

Fundamentals of
Anatomy & Physiology
SIXTH EDITION

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The Endocrine System

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Endocrine system

- Includes all cells and endocrine tissues that produce hormones or paracrine factors

The Endocrine System

- **Hormones control several major processes**
 - **Reproduction**
 - **Growth and development**
 - **Mobilization of body defenses: against stressors**
 - **Maintenance of much of homeostasis**
 - **Regulation of metabolism**
- **The primary responsibility of the endocrine system is regulation of the body processes for relatively long periods of time**
- **Although some endocrine responses may occur in seconds**
 - **i.e. action of epinephrine from the adrenal glands**
 - **most are slow in onset**
 - **requiring hours or days and long in duration**

The Endocrine System

- Includes: pituitary, pineal, thyroid, parathyroids, thymus, pancreas, adrenals, ovaries, and testes
- Ductless endocrine glands secrete hormones directly into blood, which circulates to target cells in body
 - e.g., thyroid gland
- Exocrine Glands
 - Example: sweat glands
 - Secrete substances through ducts

Endocrine and Exocrine Glands

- **Example: pancreas**
 - Releases pancreatic enzymes through a duct into duodenum
 - Releases insulin directly into bloodstream
- **Indirect-Acting Hormones**
 - Also called tropic hormones
 - Secreted by one gland and target another
 - (TSH) Thyroid Stimulating Hormone
 - is secreted by pituitary
 - stimulates target cells in thyroid gland to release thyroid hormones

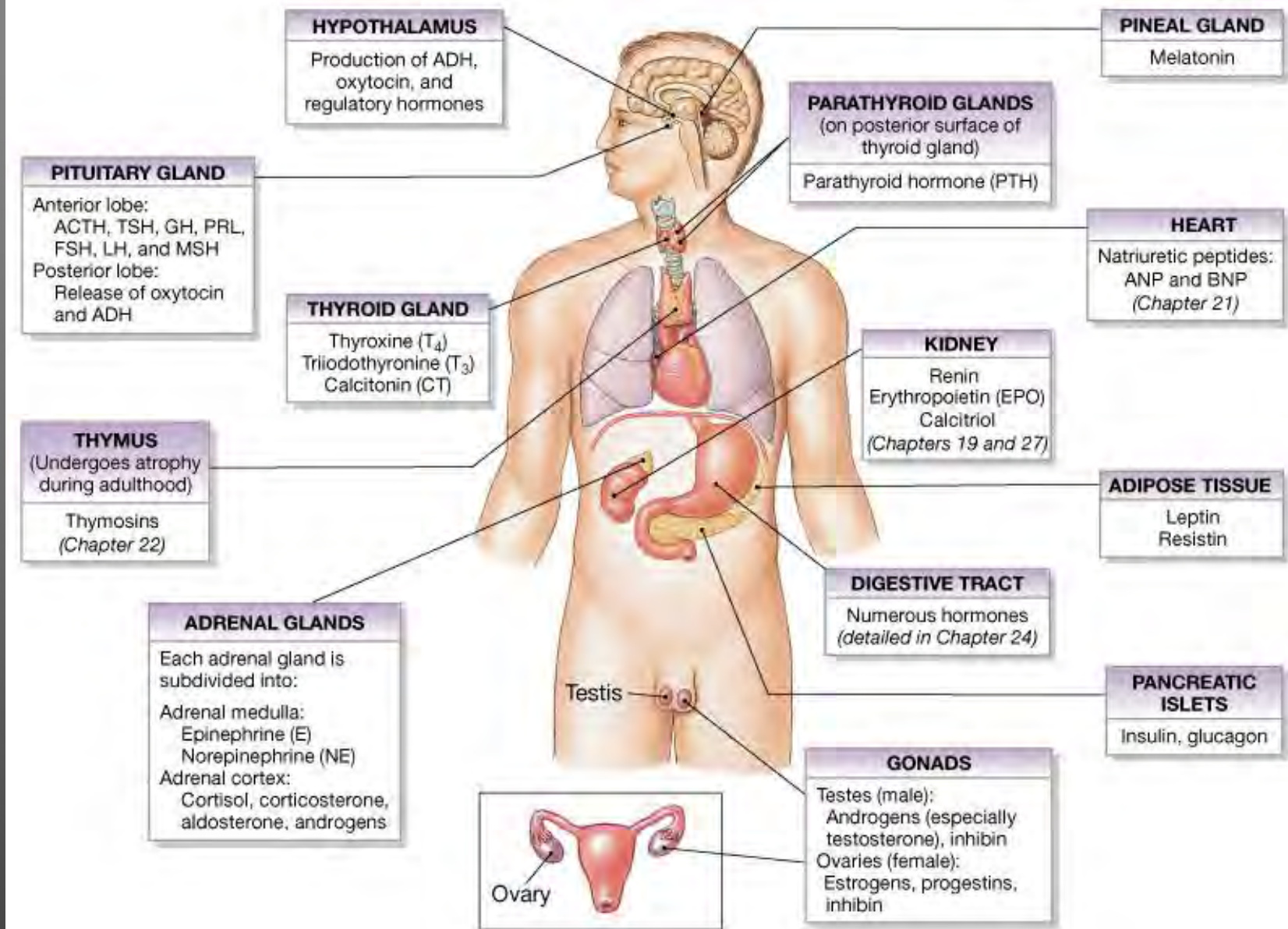
Terminology

- **Target Cells:** In order for a target cell to respond to a hormone, specific protein receptors must be present on its plasma membrane or its interior to which that hormone can attach.
 - Binding needs to occur for that hormone to influence workings of a cell
 - The key to the incredible power of the endocrine glands is the hormones they produce and secrete.
- **Target Organs:** organs that respond to the affects of a hormone
- **Receptors/Receptor Sites:** proteins or membrane regions that recognize the hormone that stimulates them
- **Recognition:** is a function of the matching of the surface configuration of the hormone and the shape of the receptor
- Receptors may be on the cell membrane or molecules inside the cells of the target organ
- Receptors are important since as the hormone move through the body via the blood every cell is potentially exposed to the hormone
 - Cells with proper receptor only are affected

Direct Acting Hormones

- Hormones that have a specific local effect
- Example: insulin
- Pancreas releases insulin specifically to affect the level of glucose in the blood

Figure 18.1 The Endocrine System



Mechanisms of Hormone Action

- Hormones affect only certain tissues or organs
 - target cells or organs
- Target cells must have specific protein receptors
- Hormone binding influences the working of the cells
- In order for a target cell to respond to a hormone - specific protein receptors must be present on its plasma membrane or its interior to which that hormone can attach
- Only when the binding occurs can the hormones influence the workings of a cell
- They arouse or bring about their effects on the body's cells primarily by altering cellular activity that is by increasing or decreasing the rate of a normal or usual metabolic process rather than by stimulating a new one.
- The precise changes that follow hormone binding depends on the specific hormone and the target cell type

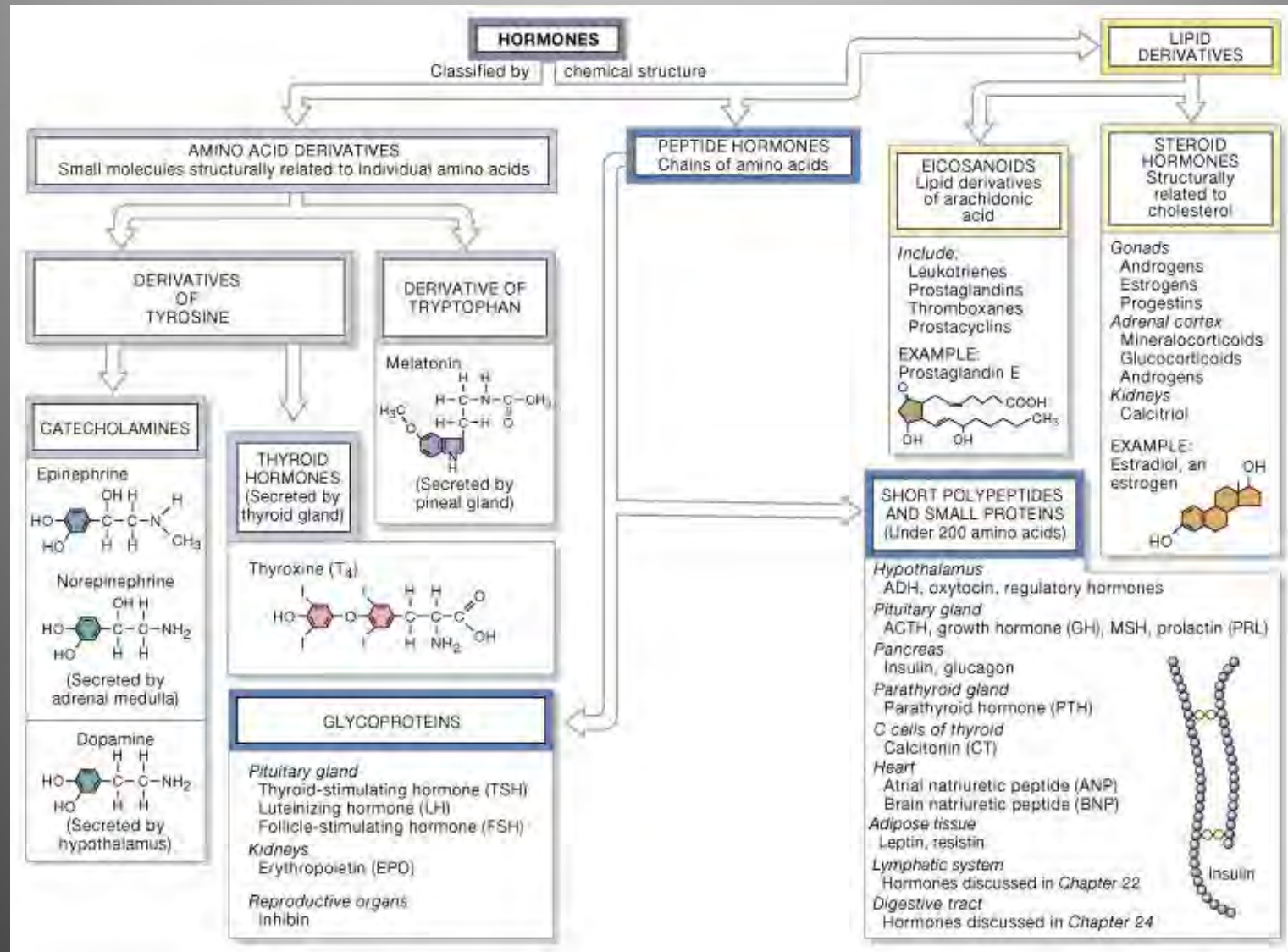
Mechanisms of Hormone Action

- Receptors for catecholamines, peptide hormones, eicosanoids are in the cell membranes of target cells
- Thyroid and steroid hormones cross the membrane and bind to receptors in the cytoplasm or nucleus

Hormone structure

- Amino acid derivatives
 - Structurally similar to amino acids
- Peptide hormones
 - Chains of amino acids
- Lipid derivatives
 - Steroid hormones and eicosanoids

Figure 18.2 A Structural Classification of Hormones



Hormones can be

- Freely circulating
 - Rapidly removed from bloodstream
- Bound to transport proteins

Figure 18.3 G Proteins and Hormone Activity

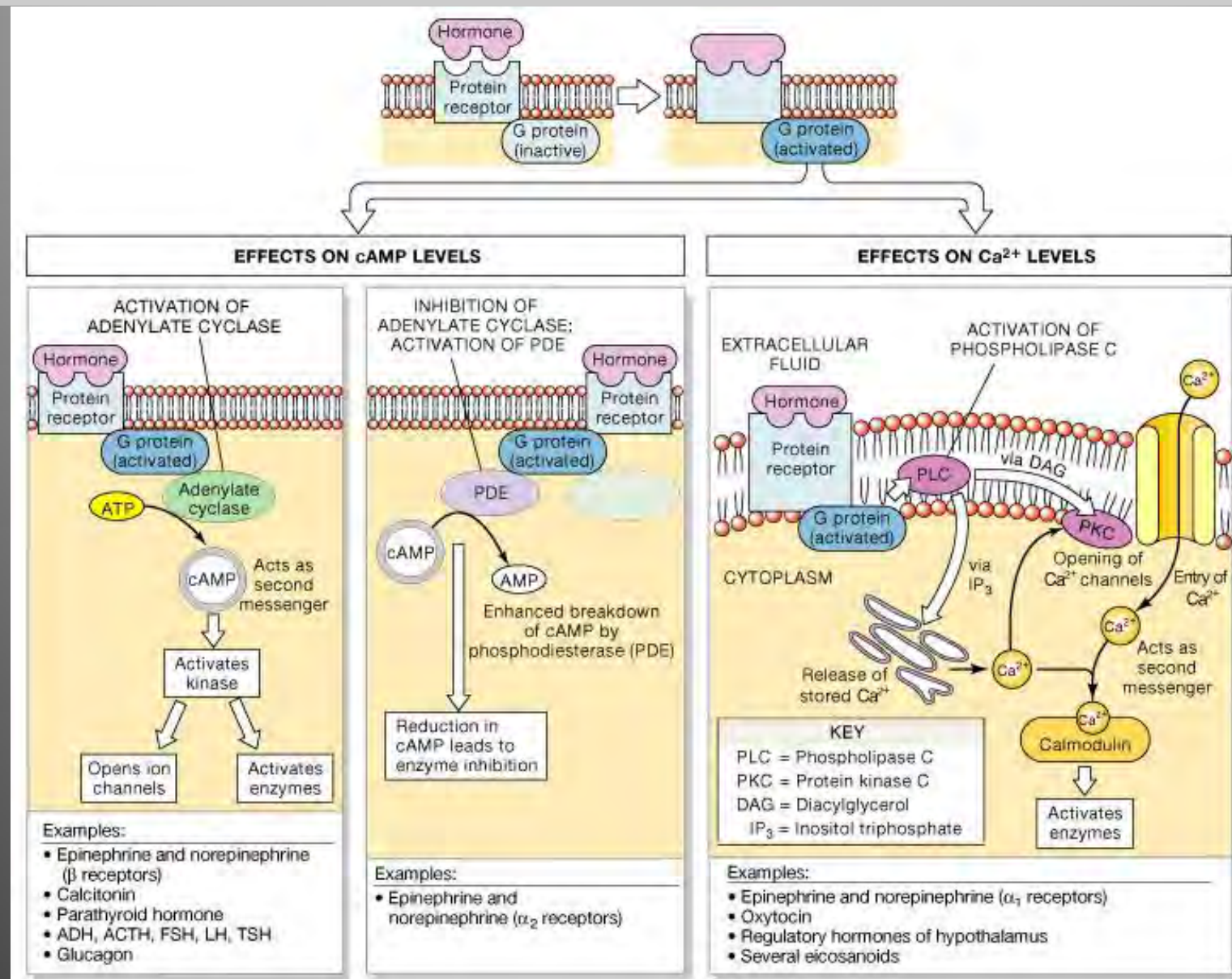
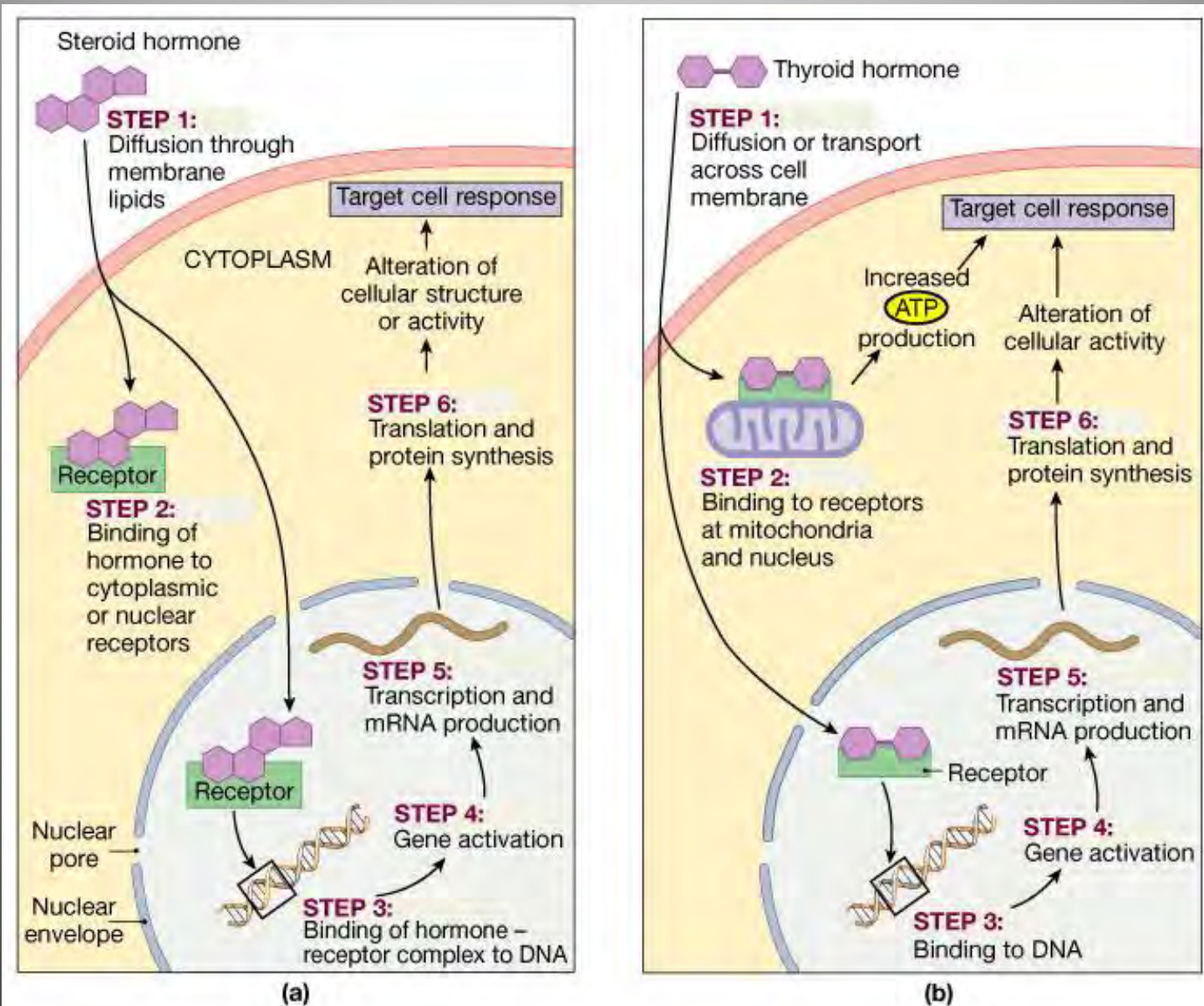


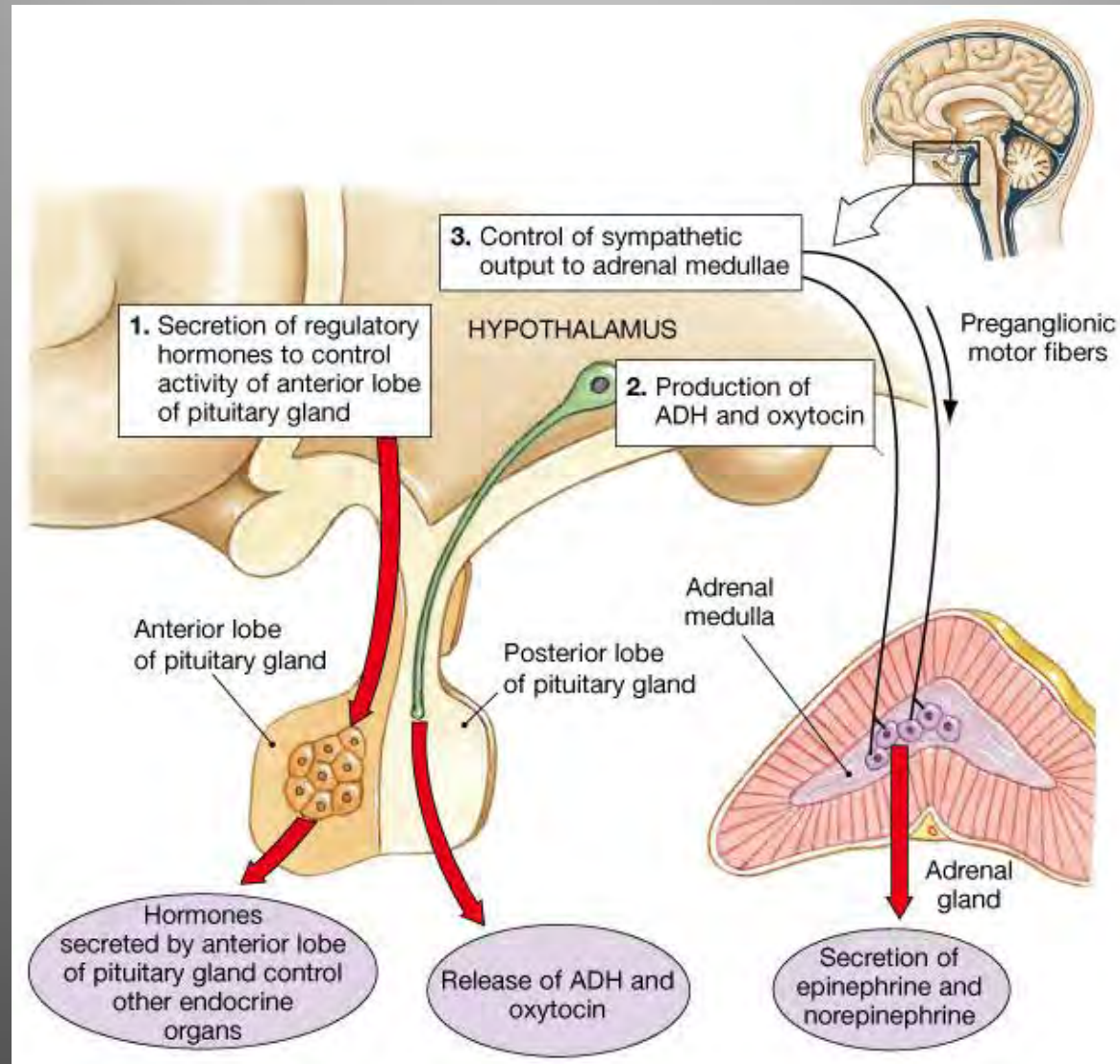
Figure 18.4 Hormone Effects on Gene Activity



