Endocrine
(Function & Assessment)

Williams & Hopper

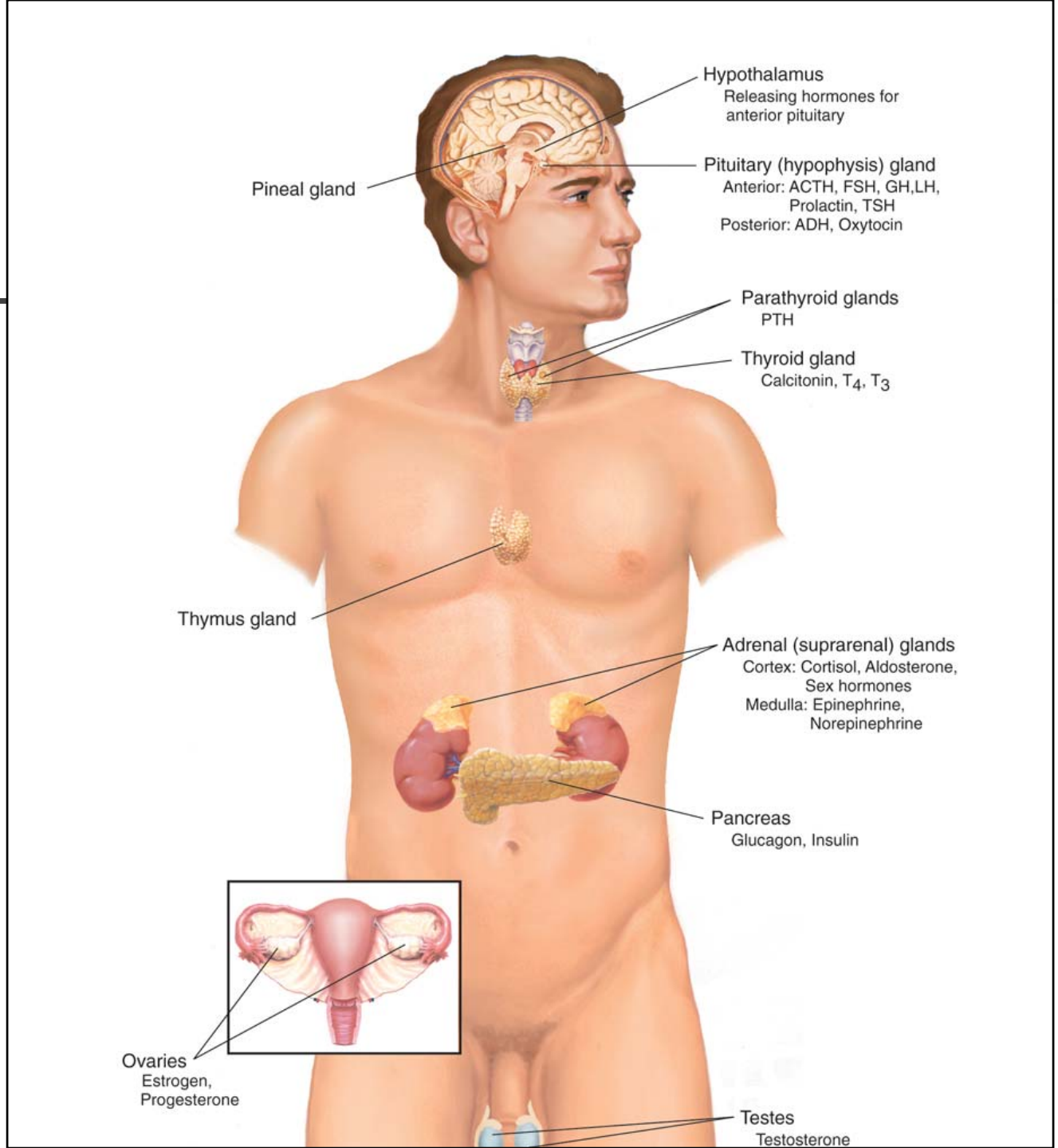
Chapter 38

Normal Anatomy & Physiology

- Consists of ductless (endocrine) glands
- Secrete hormones internally carried through body fluids
  - Regulation of metabolism
    - Growth
    - Energy production
    - Regulation of fluid/electrolyte balance & pH
    - Resistance to stress
    - Reproduction

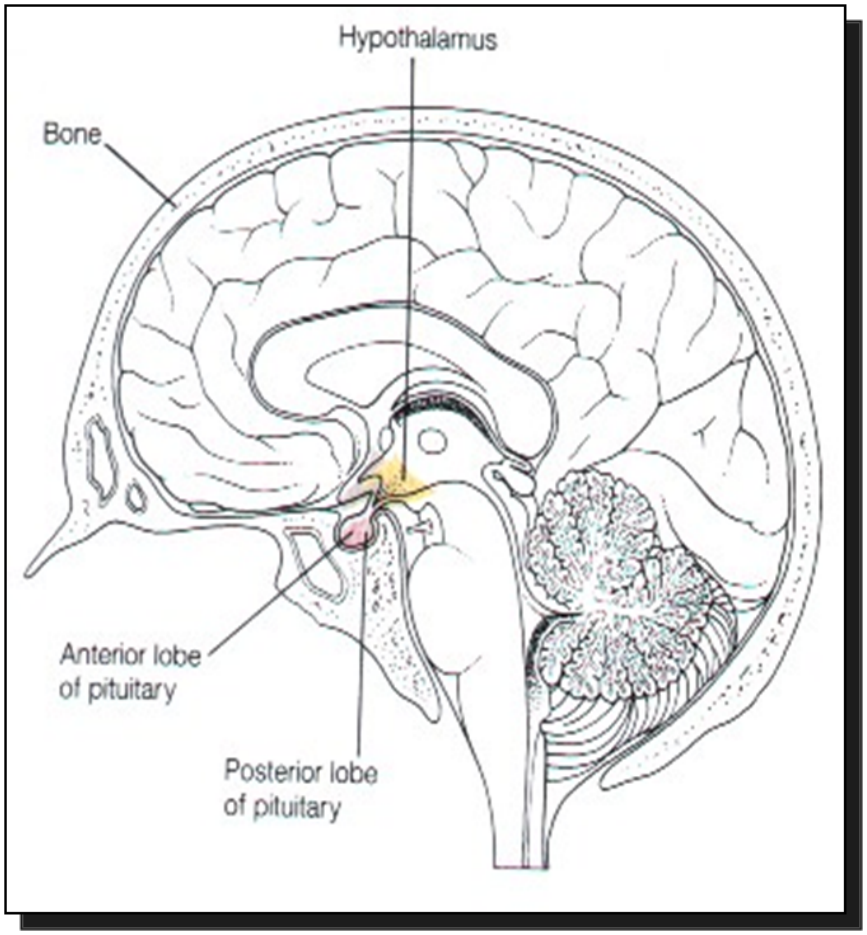
Normal Anatomy & Physiology (cont.)

