abdominal sac (scrotum) produce testosterone
- Testosterone:
  - Initiates maturation of male reproductive organs
  - Causes appearance of secondary sexual characteristics and sex drive
  - Is necessary for sperm production
  - Maintains sex organs in their functional state

# PINEAL GLAND

- Small gland hanging from the roof of the third ventricle of the brain
- Secretory product is melatonin
- Melatonin is involved with:
  - Day/night cycles
  - Physiological processes that show rhythmic variations (body temperature, sleep, appetite)

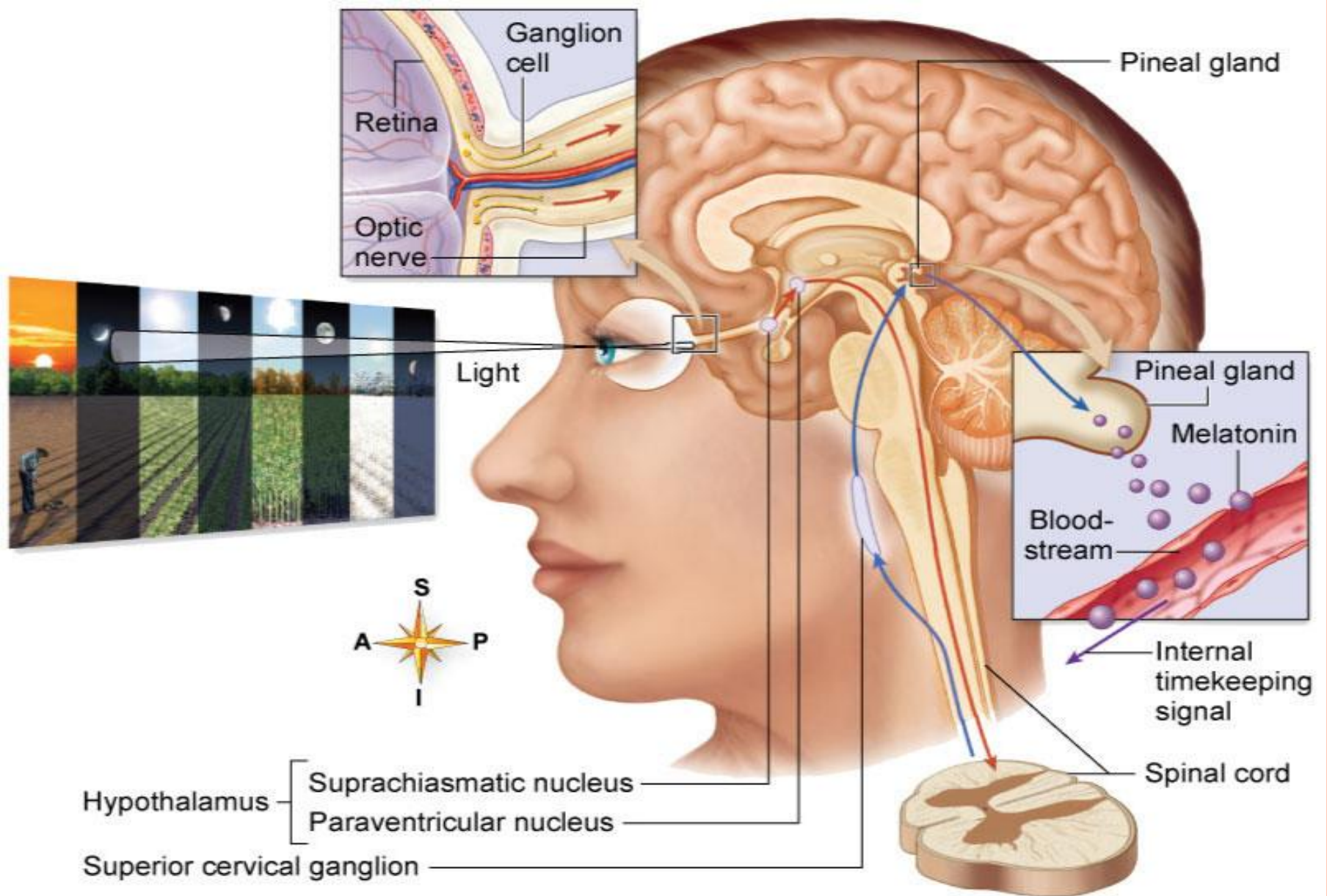


Fig. 13-14. **Role of pineal gland in timekeeping.** Changing external levels of light are detected by special receptors in the retina of the eye, and the information is relayed to the suprachiasmatic nucleus (SCN) of the hypothalamus. When light levels decrease, signals from the SCN increase, triggering the paraventricular nucleus and a pathway of nervous system signals that eventually result in the release of increased amounts of melatonin from the pineal gland. The changing levels of melatonin throughout the day serve as an internal timekeeping signal.