Control of Endocrine Activity

- Endocrine reflexes are the counterparts of neural reflexes
- Hypothalamus regulates the activity of the nervous and endocrine systems
 - Secreting regulatory hormones that control the anterior pituitary gland
 - Releasing hormones at the posterior pituitary gland
 - Exerts direct neural control over the endocrine cells of the adrenal medullae

Figure 18.5 Three Methods of Hypothalamic Control over the Endocrine System



Control of Hormone Release

- Hormone levels in the blood are maintained by negative feedback
- A stimulus or low hormone levels in the blood triggers the release of more hormone
- Hormone release stops once an appropriate level in the blood is reached
- In such systems hormone secretion is triggered by some internal or external stimulus then rising hormone levels inhibit further hormone release even while promoting responses in their target organs
 - As a result blood levels of many hormones vary only within a very narrow range
- Negative Feedback: mechanisms are the chief means of regulating blood levels of nearly all hormones

Effects Caused by Hormones

- Changes in plasma membrane permeability or electrical state
- Synthesis of proteins or certain regulatory molecules such as enzymes in the cell
 - Activation or inactivation of enzymes
 - Stimulation of mitosis
- Despite the huge variety of hormones there are really only two mechanisms by which hormones trigger changes in the cells.
- The total weight of the endocrine glands is less than half a pound but they exert a very powerful influence over the regulation of the body systems –
 - the slightest change in hormonal levels can upset the metabolic balance of the body

Hormonal Stimuli of Endocrine Glands

- ***Endocrine glands are activated by other hormones***

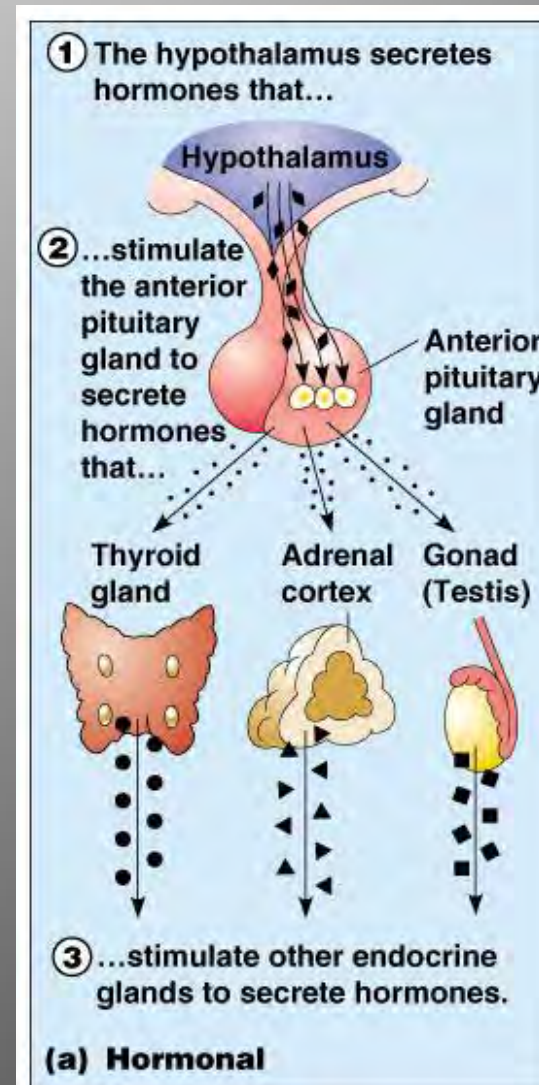


Figure 9.2a

Humoral Stimuli

- Chemicals other than hormones can trigger hormone release
 - Example: a decrease in serum calcium triggers the release of parathyroid hormone – PTH
 - Changing blood levels of certain ions and nutrients may also stimulate hormone release
 - Ex. Calcitonin – by thyroid gland
 - Insulin – produced by pancreas
- From the parathyroid gland which causes metabolic changes in bone, small intestine and kidney tubule cells,
 - thus releasing calcium into circulation
 - When serum calcium levels reach normal, parathyroid hormone is inhibited
 - Another example: A decrease in renal blood flow triggers the release of aldosterone from the adrenal cortex, which reduces excretion of water thus maintaining or increasing blood volume

Humoral Stimuli of Endocrine Glands

- *Changing blood levels of certain ions stimulate hormone release*
- *The term humoral refers to the ancient use of humor to indicate the various body fluids blood, bile and others*

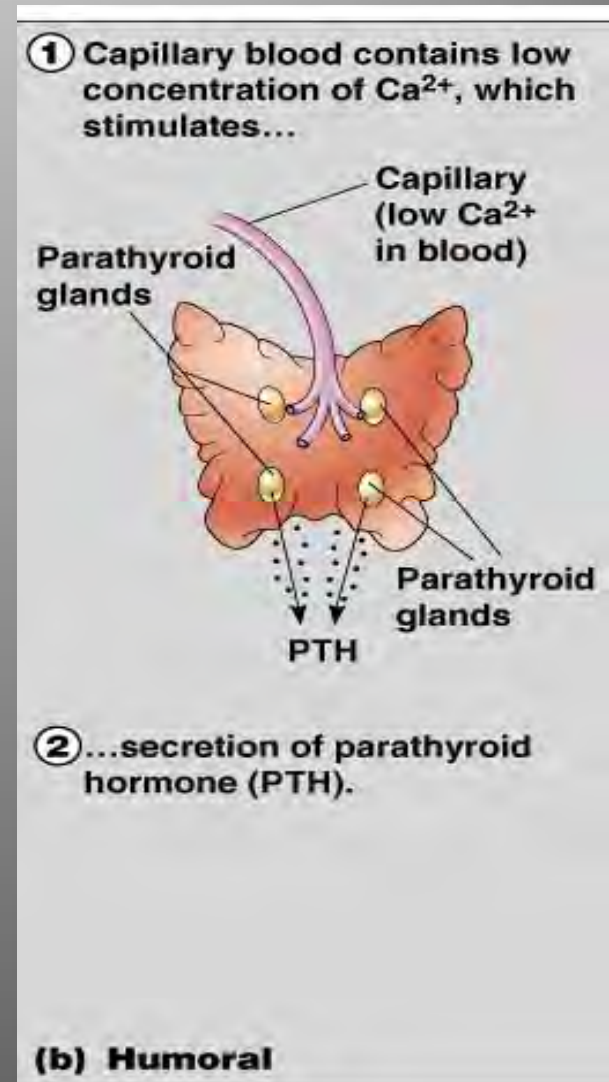


Figure 9.2b

Neural Stimuli of Endocrine Glands

- ***Nerve impulses stimulate hormone release***
- ***Most are under control of the sympathetic nervous system***

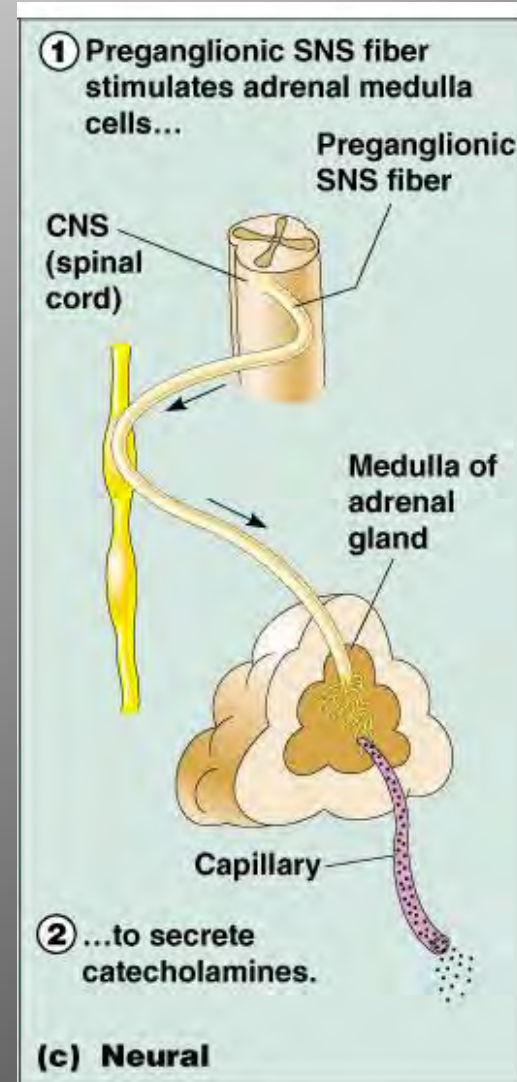


Figure 9.2c

Hormonal Stimuli

- The most common in which endocrine organs are prodded into action by other hormones
- Negative feedback system: decrease in available or circulating hormone signals the hypothalamus to produce the HRH(hormone releasing factor)
 - which causes the APG to release the corresponding tropic (regulating) hormone:
 - which in turn signals the target endocrine gland t to release the regulatory hormone to release the hormone.
 - as the hormones produced by the final target endocrine glands to secrete its hormone
 - when circulatory hormone levels reach normal the hypothalamus releases hormone inhibiting factors that shut-off tropic hormone release from the APG
 - hormone release by this mechanism tends to be rhythmic with hormone levels rising and falling again and again
 - because thee is such a wide range in onset and duration of action among the various hormones

The Pituitary Gland

Pituitary - Hypothalamus Relationship

- Release of hormones is controlled by releasing and inhibiting hormones produced by the hypothalamus
- Hypothalamus produces two hormones that are transported to neurosecretory cells of the posterior pituitary
 - Oxytocin and ADH

Hypothalamus

- **Lies beneath the thalamus**
 - **Located at base of brain; is command center for autonomic nervous system, influencing involuntary activities**
 - **Joined to pituitary by nerve fibers and blood vessels**
- **Even though it is insignificant in size:**
 - **Plays a vital role in the control of body**
 - **temperature**
 - **fluid balance**
 - **appetite**
 - **certain emotions such as fear, pleasure and pain**
- **Both the sympathetic and parasympathetic divisions are under the control of the hypothalamus as well as the pituitary gland**

The Pituitary Gland

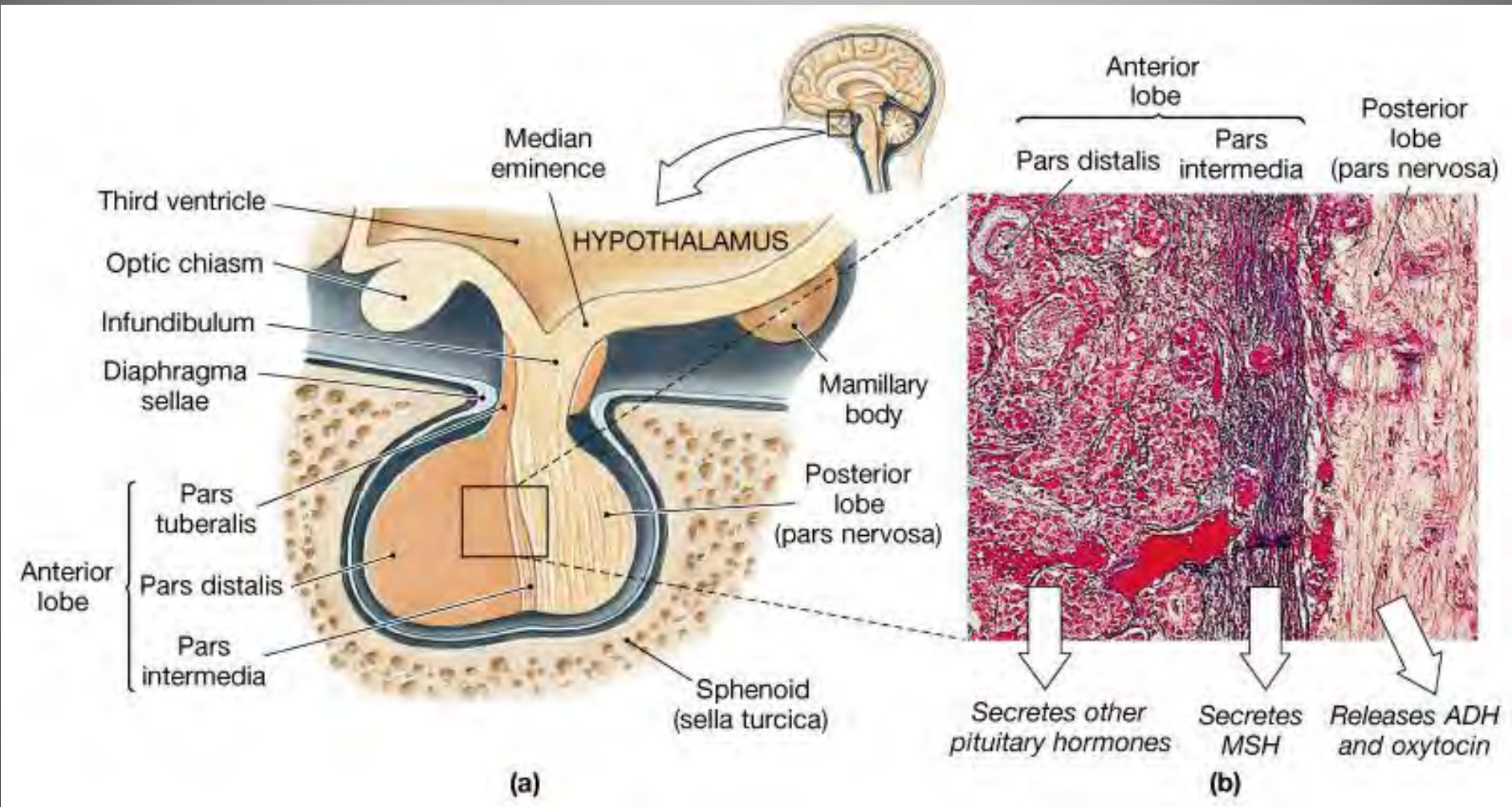
Pituitary called master gland of endocrine system, but is controlled by hypothalamus

- Located in the cranial cavity
- Size of a grape
- Hangs by a stalk from the hypothalamus
- Directly affects the function of other endocrine glands
- Promotes growth of body tissue (Turk's Saddle)
- Influences water absorption by the kidney
- Controls sexual development and function
- Starts out in the embryo as two glands anterior and posterior but later the two glands grow together and create three lobes that function separately
 - Is a small but powerful gland
 - Is well protected at base of skull in sella turcica
- Connected by a projection to hypothalamus
- Has two parts: anterior and posterior lobes

Hypophysis

- Releases nine important peptide hormones
- All nine bind to membrane receptors and use cyclic AMP as a second messenger

Figure 18.6 The Anatomy and Orientation of the Pituitary Gland



Hormones of the Anterior Pituitary

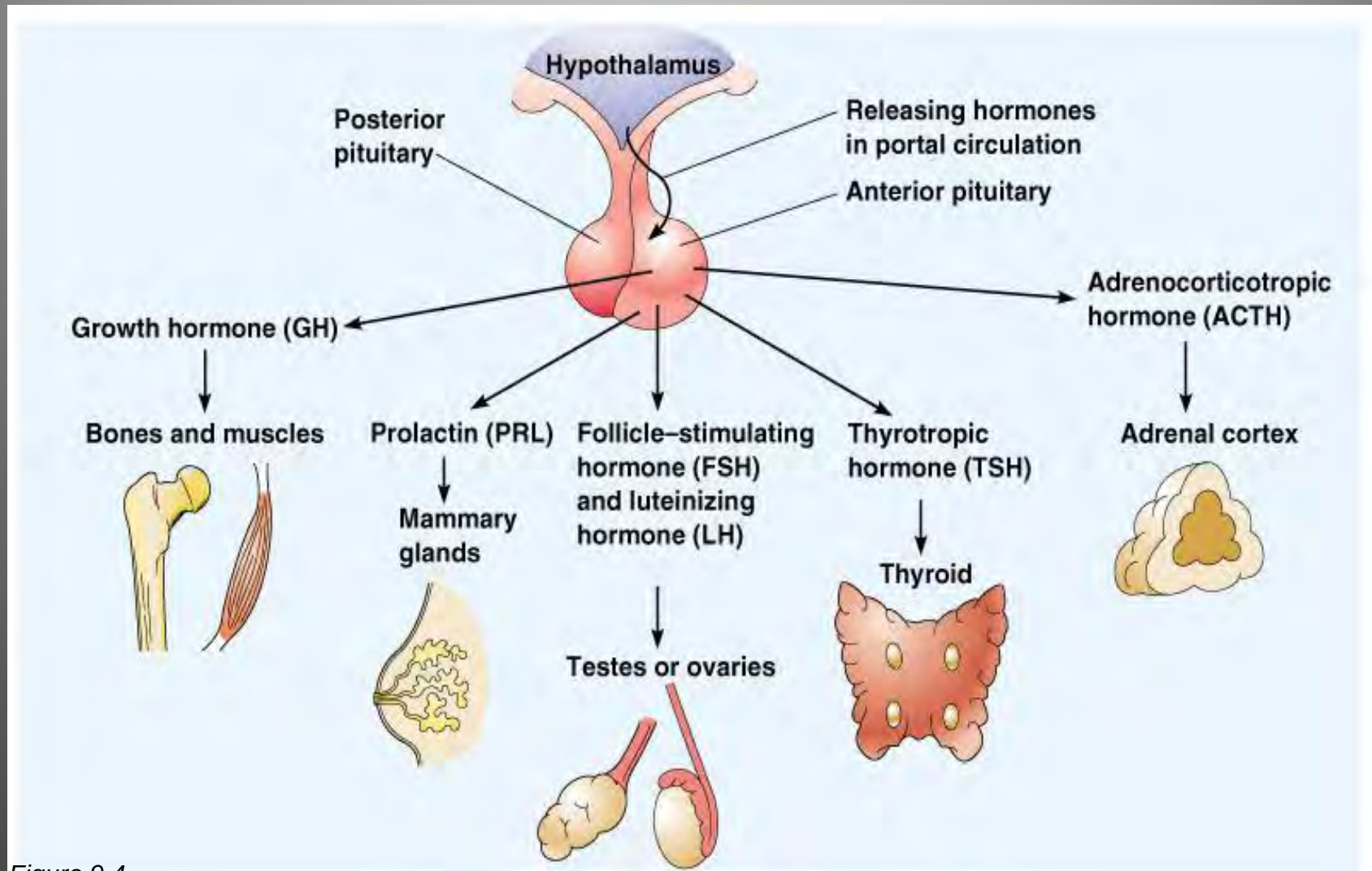


Figure 9.4

The anterior lobe (adenohypophysis)

- Subdivided into the pars distalis, pars intermedia and pars tuberalis
- At the median eminence, neurons release regulatory factors through fenestrated capillaries
 - Releasing hormones
 - Inhibiting hormones

Hormones of the Anterior Pituitary Gland

- Six Anterior Pituitary Hormones
 - Two affect non-endocrine targets
 - Four stimulate other endocrine glands
 - tropic hormones
 - stimulate their target organs which are also endocrine glands to secrete their hormones which in turn exert their effects in other body organs and tissues
- Characteristics of all Anterior Pituitary Hormones:
 - Act through second-messenger systems
 - Regulated by hormonal stimuli, mostly negative feedback

Growth Hormone (GH)

- General metabolic hormone
- Major effects are directed to growth of skeletal muscles and long bones
- Stimulates most target cells to grow in size and divide
- Causes amino acids to be built into proteins
- Causes fats to be broken down for a source of energy
- increases the rate of cell division and increases the rate of protein synthesis
- Growth hormone and Prolactin
 - Exert their major effects on non endocrine targets
- Plays an important role in determining final body size
- Spares glucose helping to maintain blood sugar homeostasis
- GH stimulates mitosis and protein synthesis in many target organs and tissues
 - Hyposecretion: pituitary dwarfism: during childhood
 - Body proportions are fairly normal but the person as a whole is a living miniature, with max adult height of four feet
 - After long bone growth has ended then acromegely results: lower jaw, facial bones and the bony ridges underlying eyebrows enlarge as do the hands and feet

Anterior Pituitary Hormones

- **Follicle-stimulating hormone (FSH)**
 - Stimulates follicle development in ovaries
 - Stimulates sperm development in testes
 - FSH: ovaries, follicles in the female and tubules of testes in the male
 - FSH: as the follicles mature they produce estrogen and eggs and readied for ovulation
- **Luteinizing hormone (LH)**
 - Triggers ovulation of an egg
 - females: causes the ruptured follicle to become a corpus luteum which then produces progesterone and some estrogen
 - Stimulates testosterone production in males
 - Referred to as interstitial cell-stimulating hormone (ICSH): in men
 - Because it stimulates testosterone production by the interstitial cells of the testes

Anterior Pituitary Hormones

- Prolactin (PRL)
 - pro = for lact = milk
 - Target: breast
 - Stimulates and maintains milk production following childbirth
 - Function in males is unknown
- Adrenocorticotrophic hormone (ACTH)
 - Regulates endocrine activity of the adrenal cortex
- Thyroid-stimulating hormone (TSH)
 - TSH: also called thyrotrophic hormone
 - Influences growth and activity of the thyroid gland