- Particular stimulus occurs
  - Specific hormone secreted
  - Circulated thru body via blood
  - Exerts effect on specific target tissue
    - Target tissue has specific receptors for that hormone
  - Reversal of stimulus (negative feedback)
  - Decreased secretion of hormone


Hypothalamus
Releasing hormones for anterior pituitary
Pineal gland
Pituitary (hypophysis) gland
Anterior: ACTH, FSH, GH,LH, Prolactin, TSH
Posterior: ADH, Oxytocin
Parathyroid glands
PTH
Thyroid gland
Calcitonin, T_4, T_3
Thymus gland
Adrenal (suprarenal) glands
Cortex: Cortisol, Aldosterone, Sex hormones
Medulla: Epinephrine, Norepinephrine
Pancreas
Glucagon, Insulin
Ovaries
Estrogen, Progesterone
Testes
Testosterone

Normal Anatomy & Physiology
Pituitary Gland

- AKA – hypophysis
- ~1cm or 0.4 inch
- Attached to hypothalamus
- Lies in the sella turcica of the sphenoid bone
- Two major parts
  - Posterior pituitary (neurohypophysis)
  - Anterior pituitary (adenohypophysis)


Hypothalamus
Bone
Anterior lobe
of pituitary
Posterior lobe
of pituitary

Normal Anatomy & Physiology
Posterior Pituitary Gland

- Stores
  - Antidiuretic hormone (ADH)
    - Aka vasopressin
  - Oxytocin
  - Both actually produced by hypothalamus
    - Released by posterior pituitary
      - In response to nerve impulses from the hypothalamus

Normal Anatomy & Physiology
Posterior Pituitary Gland

- ADH
  - ↑ amount of water reabsorbed by kidney
    - Decreases urinary output
    - Reabsorbed into blood
      - Maintains normal blood volume thus normal BP
  - Stimulated by dehydration (↓ H2O content)
    - ↑ concentration
      - Osmoreceptors of hypothalamus are stimulated
      - ADH secreted to ↓ further loss of water in urine

Normal Anatomy & Physiology
Posterior Pituitary Gland

- Oxytocin
  - Causes contractions of smooth muscle of:
    - Uterus
    - Mammary glands
  - Near pregnancy end
    - Cervix stretches
      - Generates sensory impulses to the hypothalamus
      - Transmits impulses to posterior pituitary
        - Release of oxytocin
  - Enhances uterine wall contractions during labor
  - "Milk letdown" reflex

Normal Anatomy & Physiology
Anterior Pituitary (AP) Gland

- "*Releasing*" hormones from hypothalamus
  - Stimulate hormone secretion from AP
- Hormones
  1. Growth hormone
  2. Thyroid-stimulating hormone
  3. Adrenocorticotropic hormone
  4. Prolactin
  5. Follicle-stimulating hormone
  6. Luteinizing hormone

Normal Anatomy & Physiology
Anterior Pituitary (AP) Gland

- Growth hormone (GH) – aka; somatotropin
  - Protein that ↑ cell division
    - In tissues capable of mitosis
  - ↑ transport of amino acids into cells for protein synthesis
  - ↑ release of fat from adipose tissue
    - ↑ use of fats for energy production

Normal Anatomy & Physiology
Anterior Pituitary (AP) Gland

- GH (cont.)
  - Regulated by hypothalamus hormones:
    - Growth hormone-releasing hormone (GHRH)
      - Secreted during hypoglycemia or when high levels of amino acids – needed for protein synthesis
    - Growth hormone-inhibiting hormone (GHIH or somatostatin)
      - Secreted during hyperglycemia
        - When carbohydrates are available for energy production
        - Mobilization of fat is not necessary

Normal Anatomy & Physiology
Anterior Pituitary (AP) Gland

- Thyroid stimulating hormone (TSH)
  - Aka thyrotropin
  - **One target organ – the thyroid**
  - Regulated by thyrotropin releasing hormone (TRH) from hypothalamus
    - In response to ↓ metabolic rate
  - Stimulates production of 2 thyroid hormones
    - Thyroxine (T4)
    - Triiodothyronine (T3)

Normal Anatomy & Physiology
Anterior Pituitary (AP) Gland

- Adrenocorticotropic hormone (ACTH)
  - Regulated by corticotropin-releasing hormone (CRH) from hypothalamus
    - In response to any type of physiological stress
      - Injury
      - Disease
      - Exercise
      - Hypoglycemia
  - Stimulates secretion of cortisol and related hormones from adrenal cortex