Hormones of the Posterior Pituitary

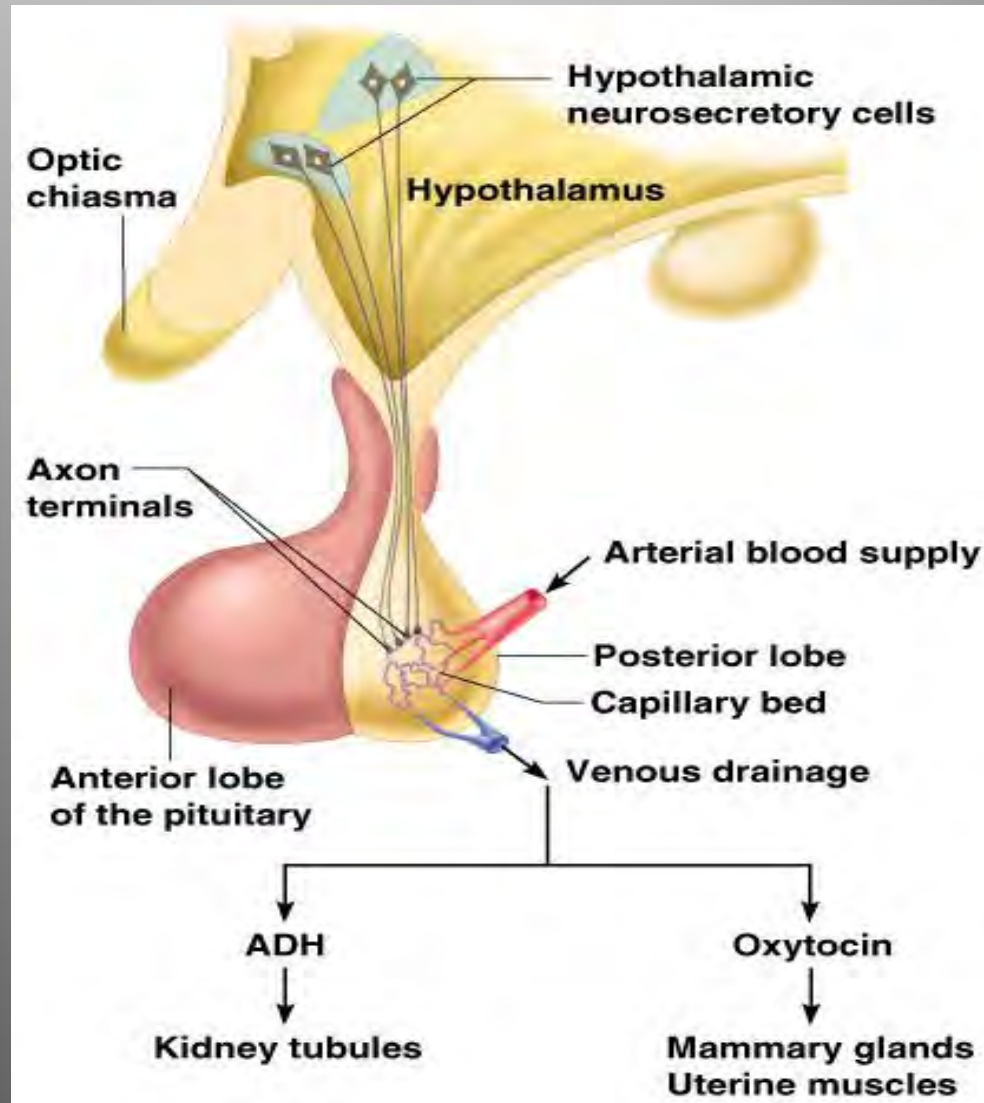


Figure 9.5

Hypophyseal portal system

- All blood entering the portal system will reach the intended target cells before returning to the general circulation

Figure 18.7 The Hypophyseal Portal System

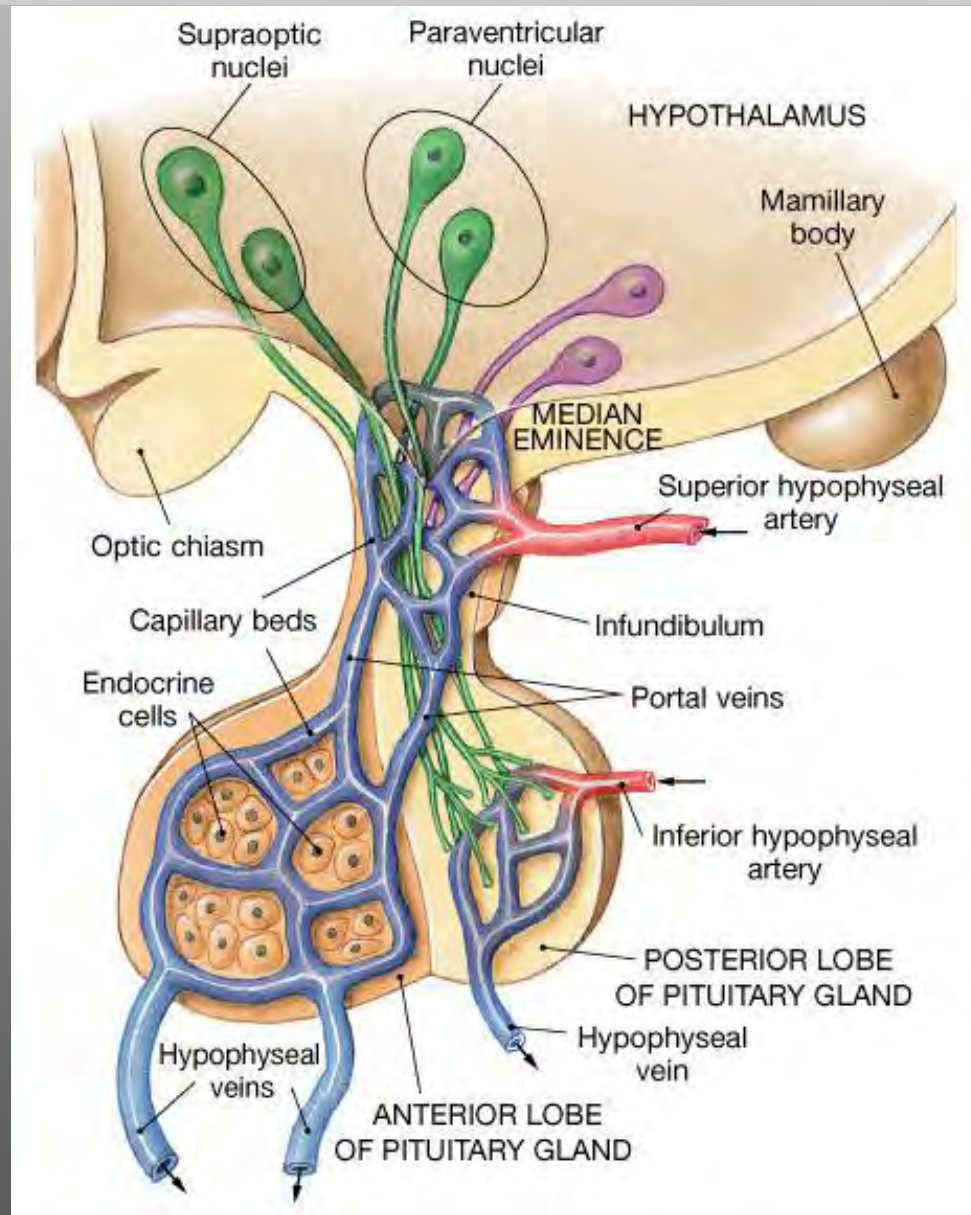


Figure 18.8 Feedback control of Endocrine Secretion

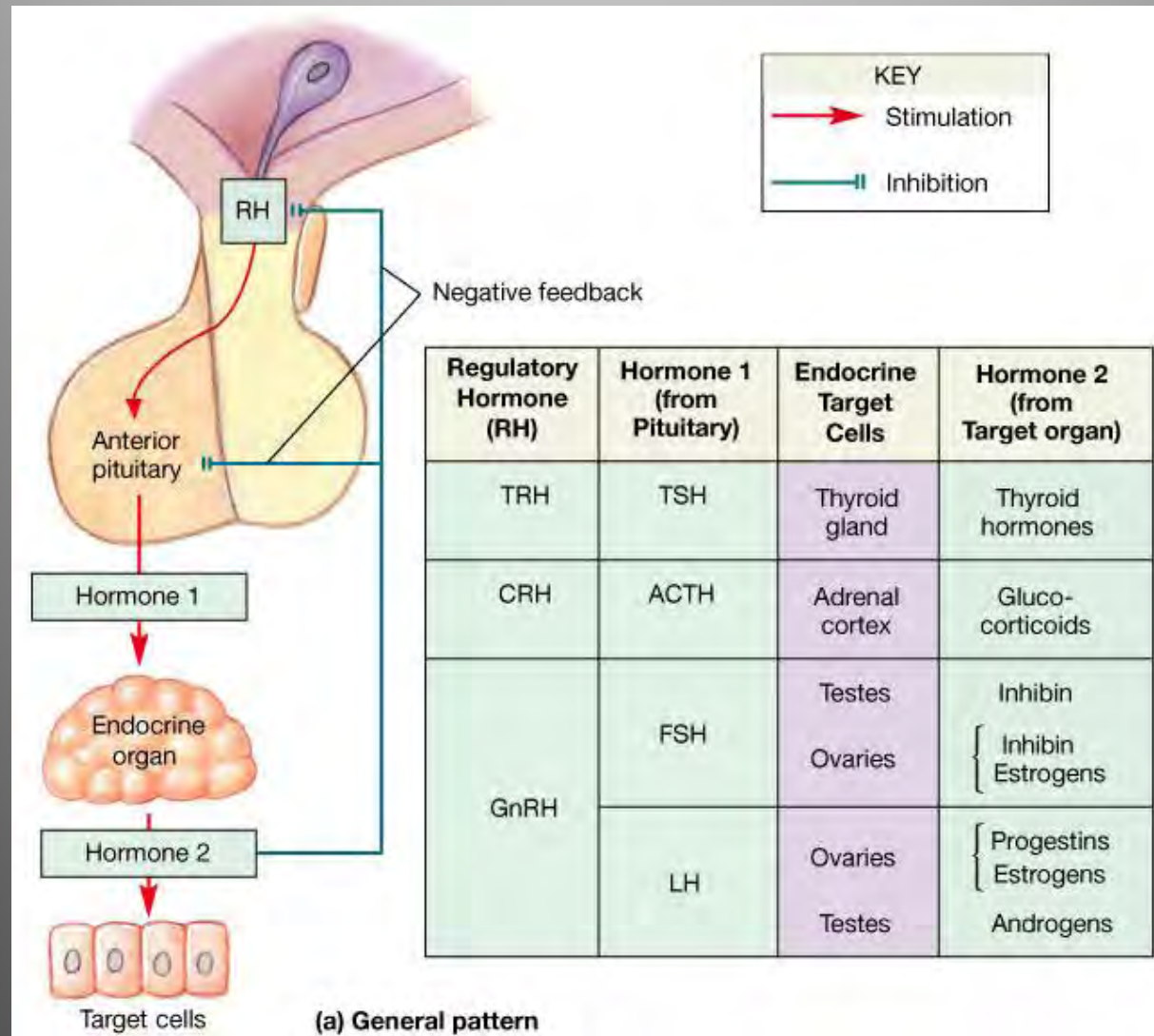
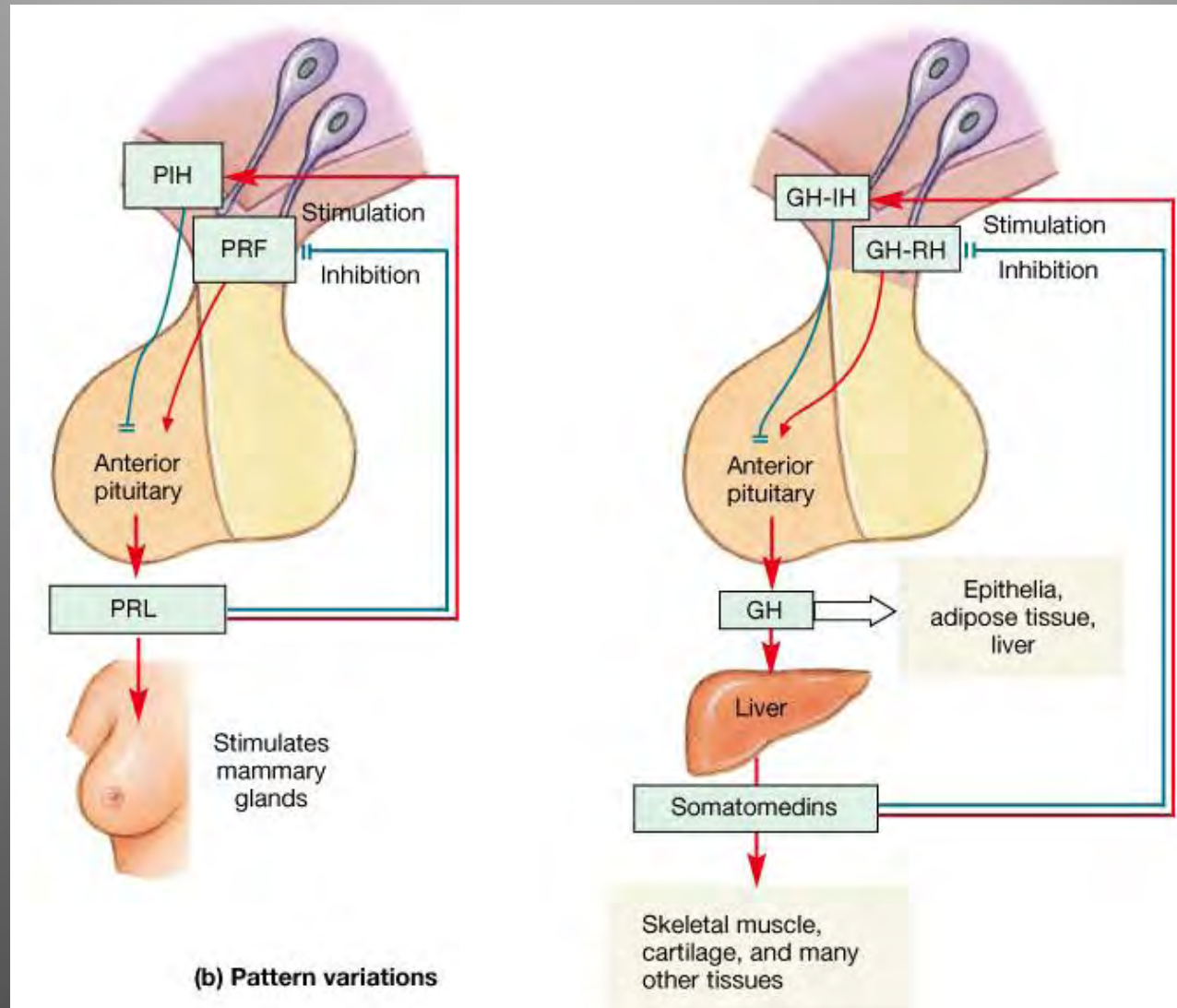


Figure 18.8 Feedback control of Endocrine Secretion



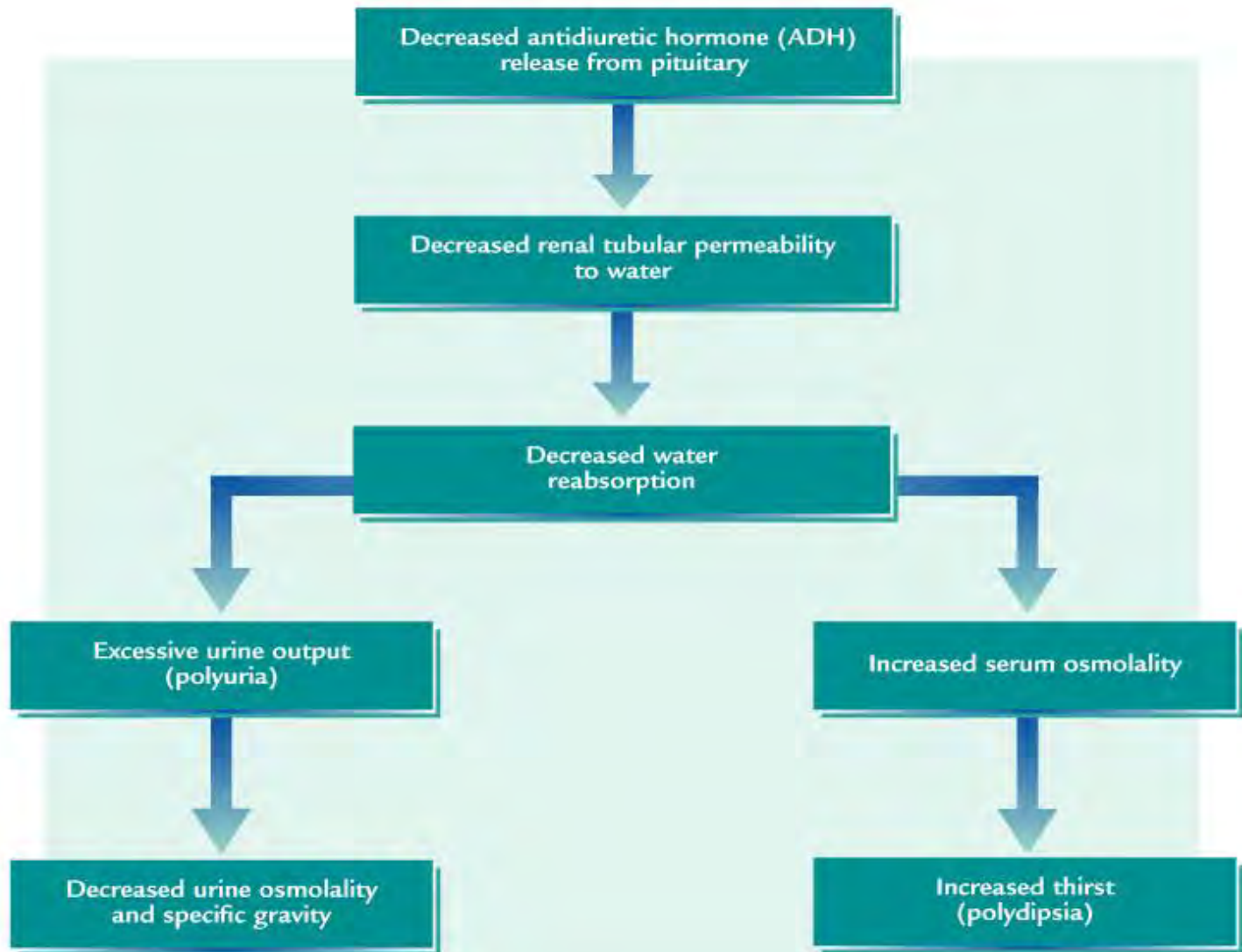
Hormones of the Posterior Pituitary Gland

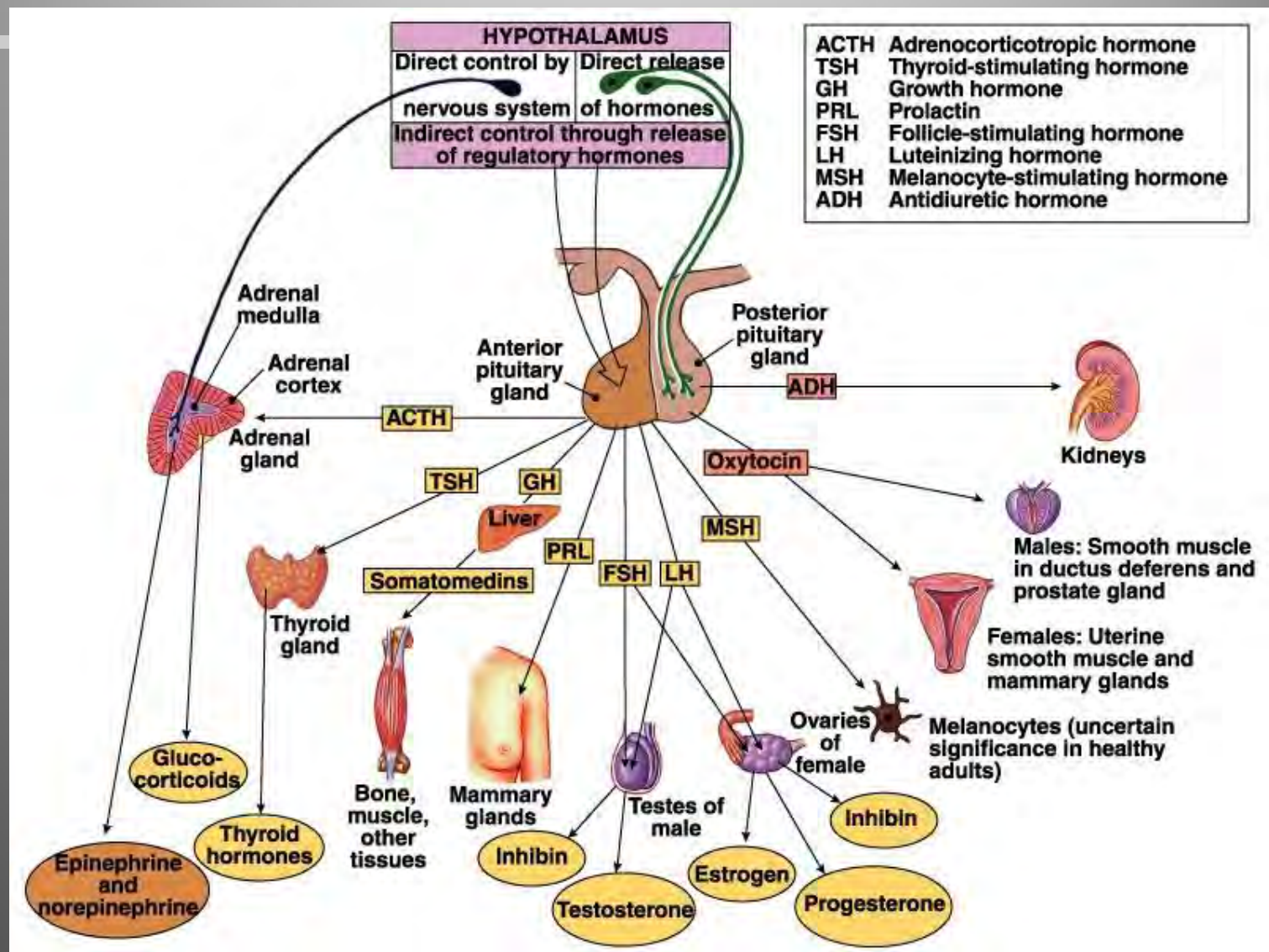
- Posterior pituitary gland is not an endocrine gland in strict sense:
- Does not make peptide hormones it releases
- Acts as a storage area for hormones
 - Oxytocin: Releases in significant amounts only during childbirth and in nursing women
 - It stimulates: powerful contractions of the uterine muscle during labor, sexual relations and breast feeding,
 - causes milk ejection (the letdown reflex)
 - Both natural and synthetic oxytocic drugs (Pitocin) are used to induce labor that is progressing normally but at a slow pace
 - used to stop postpartum bleeding by causing constriction of the ruptured vessels @ the placental site and to stimulate the milk ejection reflex

Antidiuretic Hormone (ADH)

- Inhibits or prevents urine production
 - Target organ is the kidneys
 - Causes kidneys to reabsorb more water from the forming urine
 - As a result, urine volume decreases and blood volume increases
 - In large doses, ADH increase BP
 - By causing constriction of the arterioles – for this reason it is sometimes referred to as vasopressin
 - Certain drugs classed together as diuretics antagonize the effects of ADH
 - Drinking alcohol beverages inhibits ADH secretion, therefore output is increased
 - Dry mouth and intense thirst reflect this dehydrating effect of alcohol
 - Diabetes Insipidus: excessive urine output
 - Diuretics antagonize the effects of ADH
 - Hyposecretion of ADH leads to a condition of excessive urine output called Diabetes Insipidus

MECHANISM OF ADH DEFICIENCY





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Hormones of the adenohypophysis

- Thyroid stimulating hormone (TSH)
 - Triggers the release of thyroid hormones
 - Thyrotropin releasing hormone promotes the release of TSH
- Adrenocorticotrophic hormone (ACTH)
 - Stimulates the release of glucocorticoids by the adrenal gland
 - Corticotrophin releasing hormone causes the secretion of ACTH

Hormones of the adenohypophysis

- Follicle stimulating hormone (FSH)
 - Stimulates follicle development and estrogen secretion in females and sperm production in males
- Leutinizing hormone (LH)
 - Causes ovulation and progestin production in females and androgen production in males
- Gonadotropin releasing hormone (GNRH) promotes the secretion of FSH and LH

Hormones of the adenohypophysis

- Prolactin (PH)
 - Stimulates the development of mammary glands and milk production
- Growth hormone (GH or somatotropin)
 - Stimulates cell growth and replication through release of somatomedins or IGF
 - Growth-hormone releasing hormone (GH-RH)
 - Growth-hormone inhibiting hormone (GH-IH)

Melanocyte stimulating hormone (MSH)

- May be secreted by the pars intermedia during fetal development, early childhood, pregnancy or certain diseases
- Stimulates melanocytes to produce melanin

The posterior lobe of the pituitary gland (neurohypophysis)

- Contains axons of hypothalamic nerves
- neurons of the supraoptic nucleus manufacture antidiuretic hormone (ADH)
 - Decreases the amount of water lost at the kidneys
 - Elevates blood pressure

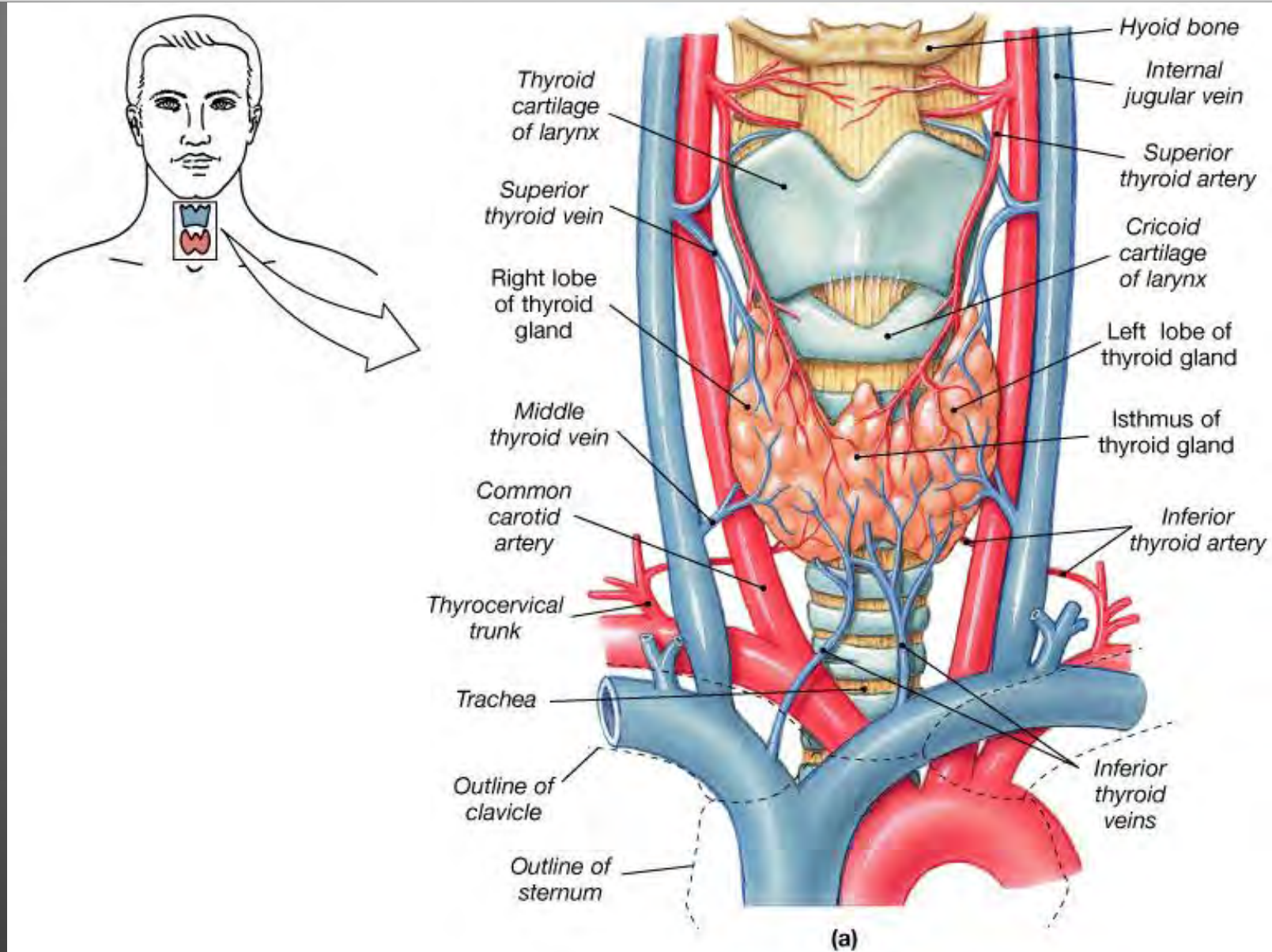
The posterior lobe of the pituitary gland (neurohypophysis)

- Neurons of the paraventricular nucleus manufacture oxytocin
 - Stimulates contractile cells in mammary glands
 - Stimulates smooth muscle cells in uterus

The Thyroid

- Lies near the thyroid cartilage of the larynx
- Two lobes connected by an isthmus

Figure 18.11 The Thyroid Gland



Thyroid Gland

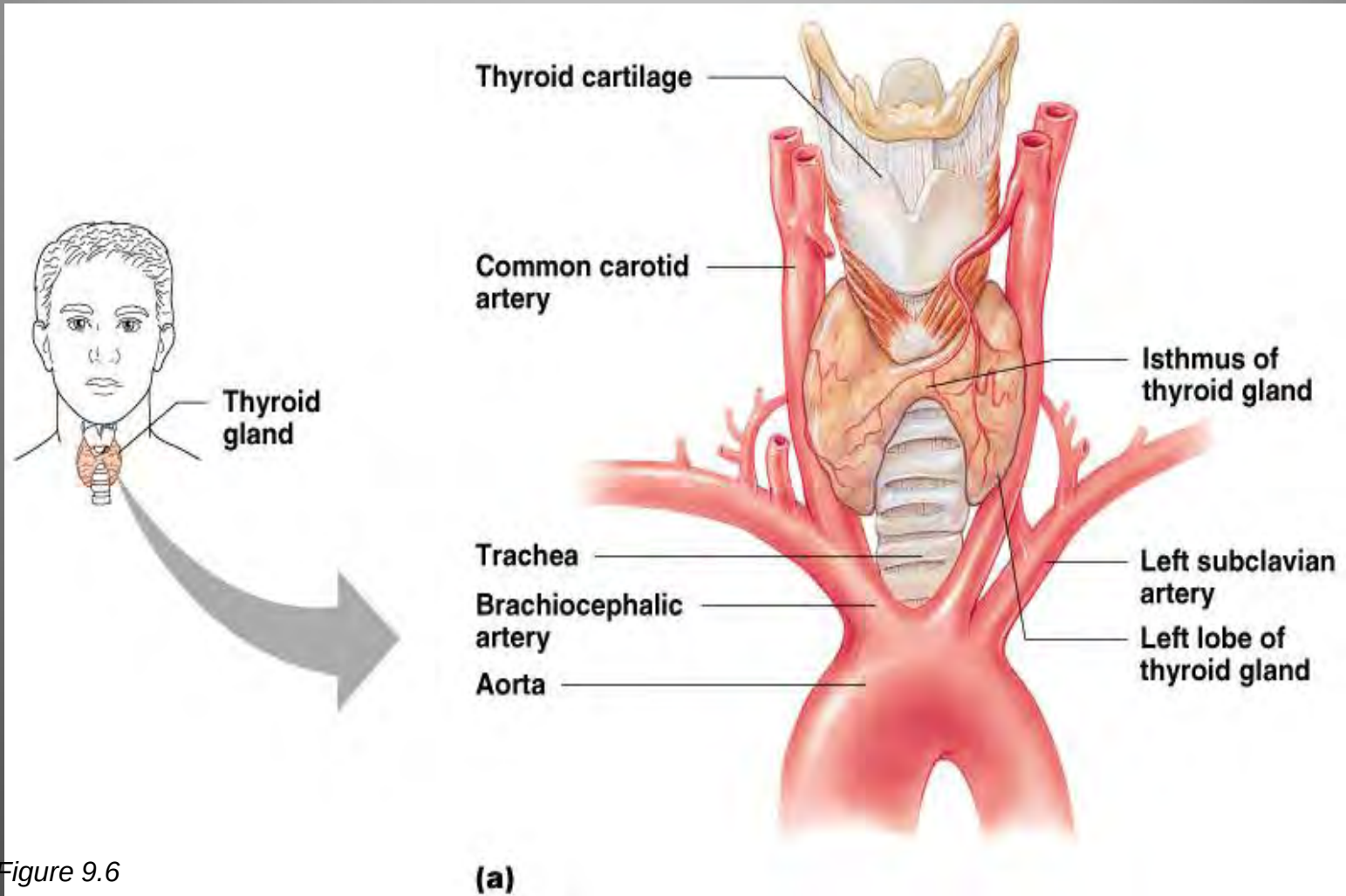
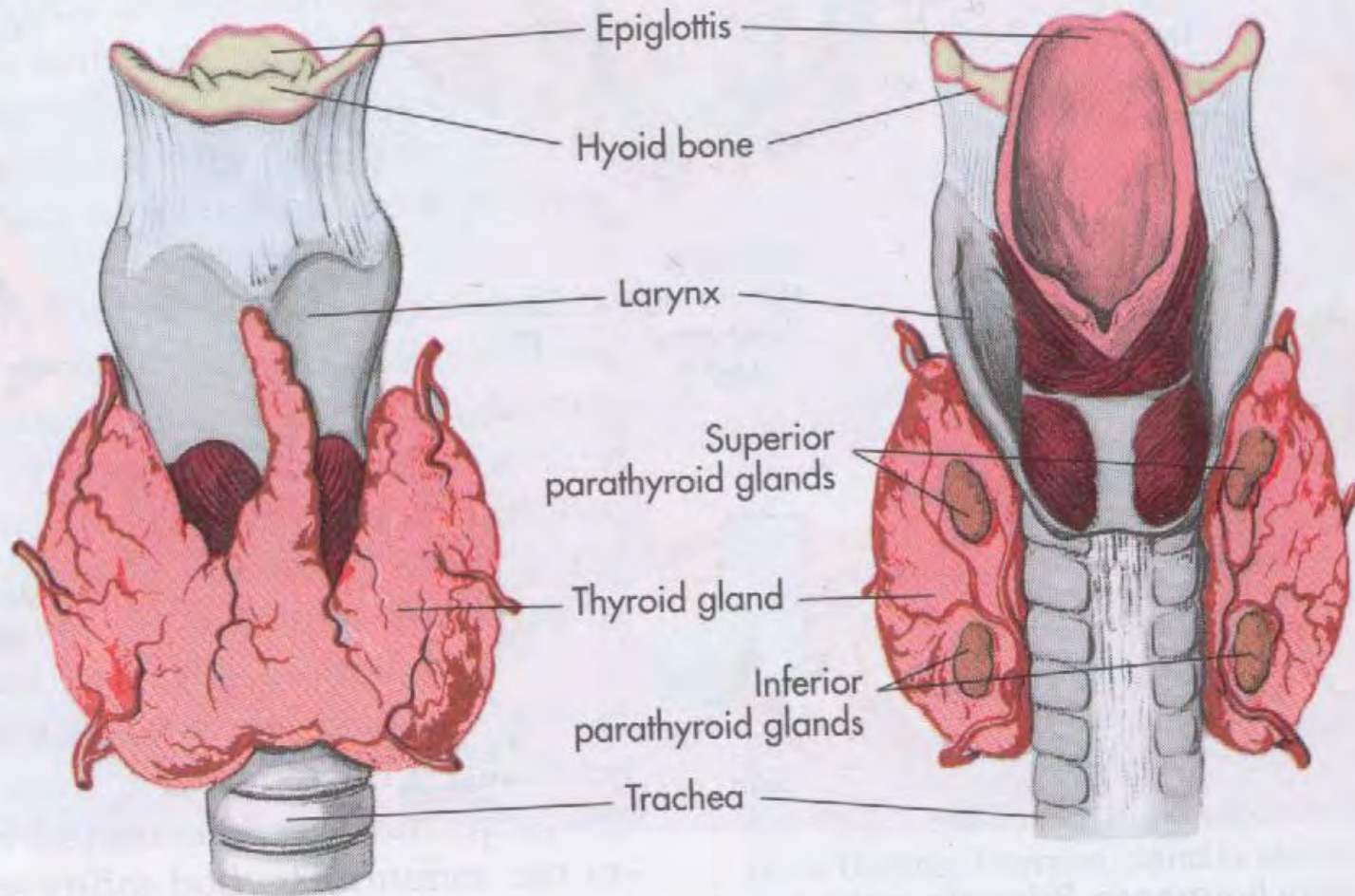
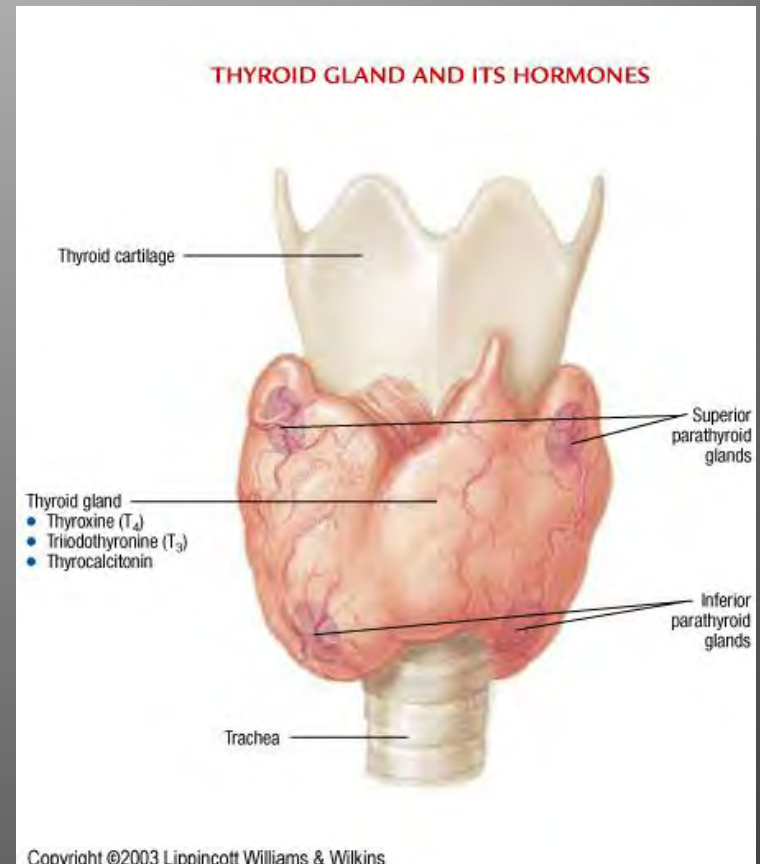
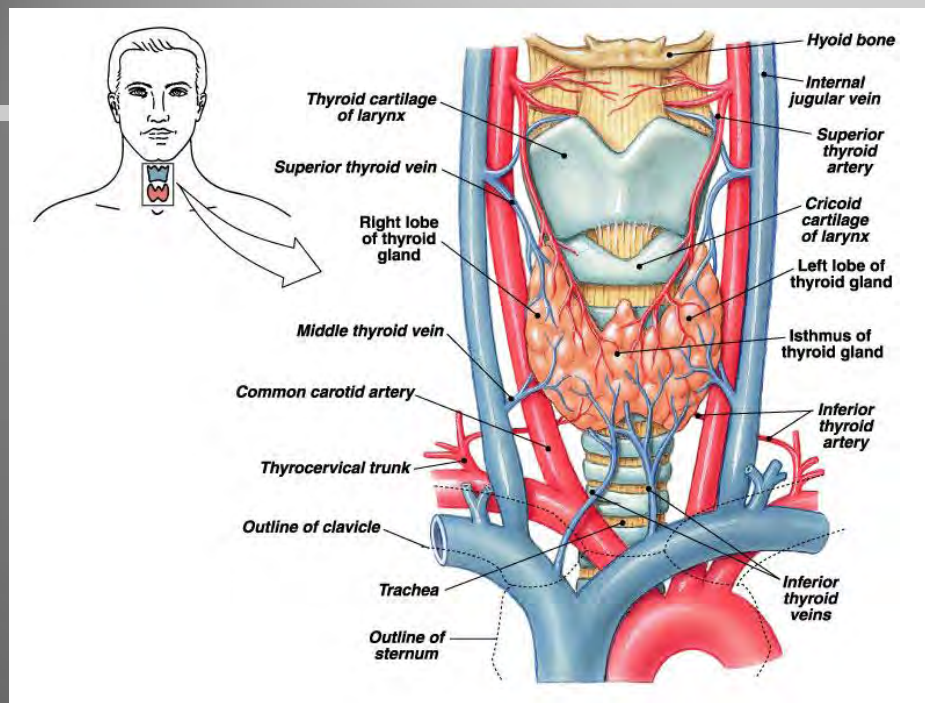


Figure 9.6

Back of larynx

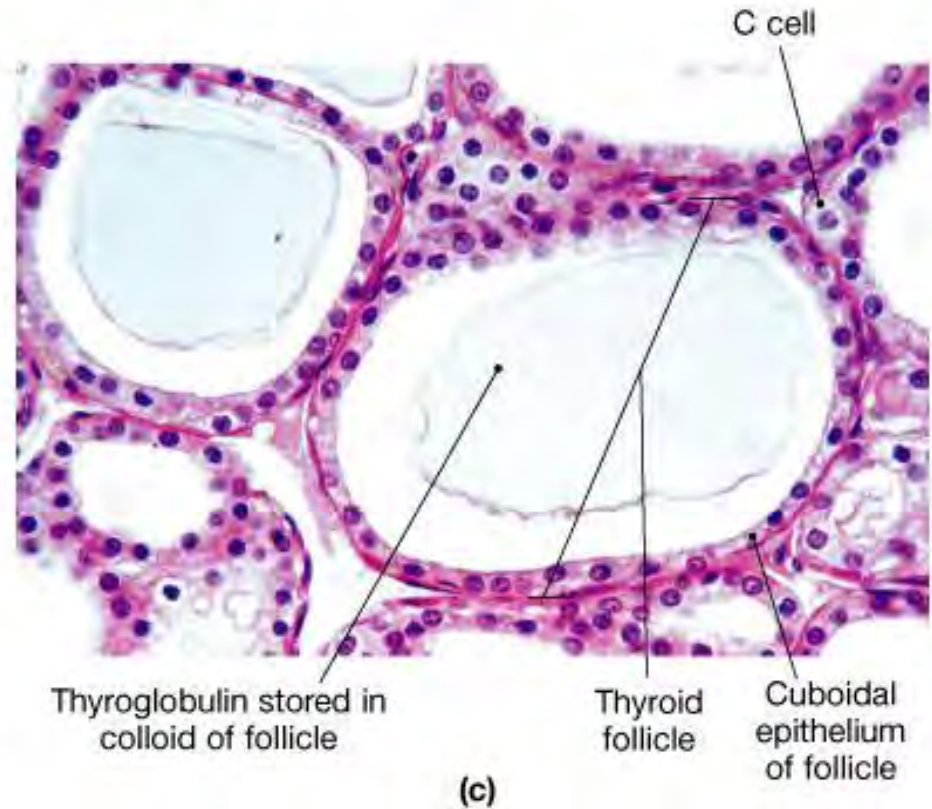
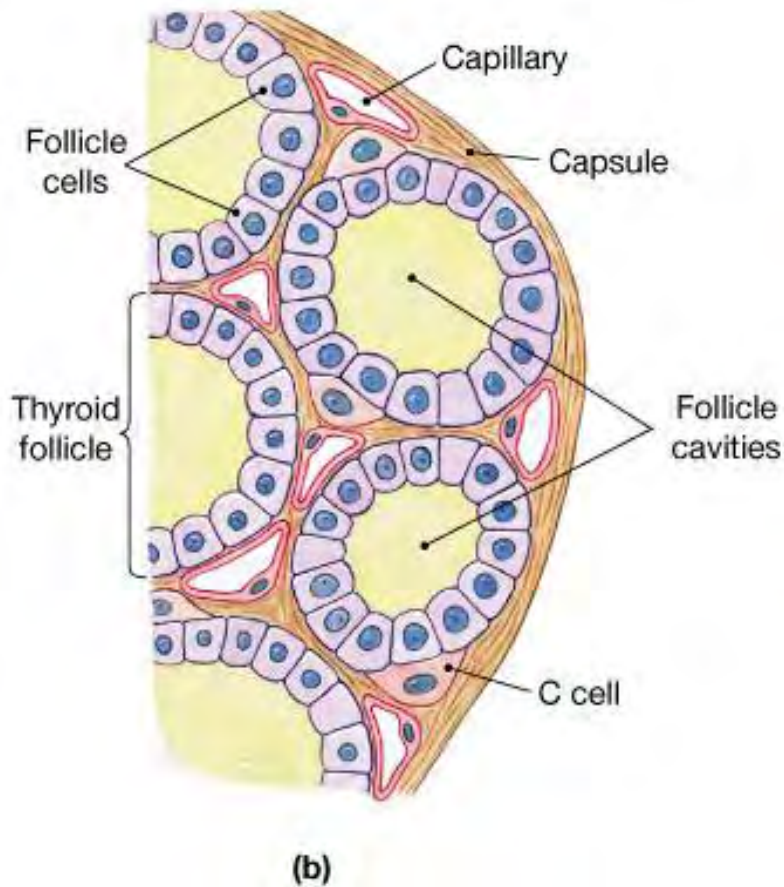