Normal Anatomy & Physiology
Anterior Pituitary (AP) Gland

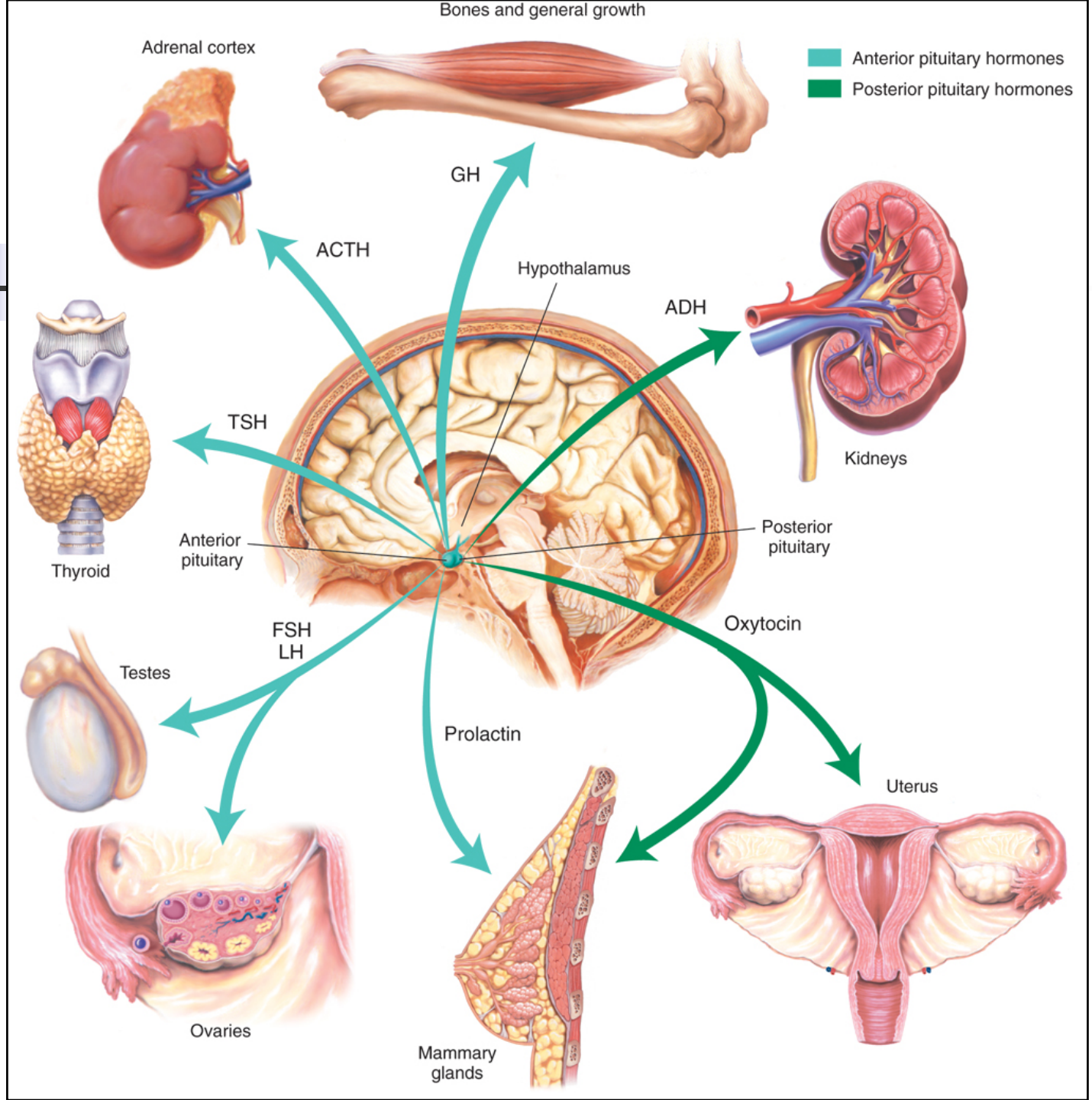
- Prolactin
  - Regulated by prolactin–releasing hormone (PRH) & prolactin–inhibiting hormone (PIH) from hypothalamus
  - Initiates & maintains milk production
  - Secreted post partum
    - In response to ↓ estrogen & progesterone
      - Normally secreted from placenta

Normal Anatomy & Physiology
Anterior Pituitary (AP) Gland

- Follicle-stimulating hormone (FSH)
  - Regulated by
    - gonadotropin-releasing hormone (GnRH) from hypothalamus - ↑ FSH
    - Inhibin from ovaries or testes - ↓ FSH
  - Gonadotropic hormone
    - Targets sex organs – ovaries & testes
  - Women
    - Initiates growth of ova in ovarian follicles
    - Secretion of estrogen by the cells of the follicle\
  - Men
    - Initiates sperm production in testes

Normal Anatomy & Physiology
Anterior Pituitary (AP) Gland

- Luteinizing hormone
  - Regulated by GnRH from hypothalamus
  - Another gonadotropic hormone
  - Women
    - Causes ovulation
    - Stimulates ruptured ovarian follicle
      - Becomes corpus luteum
        - Begin secreting progesterone as well as estogen
  - Men
    - Stimulates secretion of testosterone by testes


Bones and general growth
Adrenal cortex
Anterior pituitary hormones
Posterior pituitary hormones
GH
ACTH
Hypothalamus
ADH
Kidneys
TSH
Thyroid
Anterior pituitary
Posterior pituitary
FSH
LH
Testes
Oxytocin
Prolactin
Uterus
Ovaries
Mammary glands