Christensen and Kockrow, Adult Health Nursing



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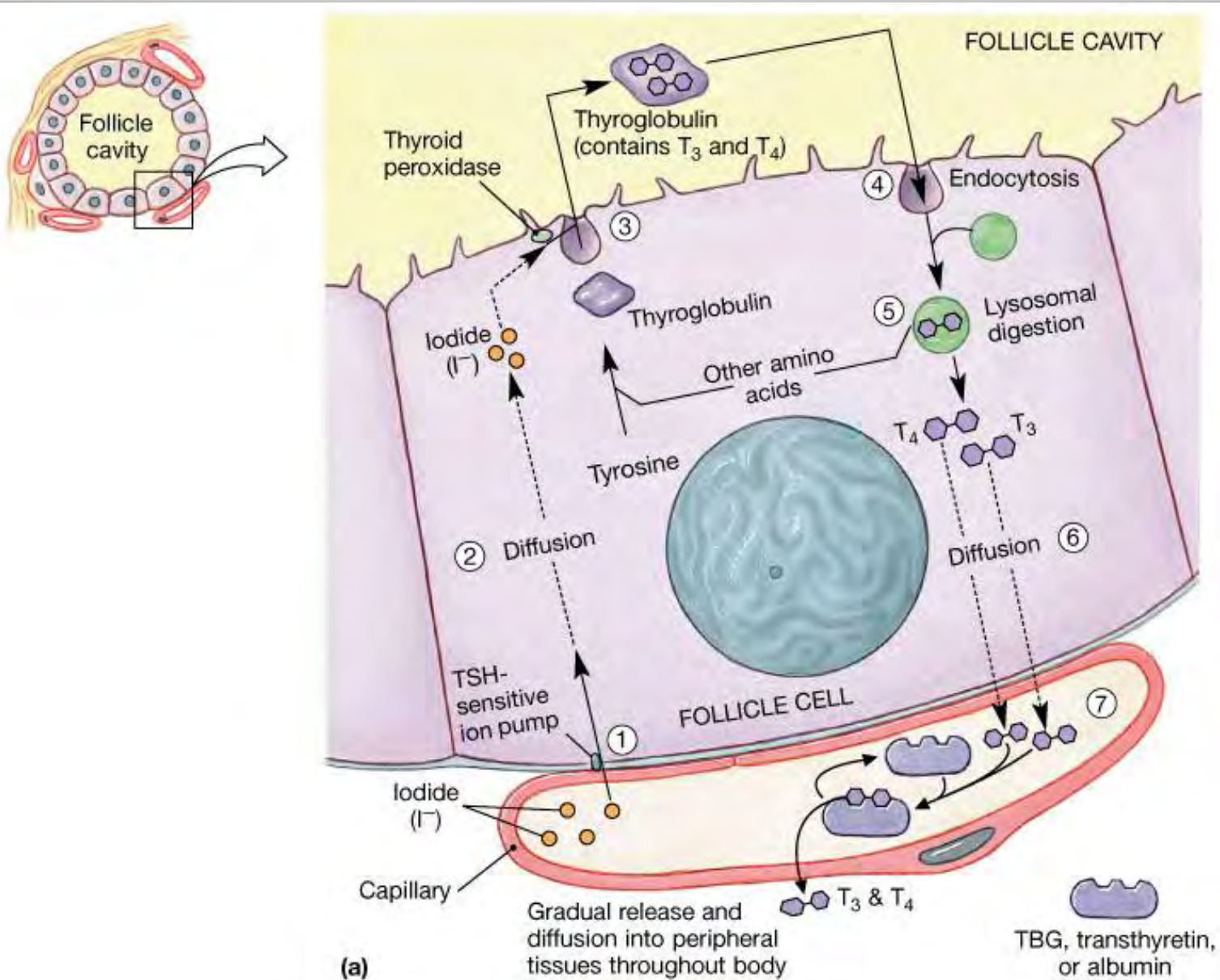
Figure 18.11 The Thyroid Gland



Thyroid follicles and thyroid hormones

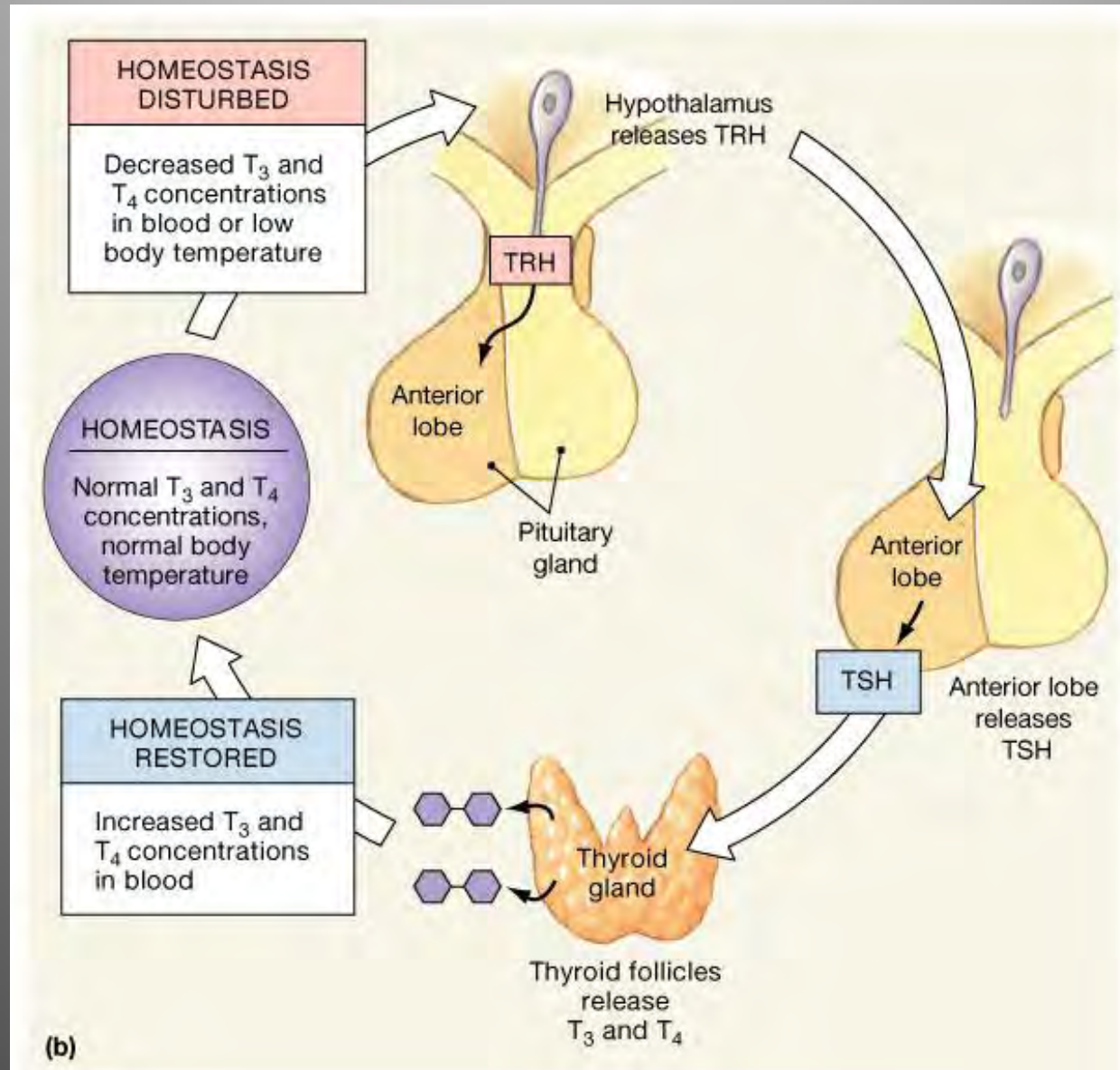
- Thyroid gland contains numerous follicles
 - Release several hormones such as thyroxine (T4) and triiodothyronine (T3)
- Thyroid hormones end up attached to thyroid binding globulins (TBG)
 - Some are attached to transthyretin or albumin

Figure 18.12 The Thyroid Follicles



(a)

Figure 18.12 The Thyroid Follicles



Thyroid

- Found at the base of the throat
 - Thyroid Gland: in the anterior part of the neck: inferior to the Adams apple
- Consists of two lobes and a connecting isthmus
 - Shaped like butterfly sitting over trachea
- Thyroid Function
 - Production & regulation of thyroid hormones
- Production
 - Secretes three hormones
 - Thyroxine (T4)
 - TSH from the anterior pituitary gland: the direct stimulus for the secretion of thyroxine
 - Triiodothyronine (T3)
 - the major hormone secreted by the thyroid follicles
 - Most T-3 is formed at the target tissues by the conversion of T-4 to T-3
 - Calcitonin reroutes blood calcium to bones

Thyroid Hormones

- Regulation
 - If T4 & T3 levels in blood fall, hypothalamus produces TRH which stimulates TSH secretion by pituitary gland.
 - Calcitonin: decreases blood calcium by inhibiting bone breakdown and release of calcium.
- Function of Thyroid Hormones
 - T3 & T4 control cellular metabolic activity
 - Calcitonin reduces plasma levels of calcium
- Regulate three main functions
 - Growth and development
 - Metabolism
 - Activity of the nervous system

Thyroid Hormone

- Often referred to as the body's major metabolic hormone
 - Controls the rate of body metabolism and growth
- Thyroid hormone: major metabolic hormone
- Thyroid hormone controls the rate at which glucose is burned or oxidized and converted to body heat and chemical energy
- Every cell in the body is a target since all body cells depend on a continuous supply of chemical energy to power their activities
- Also important for normal tissue growth and development especially in the reproductive and nervous systems
- Adequate intake of iodine is necessary for formation of thyroid hormones

Thyroid Hormones

- Held in storage
- Bound to mitochondria, thereby increasing ATP production
- Bound to receptors activating genes that control energy utilization
- Exert a calorigenic effect

Cells of the thyroid gland

- C cells produce calcitonin
 - Helps regulate calcium concentration in body fluids

Calcitonin

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

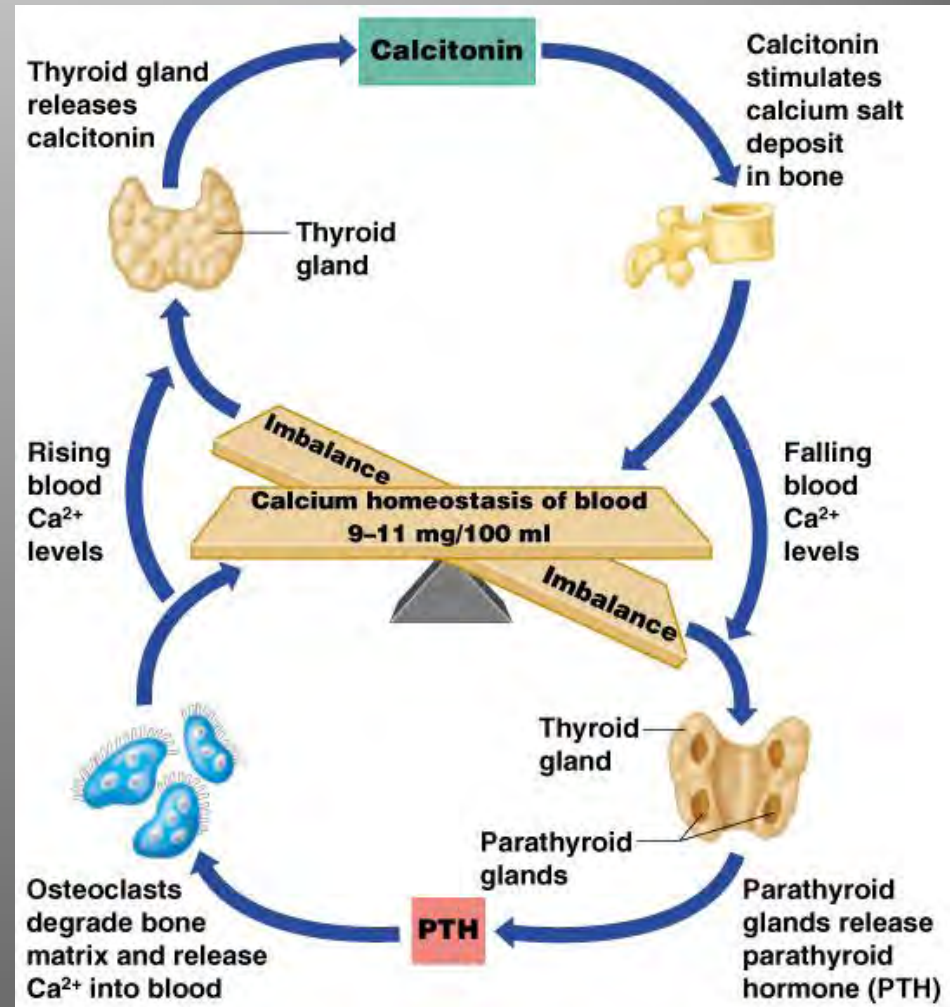
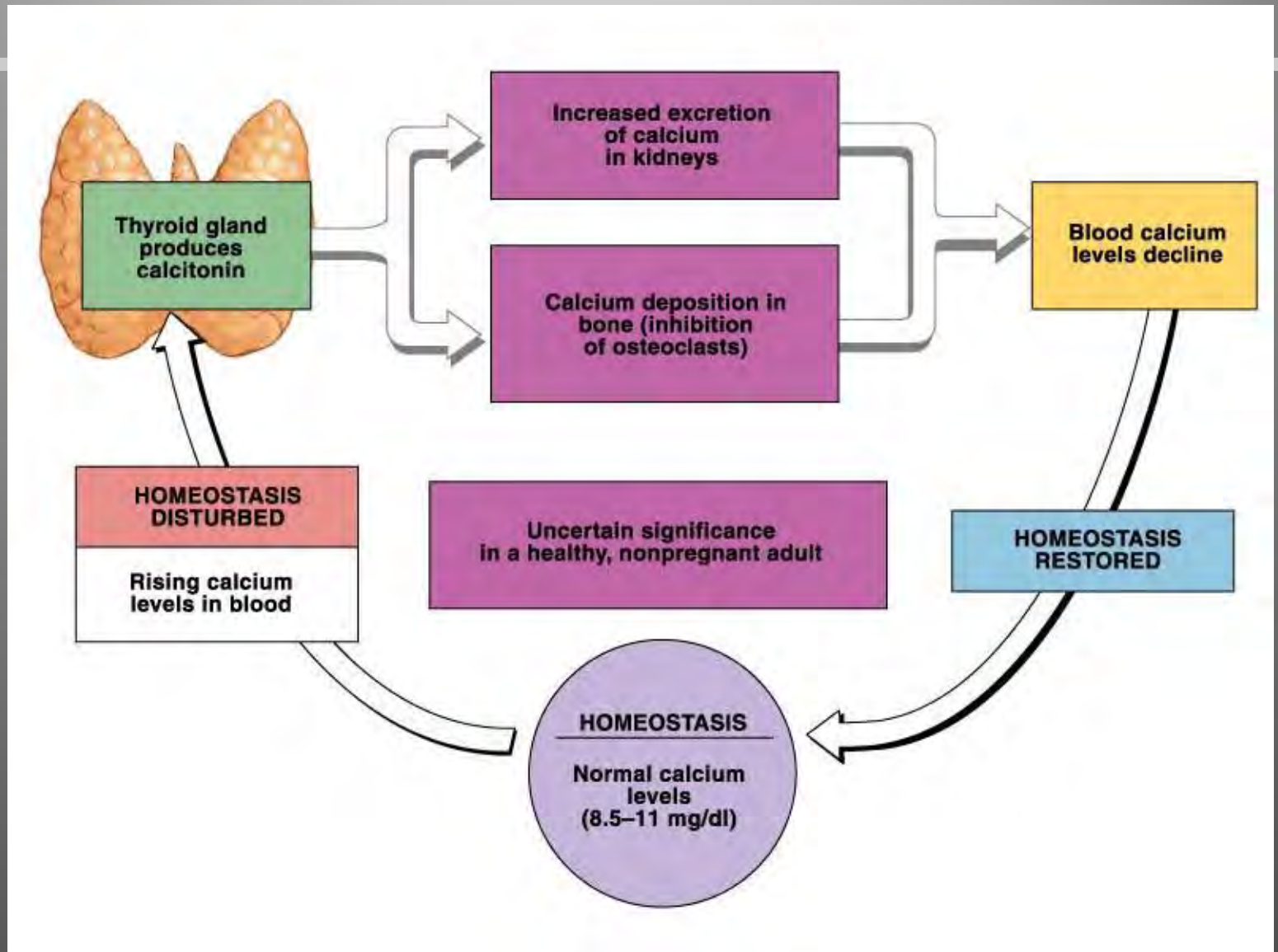


Figure 9.9



Four parathyroid glands

- Embedded in the posterior surface of the thyroid gland
- Chief cells produce parathyroid hormone (PTH) in response to lower than normal calcium concentrations
- Parathyroid hormones plus calcitriol are primary regulators of calcium levels in healthy adults

Figure 18.14 The Parathyroid Glands

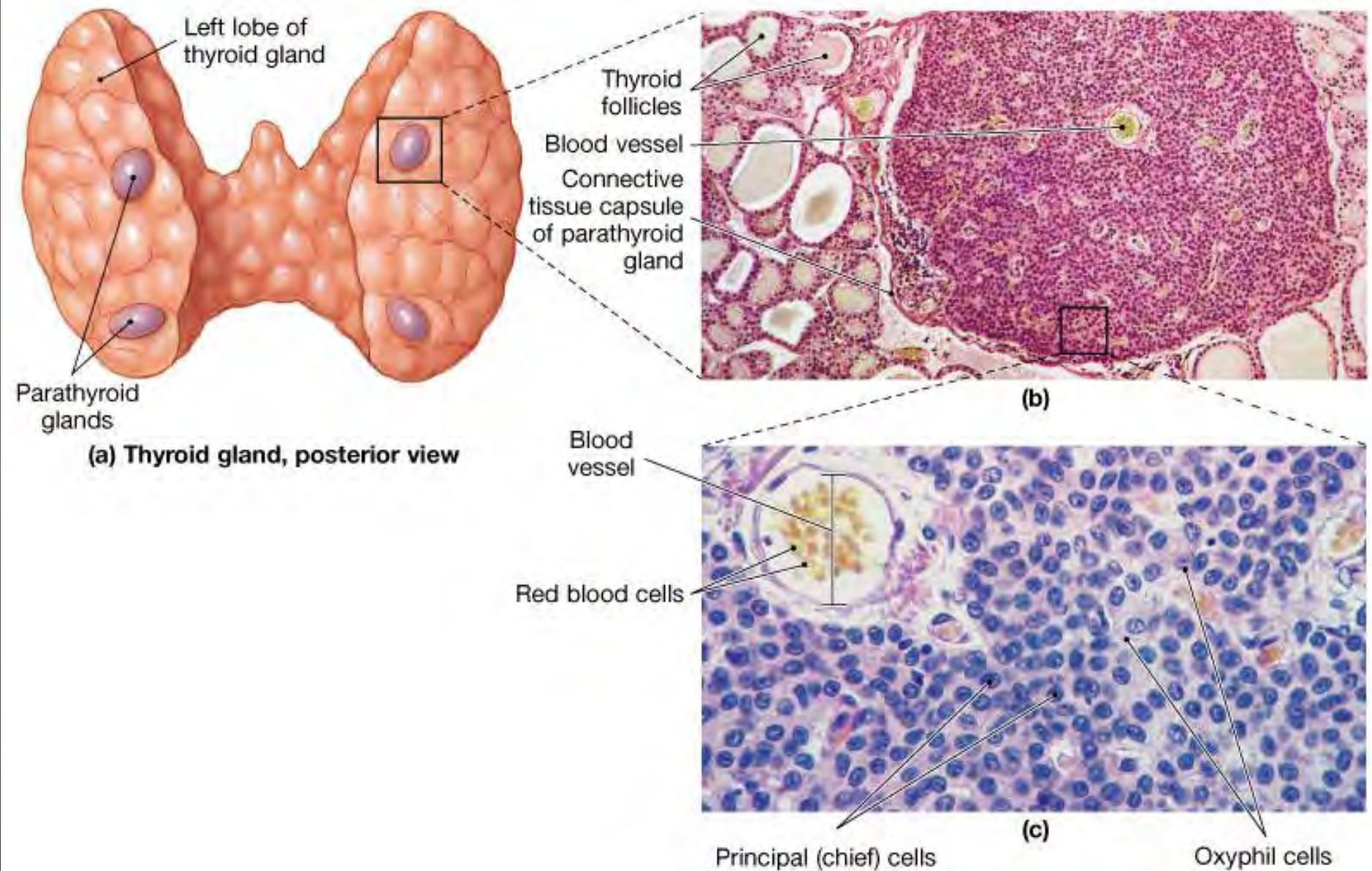
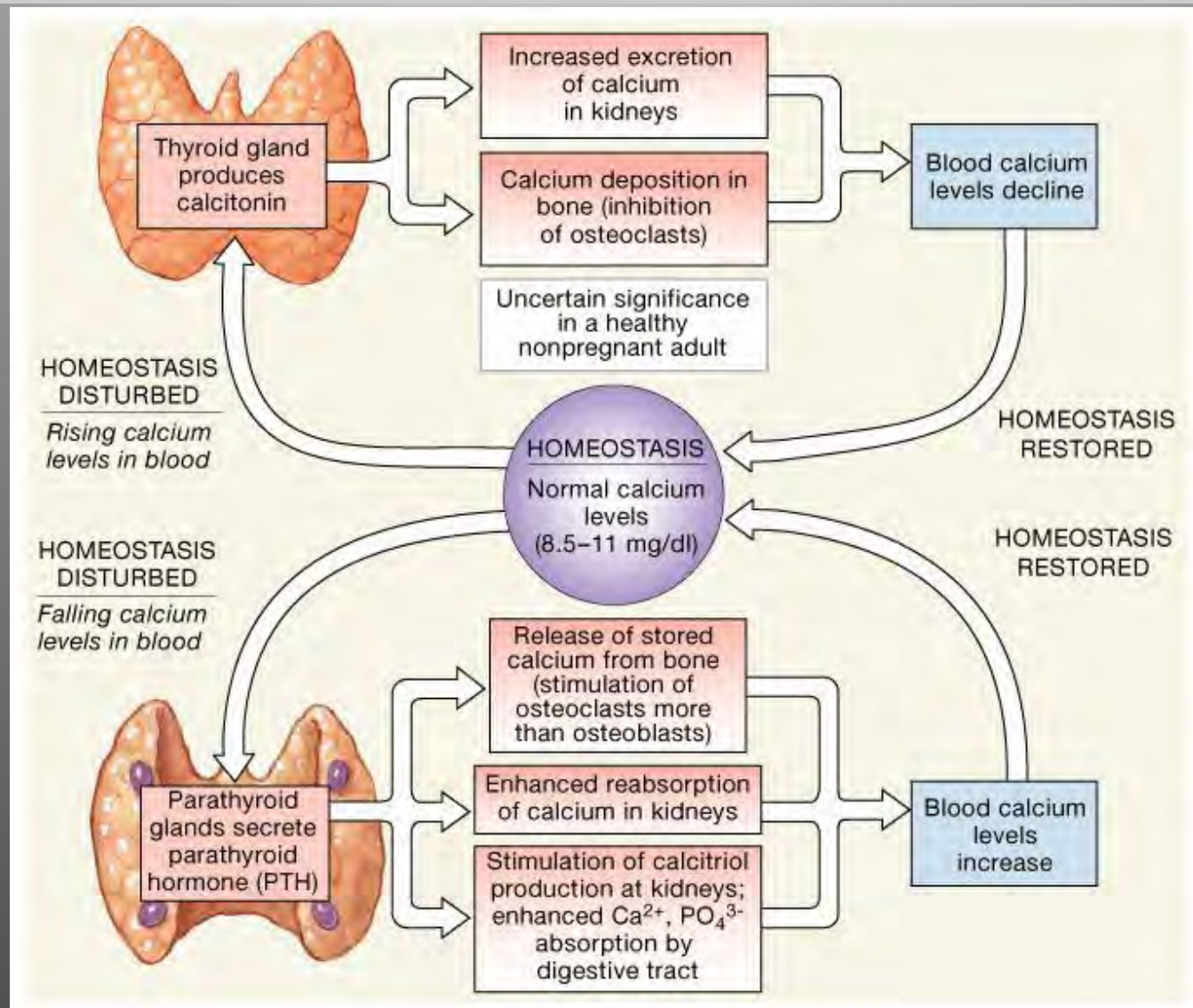


Figure 18.15 The Homeostatic Regulation of Calcium Ion Concentrations



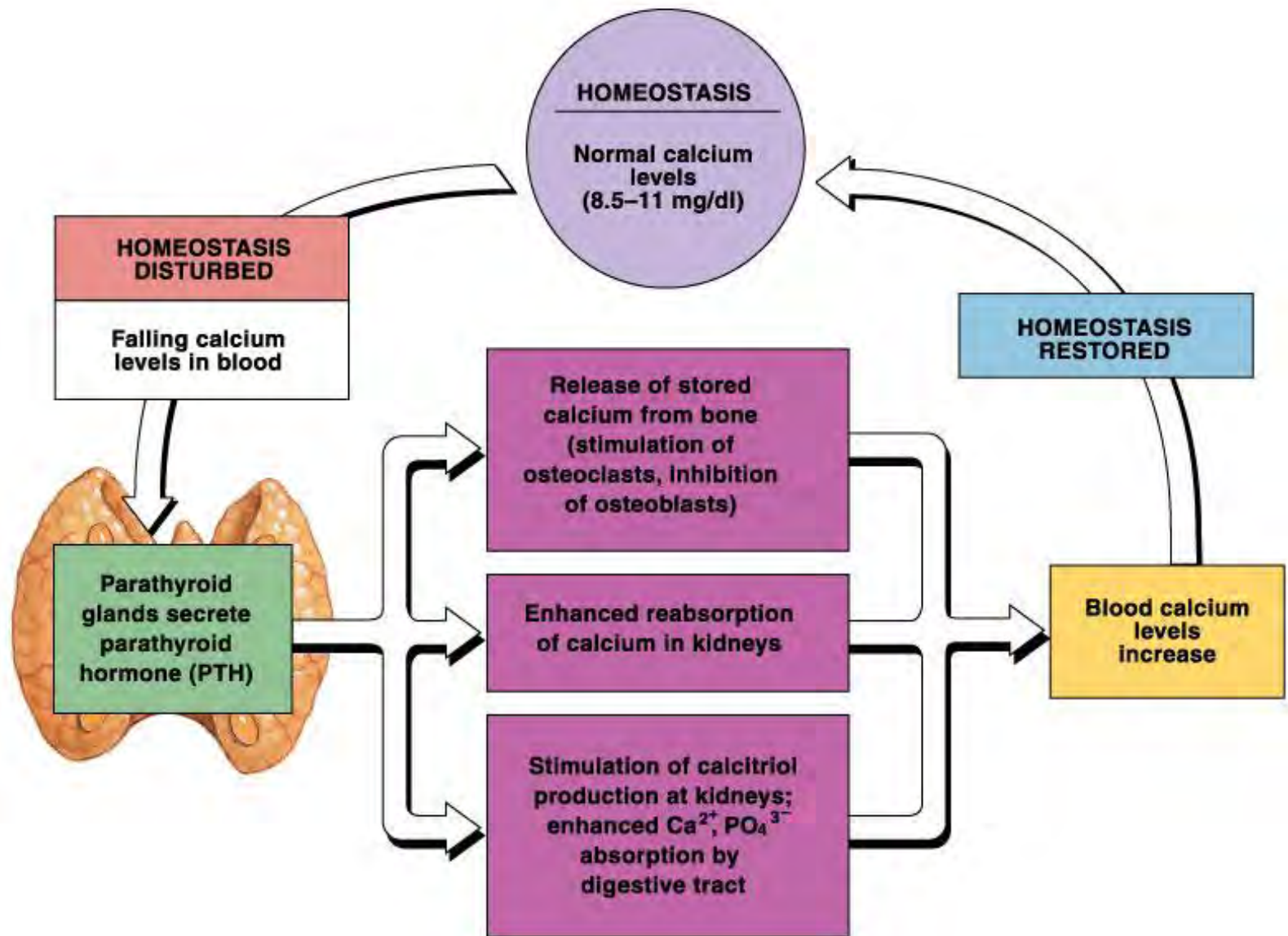
Parathyroid Glands

- **Tiny masses on the posterior of the thyroid**
 - **Four small, beanlike structures**
 - **Embedded in posterior surface of thyroid gland**
 - **Secrete PTH**
- **Secrete parathyroid hormone**
 - **Stimulate osteoclasts to remove calcium from bone**
 - **Stimulate the kidneys and intestine to absorb more calcium**
 - **Raise calcium levels in the blood**
 - **Controls calcium and phosphorus metabolism**
- **PTH: bone, kidney, digestive tract – increases blood calcium by stimulating bone breakdown bone destruction = osteoclasts of the bone matrix**

Parathyroid Hormone (PTH)

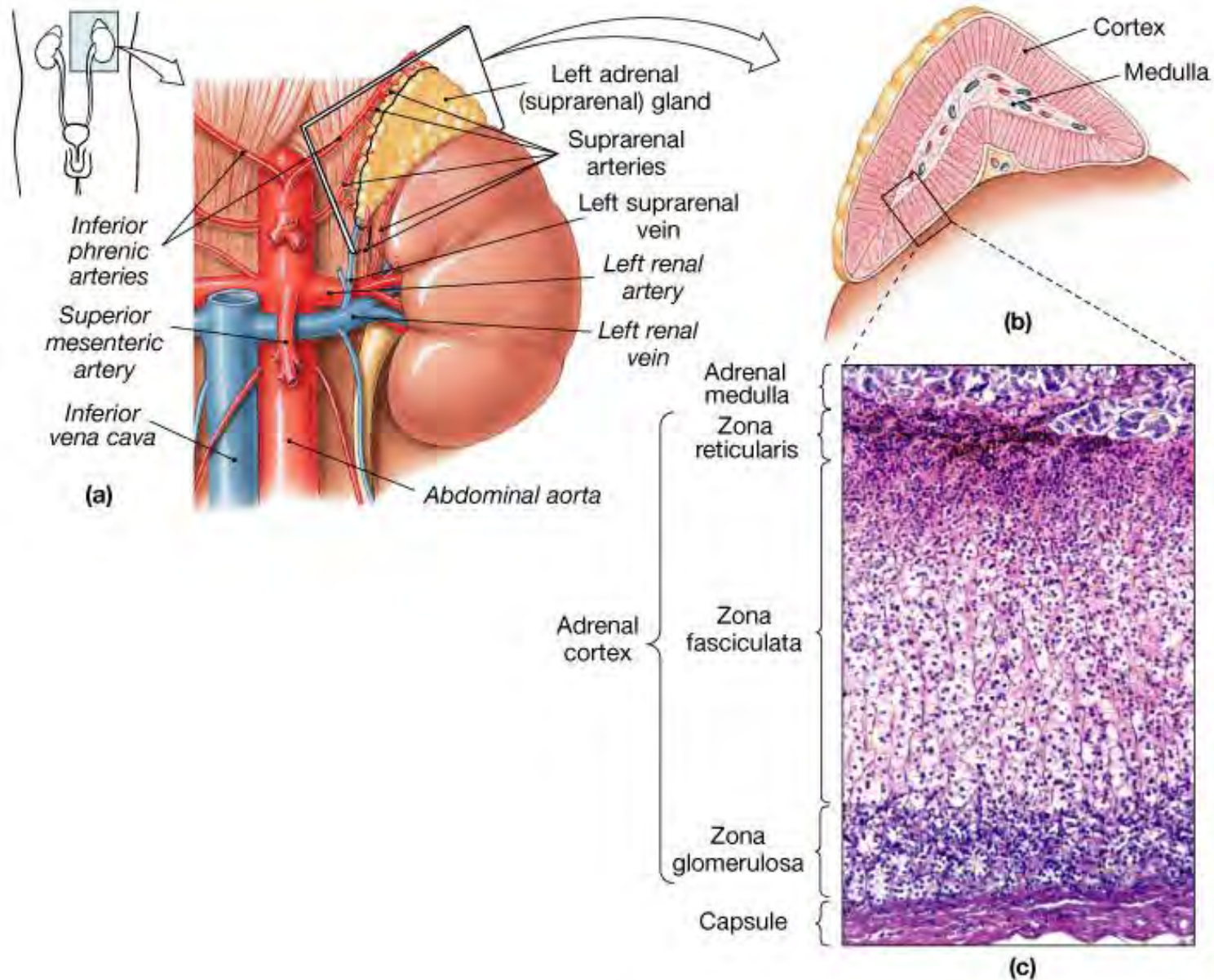
- Maintains calcium and phosphate balance in body
- Antagonist to calcitonin produced by the thyroid gland
- Targets:
 - bones, kidneys, and intestinal cells to increase calcium level in blood
 - Targets kidneys to increase phosphate excretion
- When PTH levels rise
 - phosphate is excreted and blood level of phosphate decreases
- Calcium needed for normal neuromuscular activity, cell permeability

- **Increases calcium absorption in the digestive tract, decreases calcium lost in urine.**
 - **Severe hyperparathyroidism causes massive bone destruction**
 - **Bones become fragile and spontaneous fractures begin to occur**
- **If blood calcium levels fall too low then neurons become extremely irritable and overactive**
- **They develop impulses to the muscle at such a rapid rate that the muscles go into uncontrolled spasms (tetny) which may be fatal**
- **Before surgeons knew the importance of these glands they would remove them when doing a thyroidectomy secondary to hyperthyroidism which many times resulting in death**
- **Blood clotting is another process that required adequate amounts of calcium**
- **A normal blood calcium level is essential for proper muscle contraction and nerve impulse transmission**



The Adrenal Glands

Figure 18.16 The Adrenal Gland



Adrenal Gland

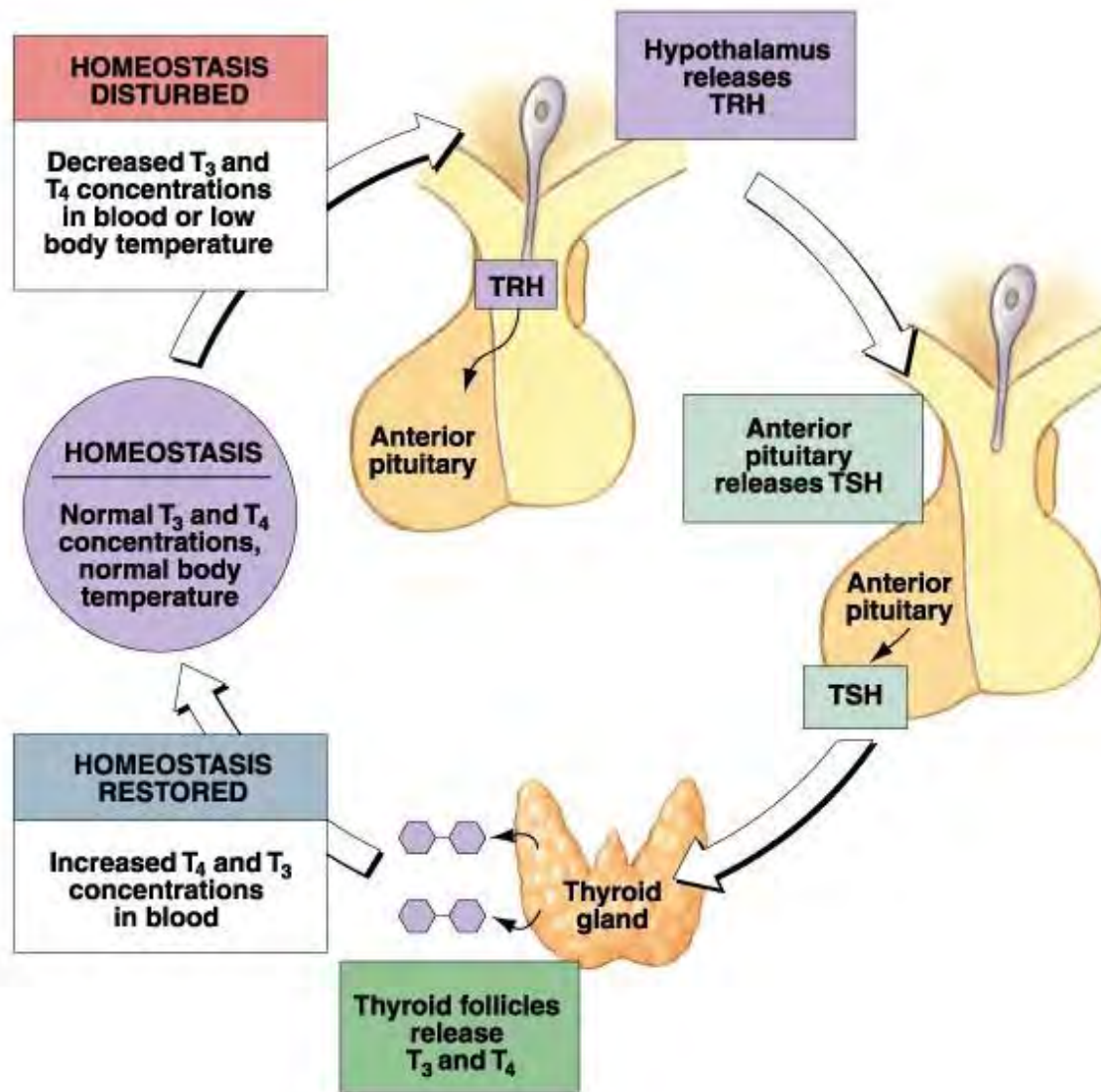
- It looks like one single organ but it is functionally two endocrine organs in one
 - Located on top of kidneys
- Rests upon each kidney
 - Regulates sodium and electrolyte balance
 - Affects carbohydrate, fat and protein metabolism
 - Influences the development of sexual characteristics
 - Sustains the flight or fight response
- Two glands
 - Cortex – outer glandular region in three layers
 - Medulla – inner neural tissue region

The Adrenal Cortex

- The inner core of the adrenal gland
- Works as part of the sympathetic nervous system
- Secretes three groups of hormones, known as the corticosteroids
- Glucocorticoids: mainly cortisol (hydrocortisone)
 - Are involved in carbohydrate, protein, and fat metabolism and body's reactions to physical and mental stress, and stimulate liver to release glucose when energy needed
 - Are targeted by ACTH from anterior pituitary gland
- The mineralocorticoids, mainly aldosterone
 - Regulate how electrolytes are processed
- Gonadocorticoids (sex hormones) are both male and female

Adrenal cortex

- Manufactures steroid hormones (corticosteroids)
- Cortex divided into three layers
 - Zona glomerulosa (produces mineralocorticoids)
 - Zona fasciculate (produces glucocorticoids)
 - Zona reticularis (produces androgens)