Normal Anatomy & Physiology
Thyroid Gland

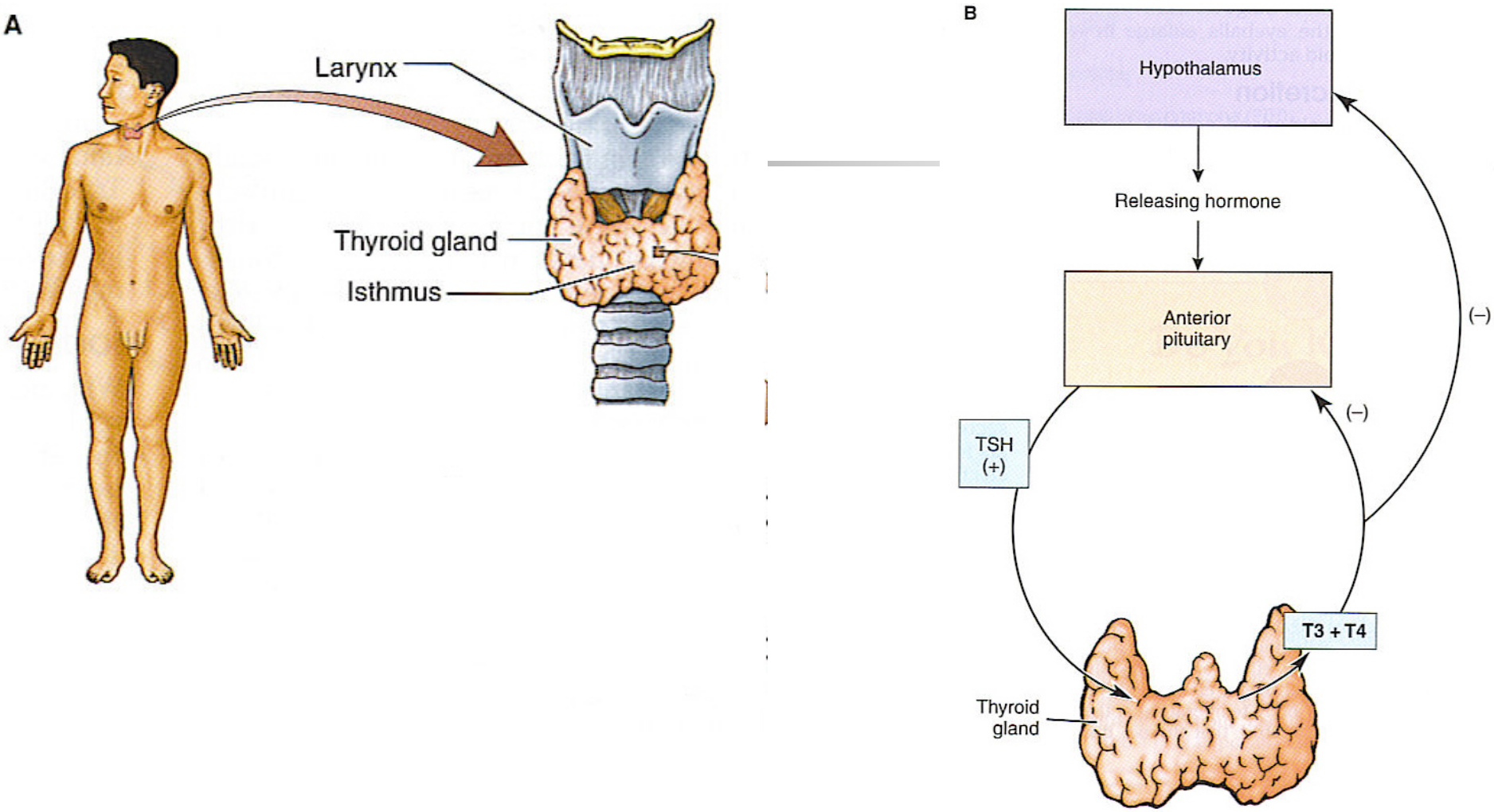
- Consists of 2 lobes
- Connected by isthmus
- Located anteriorly & laterally of trachea
  - Just below larynx
- Secretes 3 hormones
  1. Thyroxine (T4)
  2. Triiodothyronine (T3)
  3. Calcitonin

Normal Anatomy & Physiology
Thyroid Gland

- T4 & T3
  - Regulate metabolic rate
  - Accelerate growth in young persons
  - Stimulate activities of the nervous system

Normal Anatomy & Physiology
Thyroid Gland

- Sequence of events for T3 & 4 secretion
  - Hypothalamus detects a ↓ metabolic rate
    - Secretes TRH
    - TRH stimulates anterior pituitary
      - Secretes TSH
      - Stimulates thyroid to ↑ secretion of T4 & T3
        - ↑ energy production to ↑ metabolic rate
  - Once ↑ metabolic rate
    - Negative feedback ↓ secretion of TRH
      - Metabolic rate ↓ again


A
Larynx
Thyroid gland
Isthmus
B
Hypothalamus
Releasing hormone
Anterior pituitary
(–)
(–)
TSH (+)
T3 + T4
Thyroid gland

Normal Anatomy & Physiology
Thyroid Gland

- Calcitonin
  - Stimulated by hypercalcemia
  - Influences & regulates serum Ca+ level
    - Inhibits rate which Ca+ leaves bones (resorption)
  - Lowers serum calcium
    - Effect directly opposite to the effect of parathyroid hormone (discussed later)

Normal Anatomy & Physiology
Parathyroid Gland

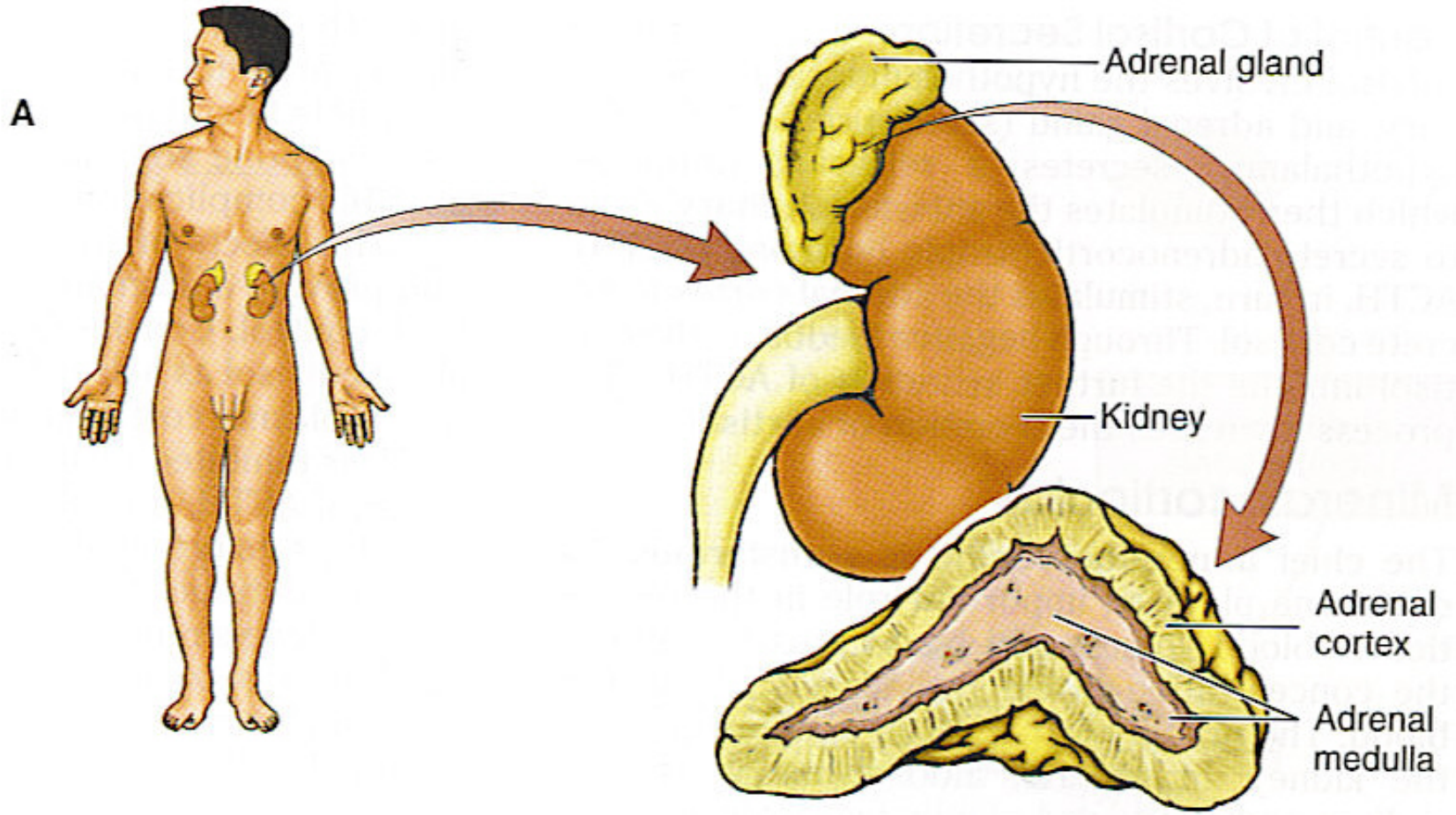
- Four glands located on thyroid gland
  - Two on the back of each lobe
- Secrete parathyroid hormone (PTH)
  - Regulates blood calcium & phosphate levels
    - ↑ blood calcium
    - ↓ blood phosphate
  - Antagonist to calcitonin
- Target tissues
  - Bone
  - Small intestine
  - Kidneys

Normal Anatomy & Physiology
Parathyroid Gland

- Parathyroid hormone (PTH)
  - ↑ **resorption** of calcium & phosphate
    - From bones to blood = ↑ blood levels
  - Activation of vitamin D (calcitriol) in kidneys
    - ↑ absorption of calcium & phosphate from food
      - Small intestine
  - ↑ resorption of calcium by kidneys
    - ↑ excretion of phosphate
  - Overall effect
    - Raise blood calcium, lower blood phosphate

Normal Anatomy & Physiology
Adrenal Gland

- Two suprarenal glands
  - Each located on top of each kidney
  - Embedded in mass of fat that encloses kidney
  - Each gland contains two parts
    - Inner adrenal medulla
    - Outer adrenal cortex


A
Adrenal gland
Kidney
Adrenal cortex
Adrenal medulla

Normal Anatomy & Physiology
Adrenal Medulla

- Contain chromaffin cells
  - Secrete catecholamines
    - Epinephrine & norepinephrine
    - Sympathomimetics (mimic sympathetic NS)
  - Stress
    - Stimulates hypothalamus
      - Sends impulses to adrenal medulla
        - Secretes epinephrine/norepinephrine
        - Able to physiologically to respond to stress

Normal Anatomy & Physiology
Adrenal Medulla

- Epinephrine
  - Secreted in amounts 4x's that of norepinephrine
  - Effects
    - ↑ heart rate & force of contraction
    - Stimulates vasoconstriction in skin & viscera
    - Vasodilatation in skeletal muscles
    - Dilates bronchioles - ↑ breathing rate
    - ↓ peristalsis
    - Stimulates liver to convert glycogen to glucose
      - Rise in blood sugar
    - ↑ use of fats for energy
    - ↑ rate of cell respiration

Normal Anatomy & Physiology
Adrenal Medulla

- Norepinephrine
  - Causes vasoconstriction of skin and viscera.
    - Thereby ↑ BP

Normal Anatomy & Physiology
Adrenal Medulla

Catecholamine Comparison:

Epinephrine	Norepinephrine
Blood pressure increases due to increased cardiac output and vasoconstriction in certain regions	Blood pressure increases due to generalized vasoconstriction
Rate of glycogen breakdown into glucose increases, so level of blood glucose rises	Same effect, but to a lesser degree
Rate of fatty acid release from fat increases, so level of blood fatty acids rises	Same effect, but to a lesser degree
Release of ACTH and TSH from anterior pituitary gland increases	No effect