Roles of the Hypothalamus and Adrenal Glands in the Stress Response

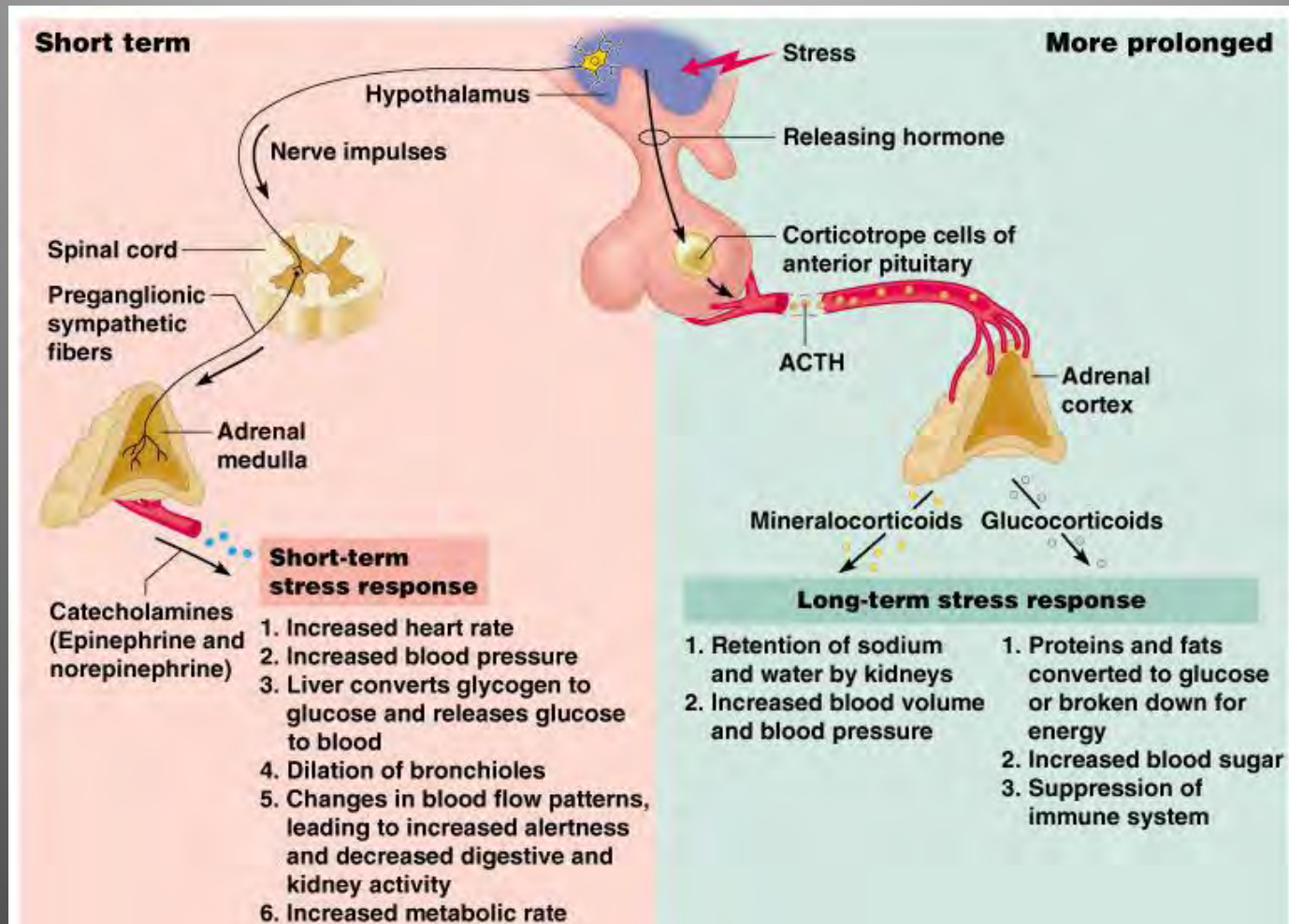


Figure 9.12

Hormones of the Adrenal Cortex

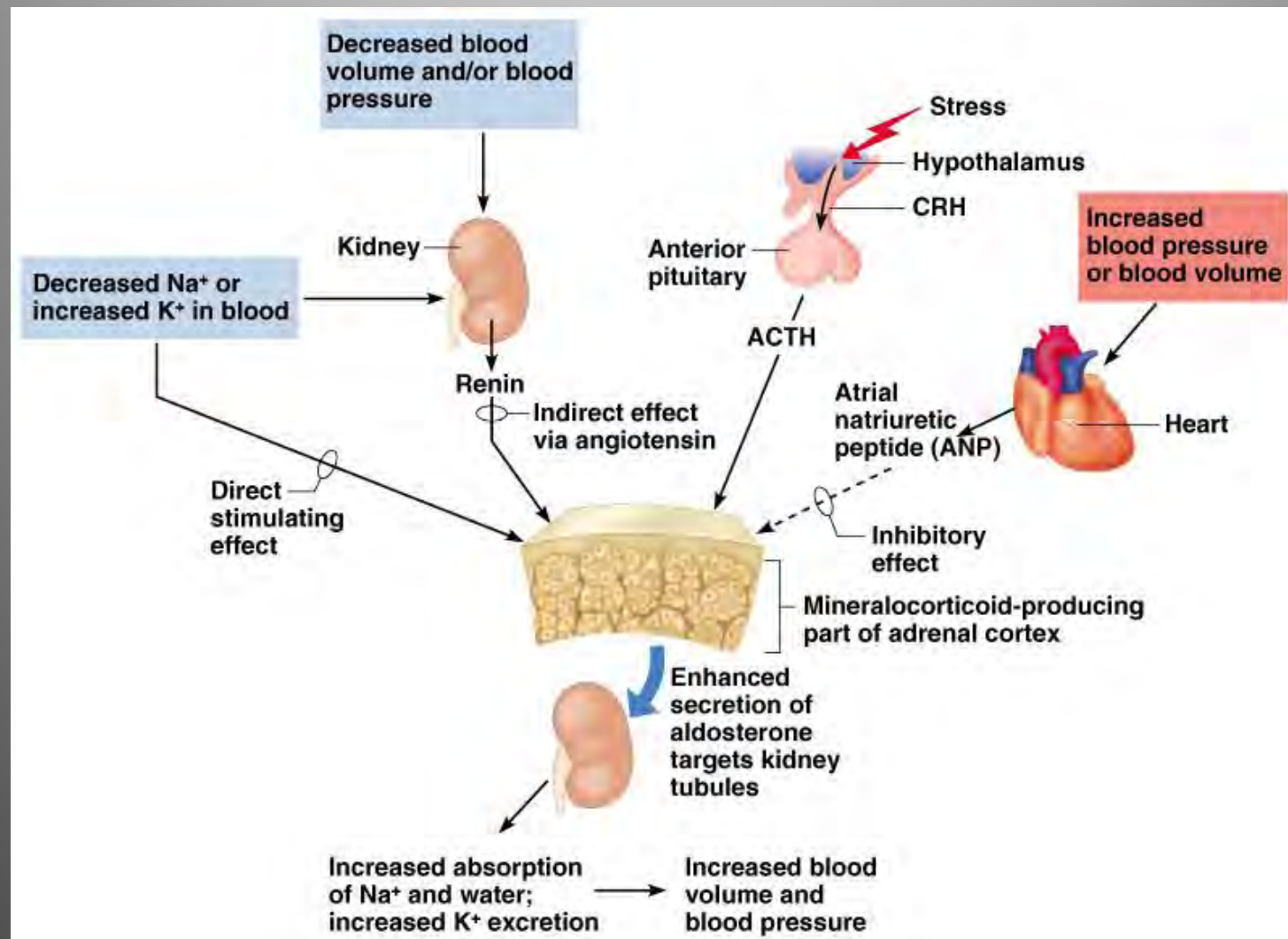


Figure 9.10

Hormones of the Adrenal Cortex

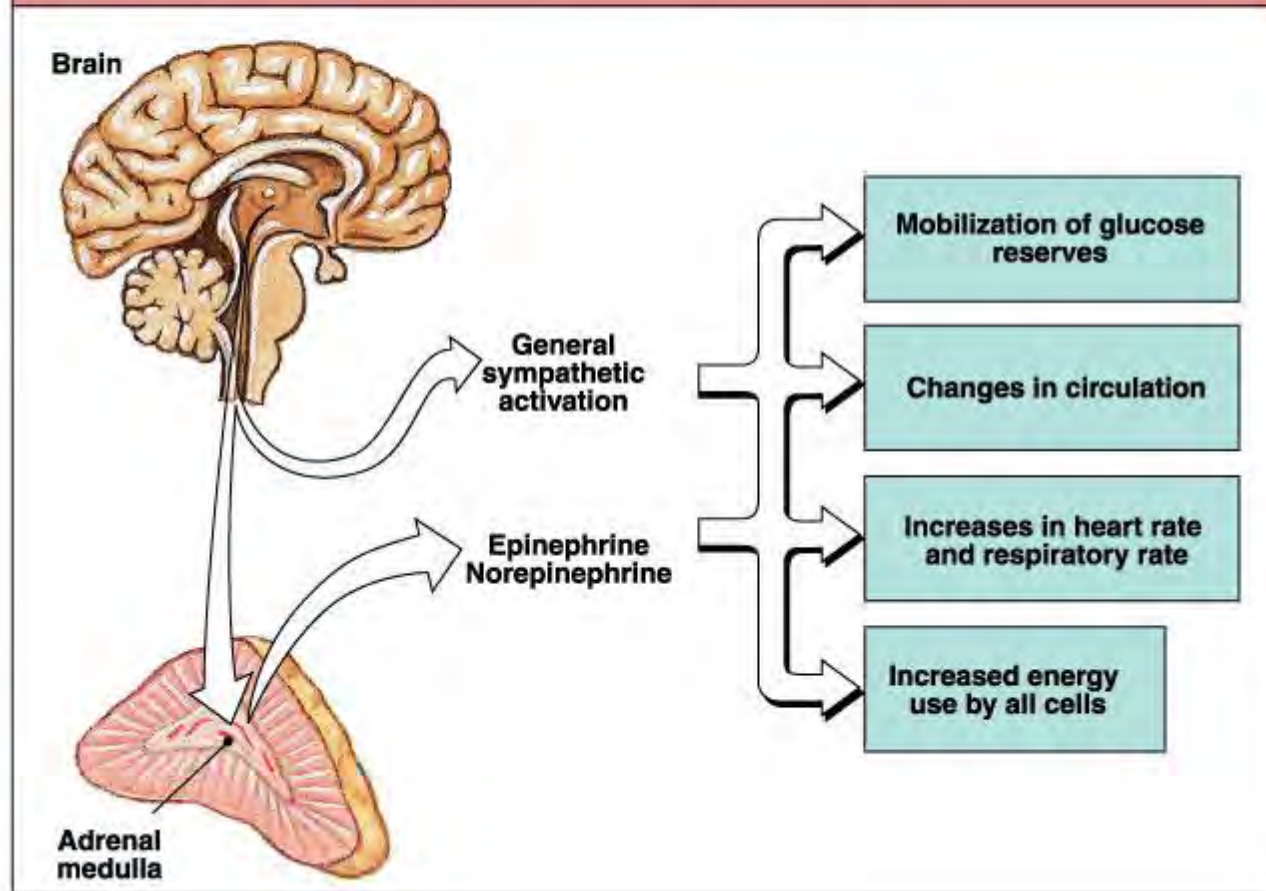
- **Glucocorticoids (including cortisone and cortisol)**
 - Produced by the middle layer of the adrenal cortex
 - Promote normal cell metabolism
 - Help resist long term stressors by increasing blood glucose levels: hyperglycemic hormones
 - Released in response to increased blood levels of ACTH
 - Cortisol helps to ensure adequate energy during stressful times
 - The direct stimulus for cortisol secretion:
 - ACTH from the anterior pituitary gland
- **Sex hormones**
 - Produced in the inner layer of the adrenal cortex
 - Androgens (male) and some estrogen (female)
 - Small amounts
 - Most body tissues – secreted in small amounts so the effect is generally masked by the hormones from the ovaries and testes

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**
 - **Mineralocorticoids – aldosterone – target is kidney which increases sodium reabsorption and potassium excretion in kidney tubules and secondarily increases water retention – help regulate both water and electrolyte balance in body fluids**

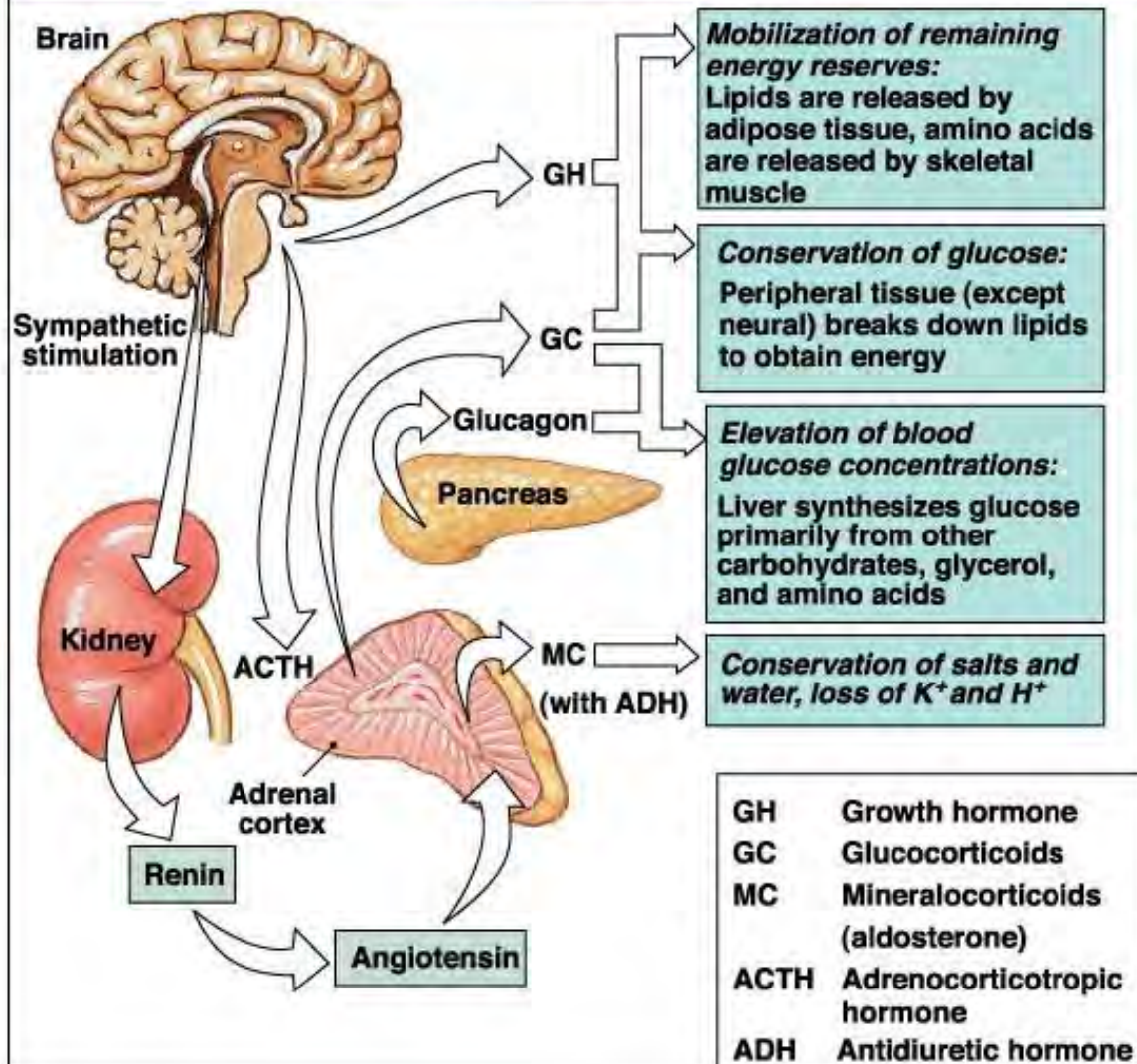
ALARM PHASE

“Fight or Flight”
Immediate short-term responses to crises



RESISTANCE PHASE

Long-term metabolic adjustments occur



Adrenal medulla

- Produces epinephrine (~75 - 80%)
- Produces norepinephrine (~25-30%)

The Adrenal Medulla

- **Secretes**
 - **Epinephrine (Adrenalin)**
 - **Norepinephrine (noradrenalin)**
- **Epinephrine and Norepinephrine**
 - **Catecholamines**
 - **Are hormones which are neurotransmitters**
 - **Released during fight or flight reaction when brain perceives threat to body**
 - **About 75 percent of secretion is epinephrine and remaining 25 percent is norepinephrine**

Epinephrine and Norepinephrine

(Catecholamines)

- **Norepinephrine**

- **Causes contraction of blood vessels and an increase in blood pressure**
- **Increases heart activity, inhibits gastrointestinal action, and dilates pupils for wider vision range**
- **Effects of norepinephrine last about 10 times longer than those of epinephrine because it is more slowly removed from the blood**

Epinephrine and Norepinephrine (Catecholamines)

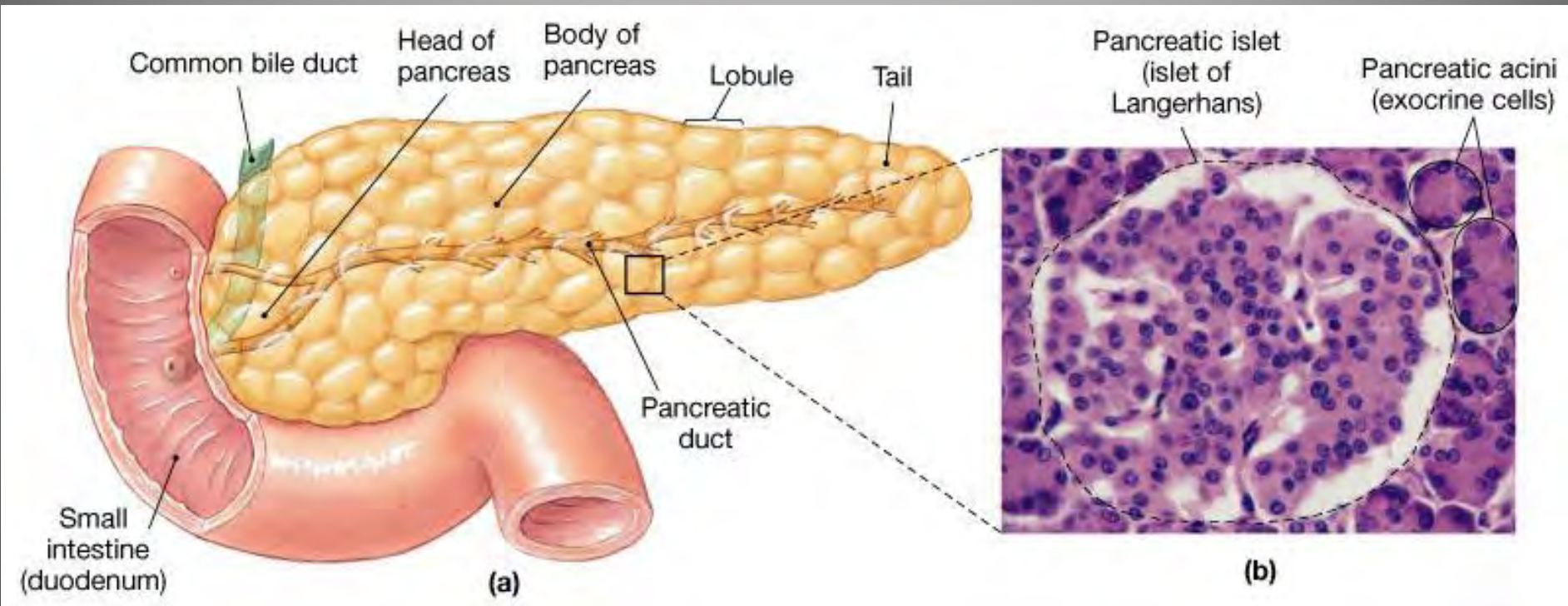
■ Epinephrine (Adrenalin)

- Increase heart rate, BP and Blood Glucose levels and dilate the passage ways of the lung
 - Inhibits gastrointestinal activity
 - Constricts arterioles in skin, causing pallor
 - Dilates blood vessels to the muscles, liver, bronchus, and heart, allowing increased activity and cardiac output
 - Works very quickly to allow for fight or flight
 - Increases body metabolism and, through gluconeogenesis, raises blood glucose level
- Pumps its hormones into the bloodstream to enhance and prolong the effects of the neurotransmitters of sympathetic and nervous system

The pancreatic islets

- Clusters of endocrine cells within the pancreas called Islets of Langerhans or pancreatic islets
 - Alpha cells secrete glucagons
 - Beta cells secrete insulin
 - Delta cells secrete GH-IH
 - F cells secrete pancreatic polypeptide

Figure 18.18 The Endocrine Pancreas



The Pancreas

- Functions as both an endocrine and an exocrine gland
- Located posterior to the liver
- Influences carbohydrate metabolism
- Indirectly influences fat and protein metabolism.
- Exocrine function of the pancreas
 - Involves secreting digestive enzymes and sodium bicarbonate that go to the duodenum through the pancreatic duct to aid in digestion
- Endocrine function of the pancreas
 - Involves production and release of insulin and glucagon

The Islets of Langerhans

- Embedded in the pancreas and secrete three hormones
 - Glucagon - alpha cells secrete glucagon, which targets liver to release glycogen, causing an increase in blood sugar.
 - Insulin - beta cells produce insulin, which moves glucose out of blood into cells. Insulin is antagonist to glucagon.
 - Somatostatin - less well known hormone causing hypoglycemic effect by interfering with release of GH and glucagon.