Normal Anatomy & Physiology
Adrenal Cortex

- Secretes 3 types of steroid hormones
  1. Mineralocorticoids
     - Helps regulate concentration of extracellular electrolytes
  2. Glucocorticoids
     - Influence metabolism of carbohydrates, proteins & fats
  3. Sex hormones
     - Effects on sexual characteristics

Normal Anatomy & Physiology
Adrenal Cortex

- Sex Hormones
  - Primarily male
    - Adrenal androgens
  - Small amount female
    - Estrogens
  - Function
    - Not clear
      - May supplement the supply of sex hormones from gonads
      - Some evidence plays a role in adult female sex drive

Normal Anatomy & Physiology
Adrenal Cortex

- Mineralocorticoids
  - Aldosterone
    - Most abundant
    - Targets kidneys
      - Reabsorbs Na+ ions – returns to blood
      - Excretes K+ ions – eliminated in urine
  - Controls occurrence of acidosis
    - As NA+ absorbed ⇨ H+ excreted
    - As Na+ reabsorbed ⇨ H2O & bicarb follow
      - Returned to blood

Normal Anatomy & Physiology

Adrenal Cortex

Mineralocorticoids (cont.)

- Low BP (Stimulant)
- Activates renin-angiotensin mechanism
  - Formation of angiotensin II
    - ↑ secretion of aldosterone
- Inhibition of aldosterone
  - Atrial natriutetic peptide (ANP) - secreted by atria
    - BP or blood volume ↑
      - Promotes kidney excretion of Na+ & water

Normal Anatomy & Physiology
Adrenal Cortex

- Glucocorticoids
  - Cortisol
    - Stimulates liver to change glucose to glycogen (for storage)
    - ↑ conversion of excess amino acids to carbohydrates – *gluconeogenesis*

Normal Anatomy & Physiology
Adrenal Cortex

- Cortisol (cont.)
  - Anti-inflammatory effect
    - Blocks effects of histamine and stabilizes the lysosomes within cells
  - Normal secretion
    - Limits the inflammation process to;
      - Tissue repair
      - Prevent excessive tissue destruction
  - Excess secretion
    - Damaging effects
      - ↓ immune response
      - Delays healing of damaged tissue.
      - Increased blood glucose

Normal Anatomy & Physiology
Adrenal Cortex

- Cortisol (cont.)
  - Stimulus for secretion
    - ACTH from anterior pituitary
    - Response to stress (injury, dx, malnutrition, etc)
      - Stimulates hypothalamus to secrete corticotropin-releasing hormone (CRH)
      - CRH increases the secretion of ACTH by anterior pituitary
        - Increases cortisol secretion by adrenal cortex

Normal Anatomy & Physiology
Pancreas

Extends from duodenal curve to spleen

- *Endocrine* & exocrine gland
- Endocrine – *islets of Langerhans*
  - Consists of cells arranged in clusters
    - Closely associated with blood vessels
    - Alpha – secrete glucagon
    - Beta – secrete insulin
    - Delta – secrete somatostatin
      - Inhibits both insulin & glucagon

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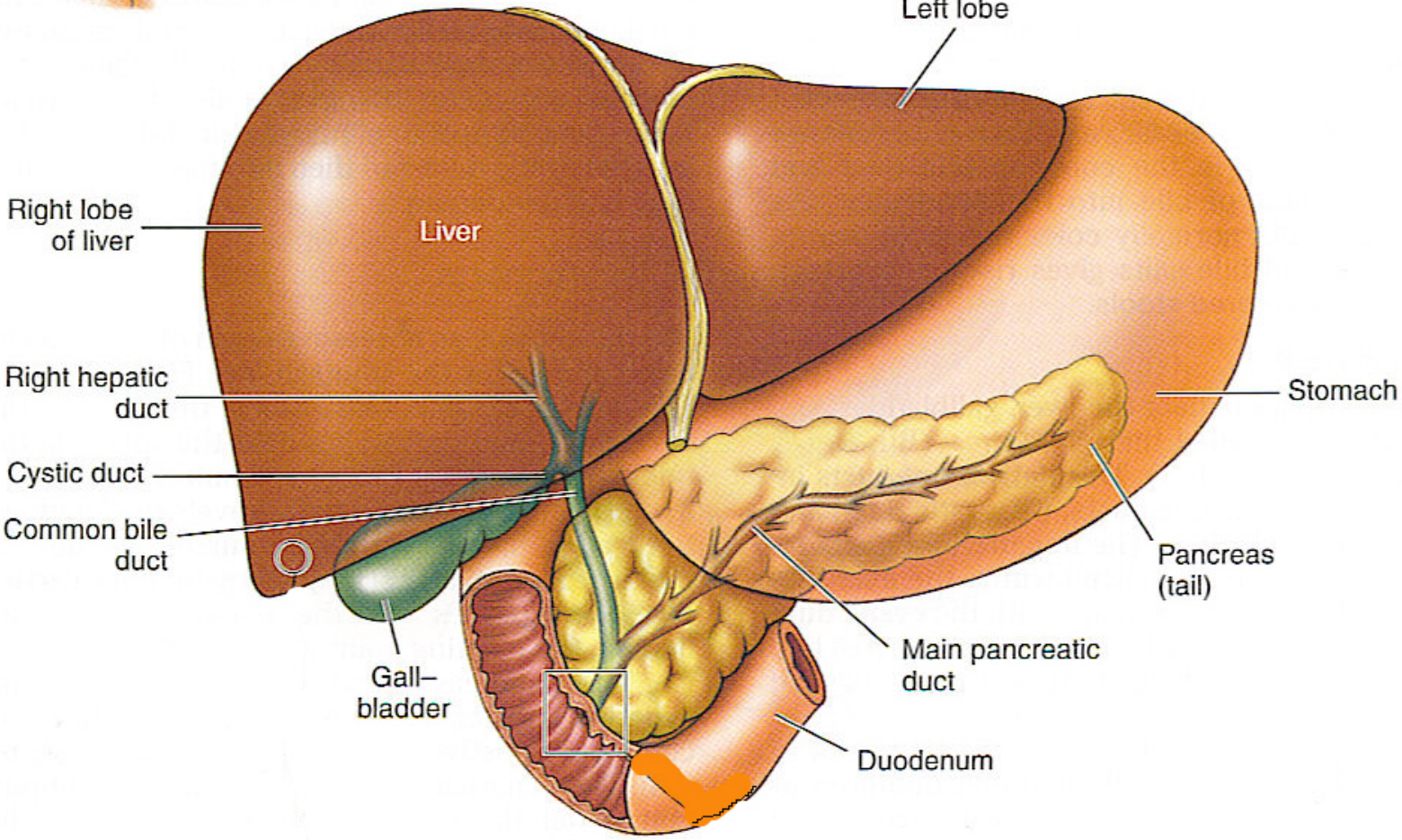
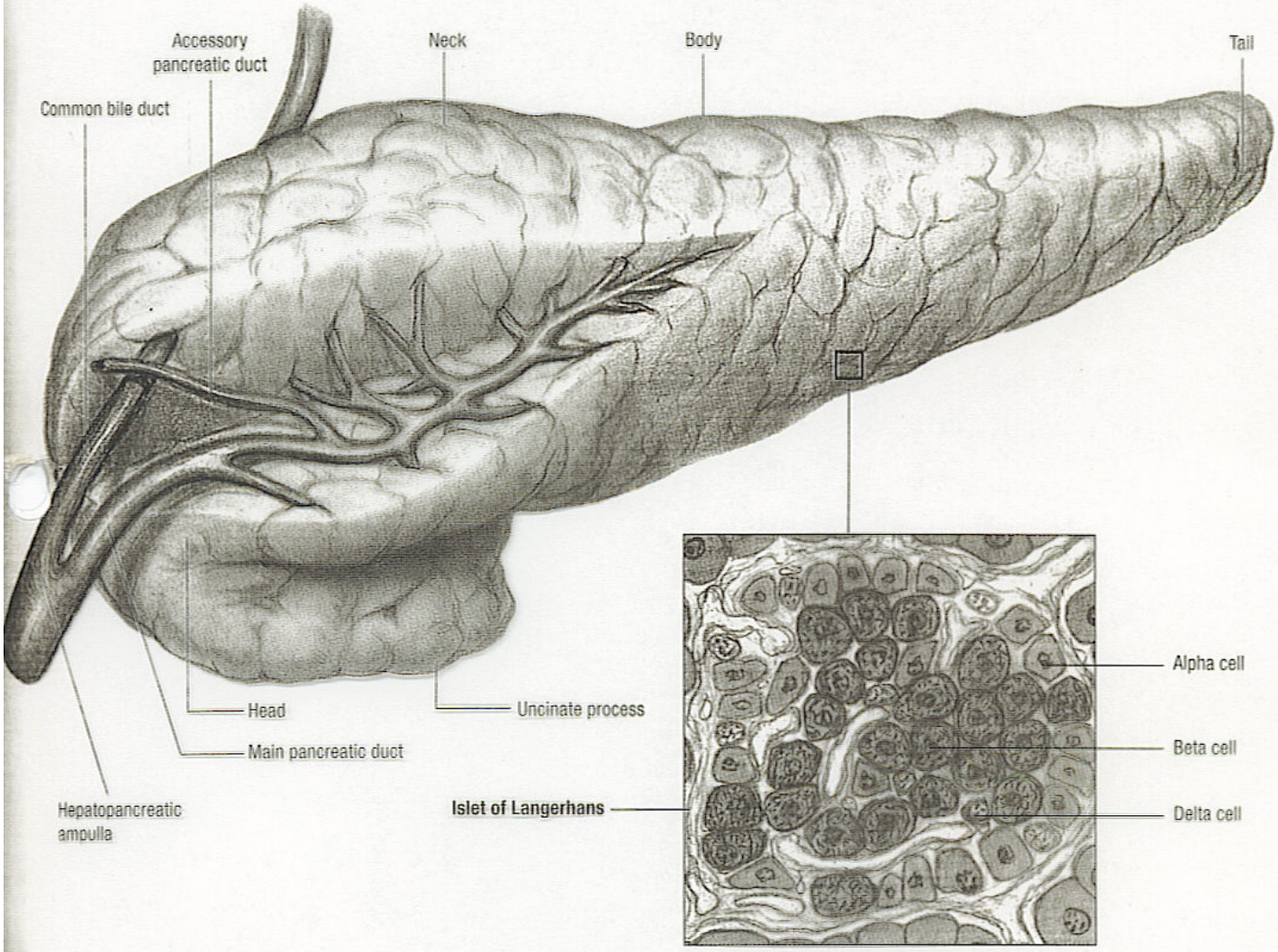

Left lobe
Right lobe of liver
Liver
Right hepatic duct
Cystic duct
Common bile duct
Stomach
Pancreas (tail)
Main pancreatic duct
Gall–bladder
Duodenum