Pancreatic Islets

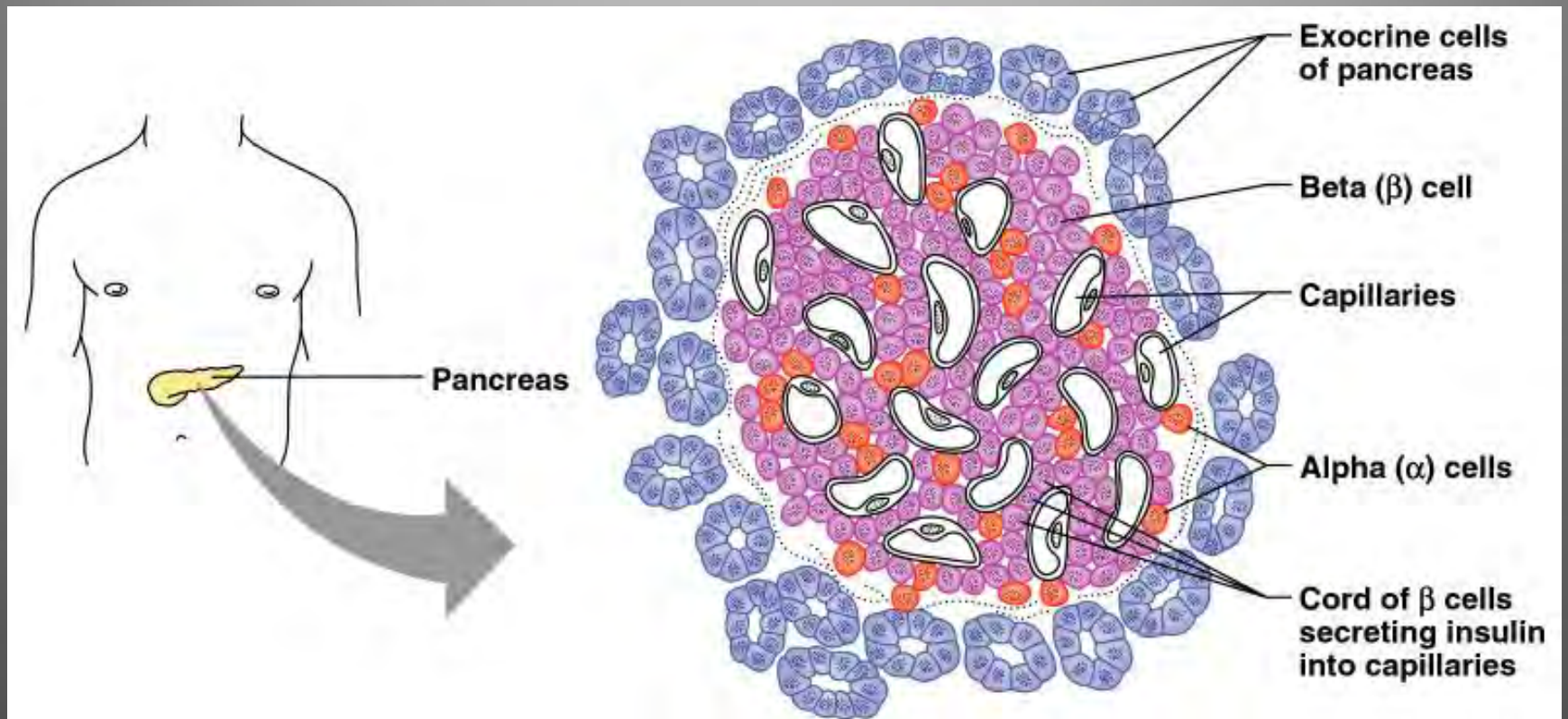


Figure 9.13

Pancreatic Hormones and Blood Sugar

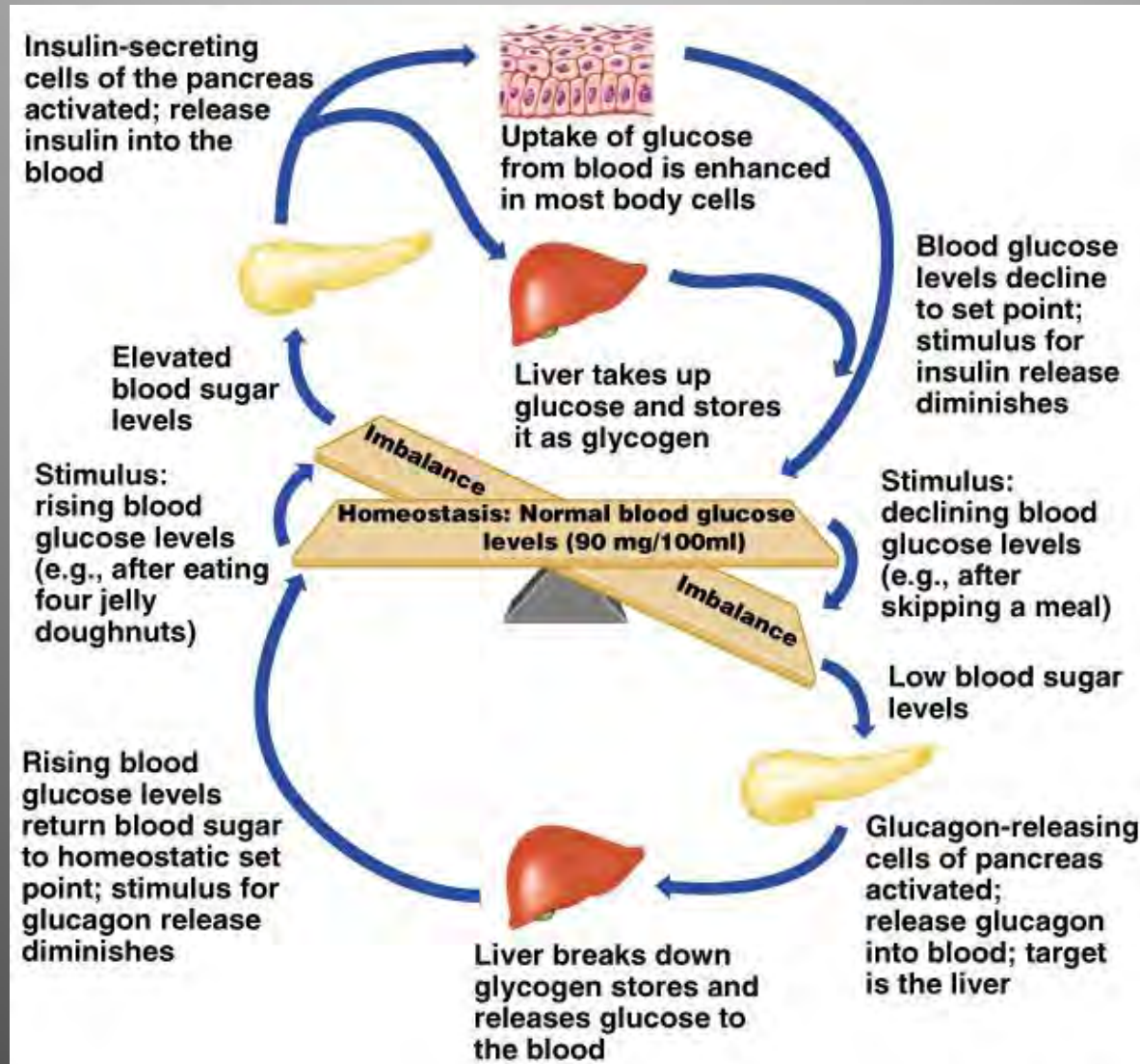
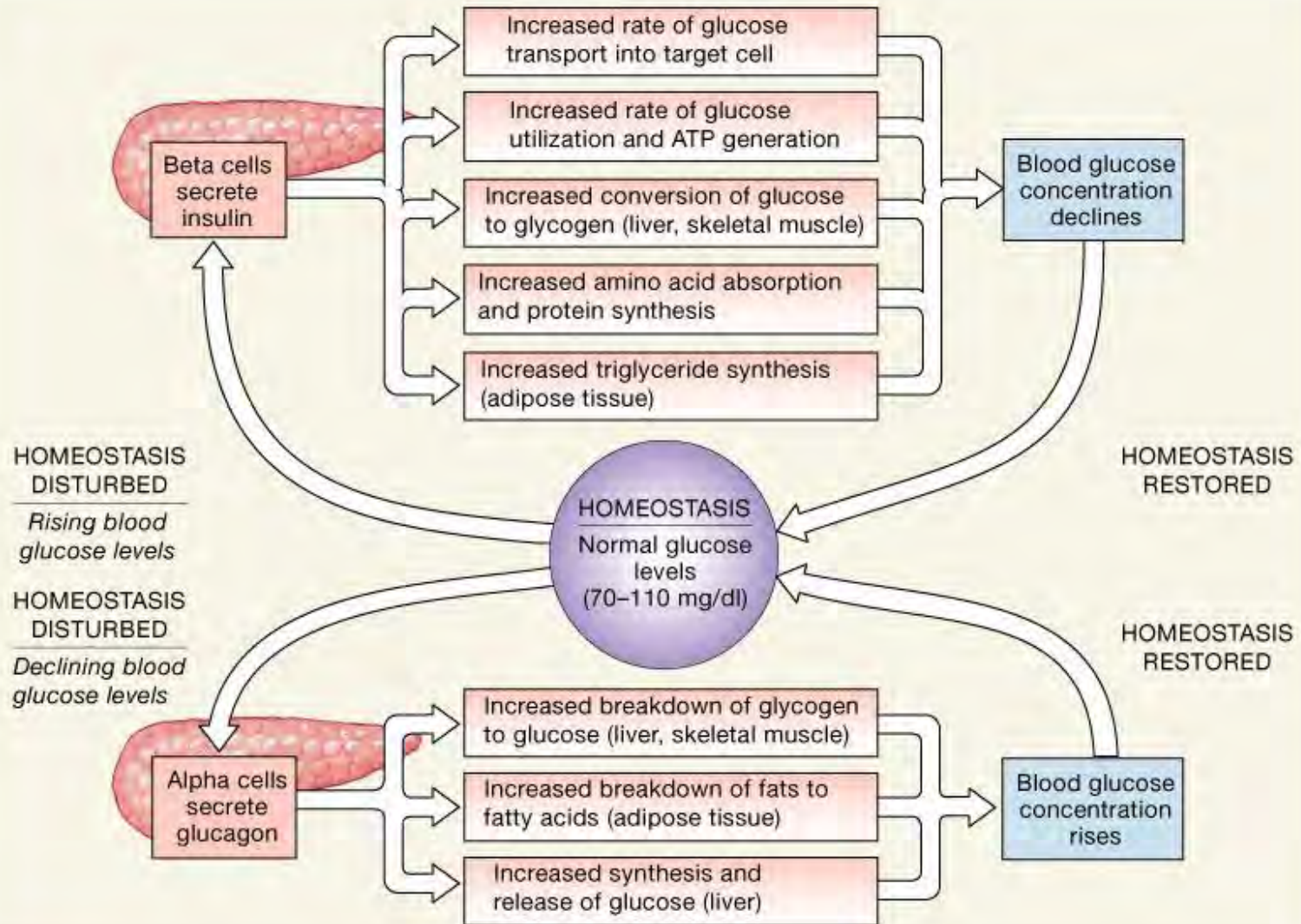


Figure 9.14

Insulin and glucagon

- Insulin lowers blood glucose by increasing the rate of glucose uptake and utilization
- Glucagon raises blood glucose by increasing the rates of glycogen breakdown and glucose manufacture by the liver

Figure 18.19 The Regulation of Blood Glucose Concentrations



The intestines

- Produce hormones important to the coordination of digestive activities

The kidneys

- Produce calcitriol and erythropoietin (EPO) and the enzyme rennin
 - Calcitriol = stimulates calcium and phosphate ion absorption along the digestive tract
 - EPO stimulates red blood cell production by bone marrow
 - Renin converts angiotensinogen to angiotensin I

Angiotensin I converted to angiotensin II in the lungs

- Stimulates adrenal production of aldosterone
- Stimulates pituitary gland release of ADH
- Promotes thirst
- Elevates blood pressure

Figure 18.20 Endocrine Functions of the Kidneys

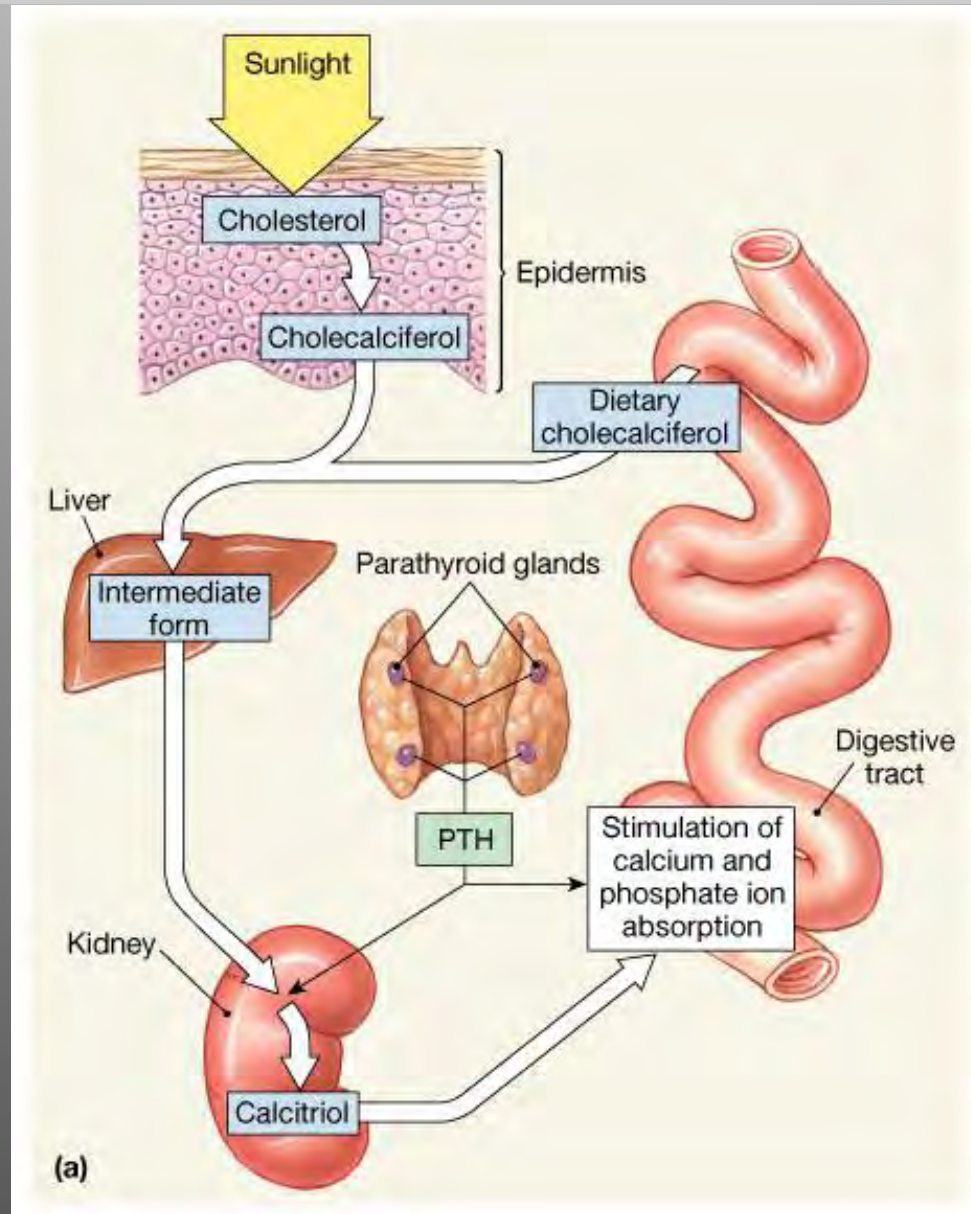
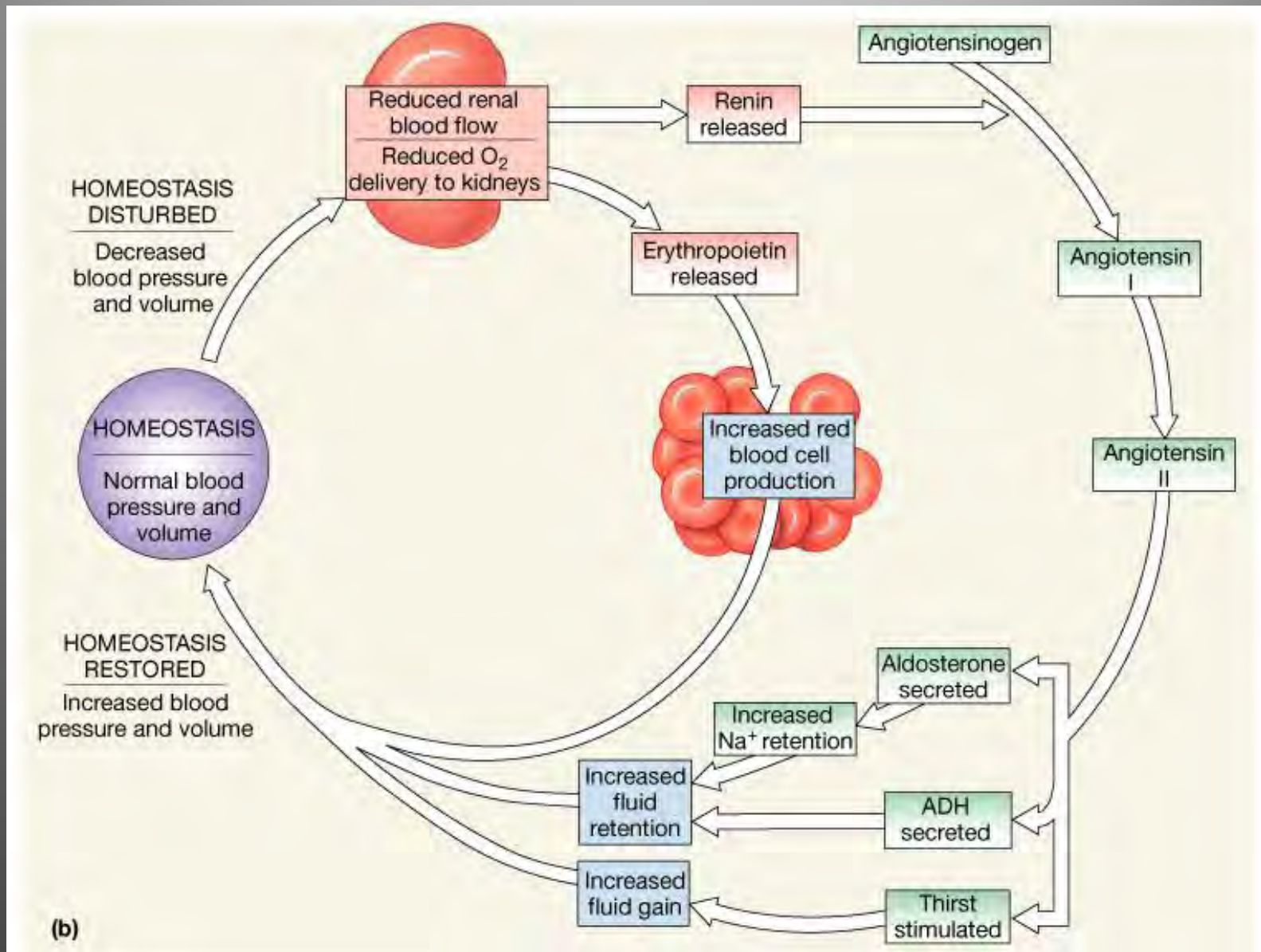


Figure 18.20 Endocrine Functions of the Kidneys



Hormones often interact, producing

- Antagonistic (opposing) effects
- Synergistic (additive) effects
- Permissive effects (one hormone is required for the other to produce its effect)
- Integrative effects (hormones produce different but complimentary results)

Hormones and growth

- Normal growth requires the interaction of several endocrine organs
- Six hormones are important
 - GH
 - Thyroid hormones
 - Insulin
 - PTH
 - Calcitriol
 - Reproductive hormones

Hormones and stress

- Stress = any condition that threatens homeostasis
- GAS (General Adaptation Syndrome) is our bodies response to stress-causing factors
- Three phases to GAS
 - Alarm phase (immediate, fight or flight, directed by the sympathetic nervous system)
 - Resistance phase (dominated by glucocorticoids)
 - Exhaustion phase (breakdown of homeostatic regulation and failure of one or more organ systems)

Figure 18.21 The General Adaptation Syndrome

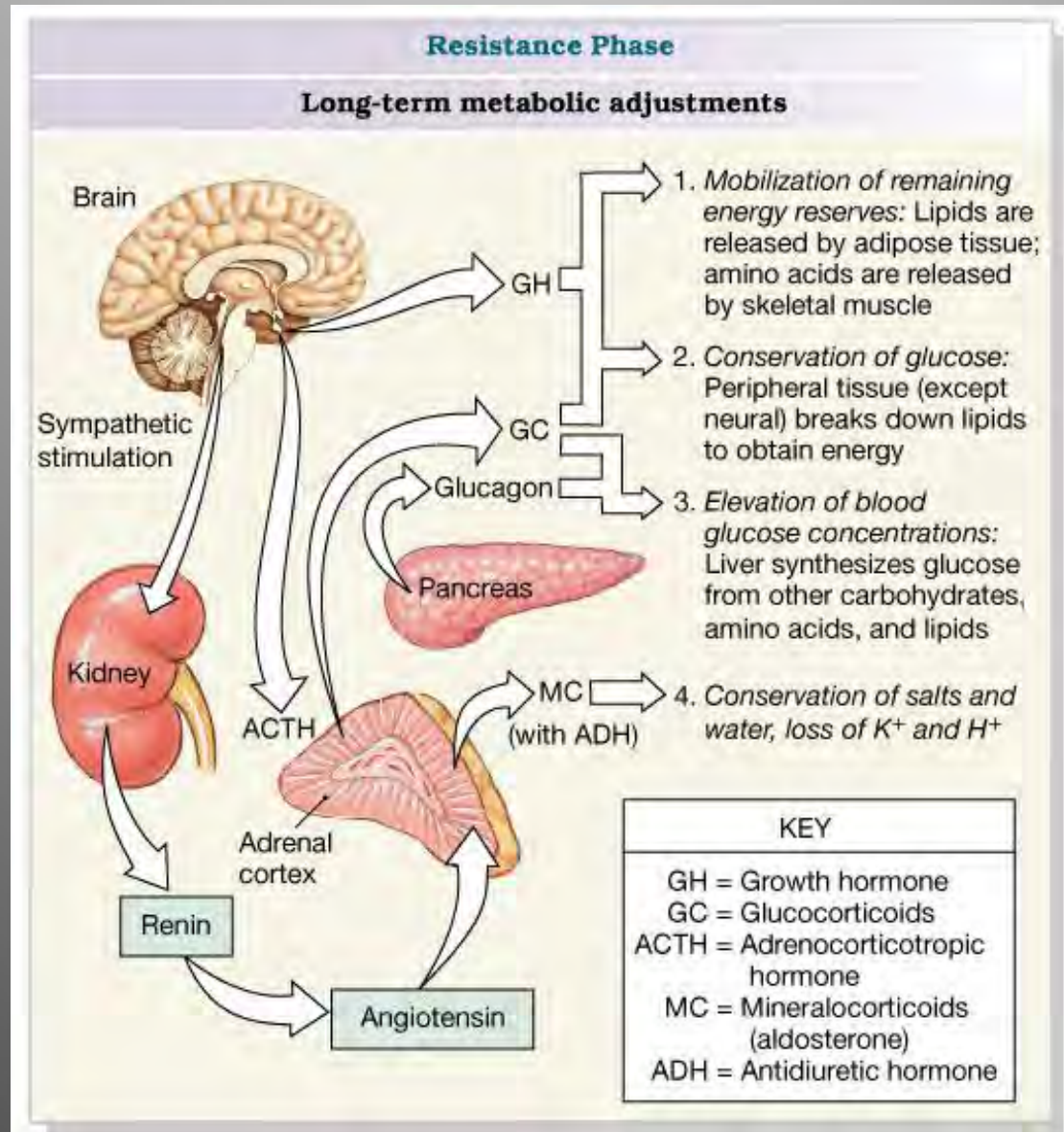
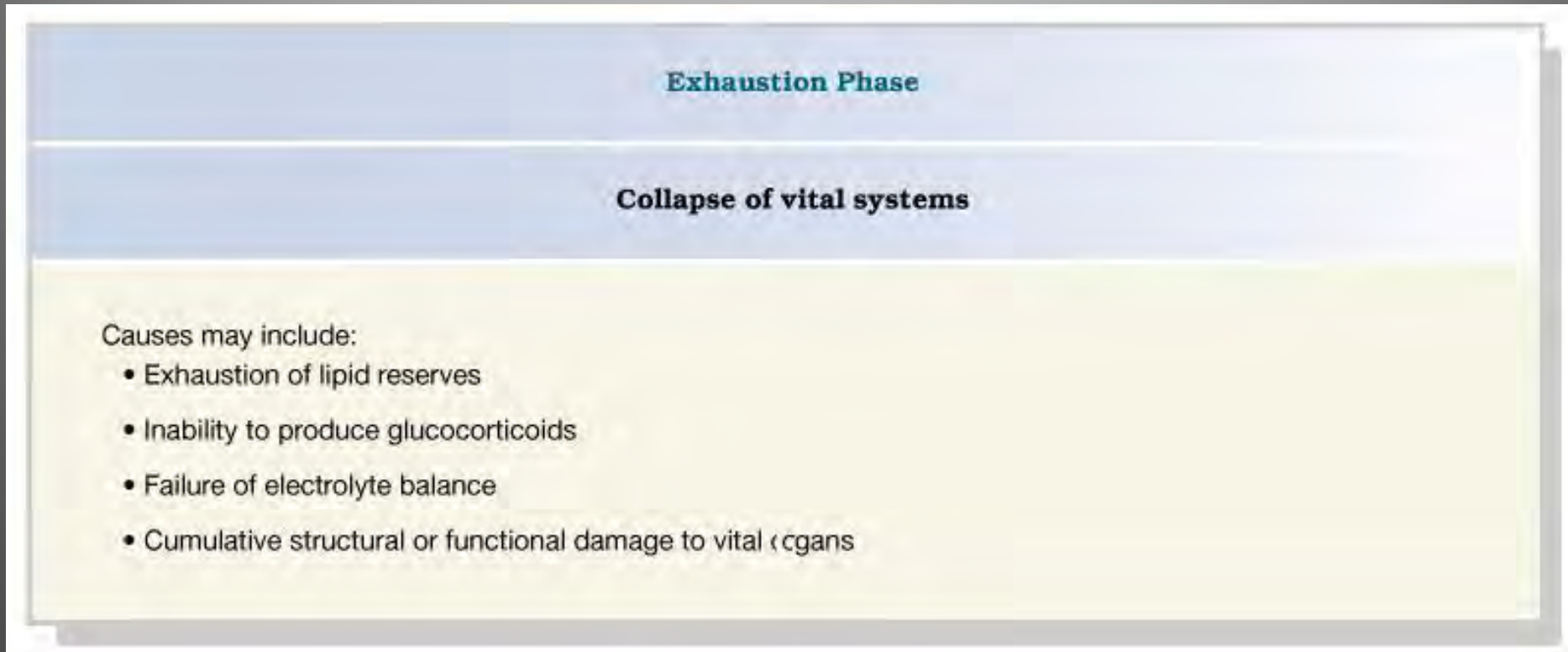


Figure 18.21 The General Adaptation Syndrome



Hormones and behavior

- Many hormones affect the CNS
- Changes in the normal mixture of hormones significantly alters intellectual capabilities, memory, learning and emotional states

Endocrine system

- Few functional changes with age
 - Chief change is a decline in concentration of reproductive hormones

You should now be familiar with:

- The major chemical classes and general mechanisms of hormones.
- The location and structure of the pituitary gland, and its structural and functional relationships with the hypothalamus.
- The location and structure of each of the endocrine glands.
- The hormones produced by each of the endocrine glands, and the functions of those hormones.

You should now be familiar with:

- The functions of the hormones produced by the kidneys, heart, thymus, testes, ovaries and adipose tissue.
- How hormones interact to produce coordinated physiological responses.

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**
- **Growth hormone production declines with age**
- **Many endocrine glands decrease output with age**