C

PANCREAS



Microscopic view

Normal Anatomy & Physiology
Pancreas

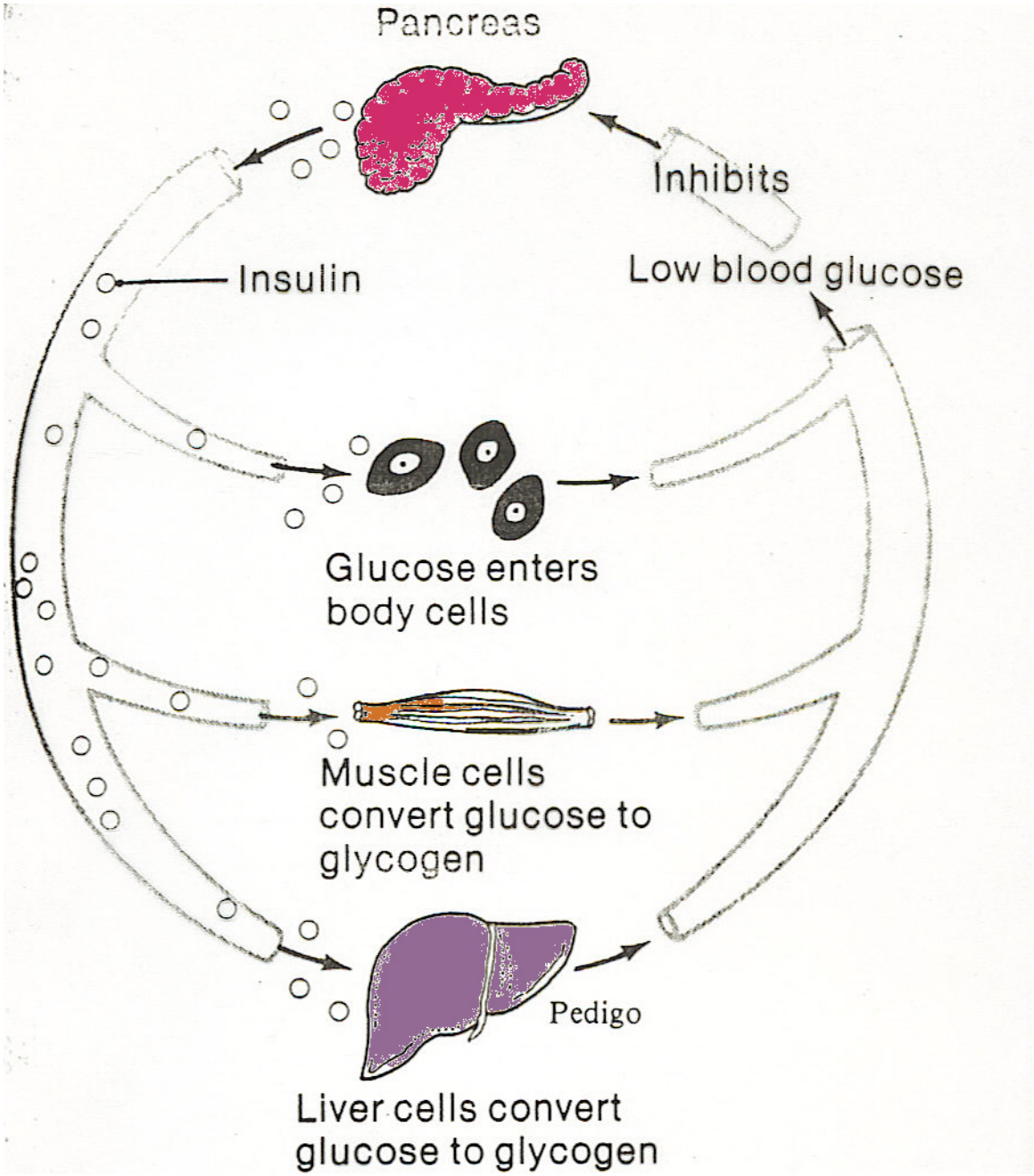
- Glucagon
  - Stimulates glycogenolysis
    - Conversion of glycogen to glucose
  - Energy production
    - ↑ use of fats and amino acids
  - Overall effect
    - ↑ blood glucose
    - ↑ availability of cellular nutrients

Normal Anatomy & Physiology
Pancreas

- Insulin
  - Action exactly opposite of glucagon
  - ↓ blood sugar level
  - ↑ transport of glucose from the blood into cells (increases membrane permeability)
    - Breakdown of glucose in cells
      - Releases energy
    - Occurs in all cells, except brain & liver cells

Normal Anatomy & Physiology
Pancreas

- Insulin (cont.)
  - Stimulates liver & muscles
    - Change glucose to glycogen for later use
      - ***Glycogenesis***
  - Enhances the synthesis of proteins & fats
    - From fatty acids and amino acids
  - Secretion stimulated by hyperglycemia
    - i.e., after meals


Pancreas
Inhibits
Insulin
Low blood glucose
Glucose enters body cells
Muscle cells convert glucose to glycogen
Pedigo
Liver cells convert glucose to glycogen

The Aging Endocrine System

- ↓ endocrine secretion
  - Without serious hormonal deficiency
  - Functions adequately to maintain homeostasis

Assessment of the Endocrine System – Health History

- Specific complaints
  - Cause suspicion of specific endocrine problem
    - Tiredness
    - Muscle spasm
    - Losing weight
    - Excessive thirst
    - Trouble w/memory
    - Family history

Assessment of the Endocrine System – Physical Exam

- Specific physical findings
  - Inappropriate affect
  - Weight change
  - Poor skin turgor
  - Temperature/pulse Δ
  - ↑ or ↓ BP
  - Tremor
  - Exophthalmos
  - Fat pads on neck/shoulders
  - thyromegally

Assessment of the Endocrine System – Physical Exam

- Inspection
  - Observe for mood/affect
  - Neck
  - Exophthalmos
  - Note posture, distribution of body fat
    - Moonlike face or "buffalo hump"
  - Presence of tremor
  - Skin/hair texture/distribution, moisture
  - Color Δ's in extremities

Assessment of the Endocrine System – Physical Exam

- Palpation
  - Thyroid gland
    - Never w/uncontrolled hyperthyroidism
      - May stimulate additional thyroid hormone secretion
  - Peripheral pulses
    - May be ↓ w/circulatory impairment
  - Skin turgor
    - Dehydration

Assessment of the Endocrine System – Diagnostic Tests

1. Serum hormone tests
   - Useful in diagnosing ↓ or ↑ in functioning
2. Stimulation tests
3. Suppression tests
4. Urine tests
5. Specific lab testing
6. Nuclear scanning (thyroid)
7. Radiographic testing