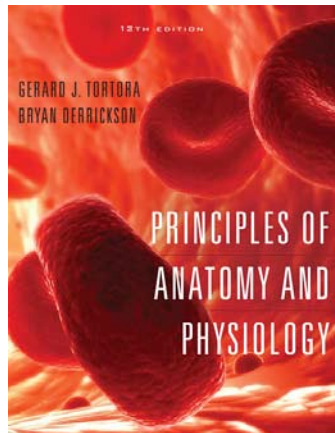


Chapter 18: The Endocrine System



Nervous and Endocrine Systems

- Act together to coordinate functions of all body systems
- Nervous system
 - Nerve impulses/ Neurotransmitters
 - Faster responses, briefer effects, acts on specific target
- Endocrine system
 - Hormone – mediator molecule released in 1 part of the body but regulates activity of cells in other parts
 - Slower responses, effects last longer, broader influence

Endocrine Glands

- 2 kinds of glands
 - Exocrine – ducted
 - Endocrine – ductless
 - Secrete products into interstitial fluid, diffuse into blood
- Endocrine glands include
 - Pituitary, thyroid, parathyroid, adrenal and pineal glands
 - Hypothalamus, thymus, pancreas, ovaries, testes, kidneys, stomach, liver, small intestine, skin, heart, adipose tissue, and placenta not exclusively endocrine glands

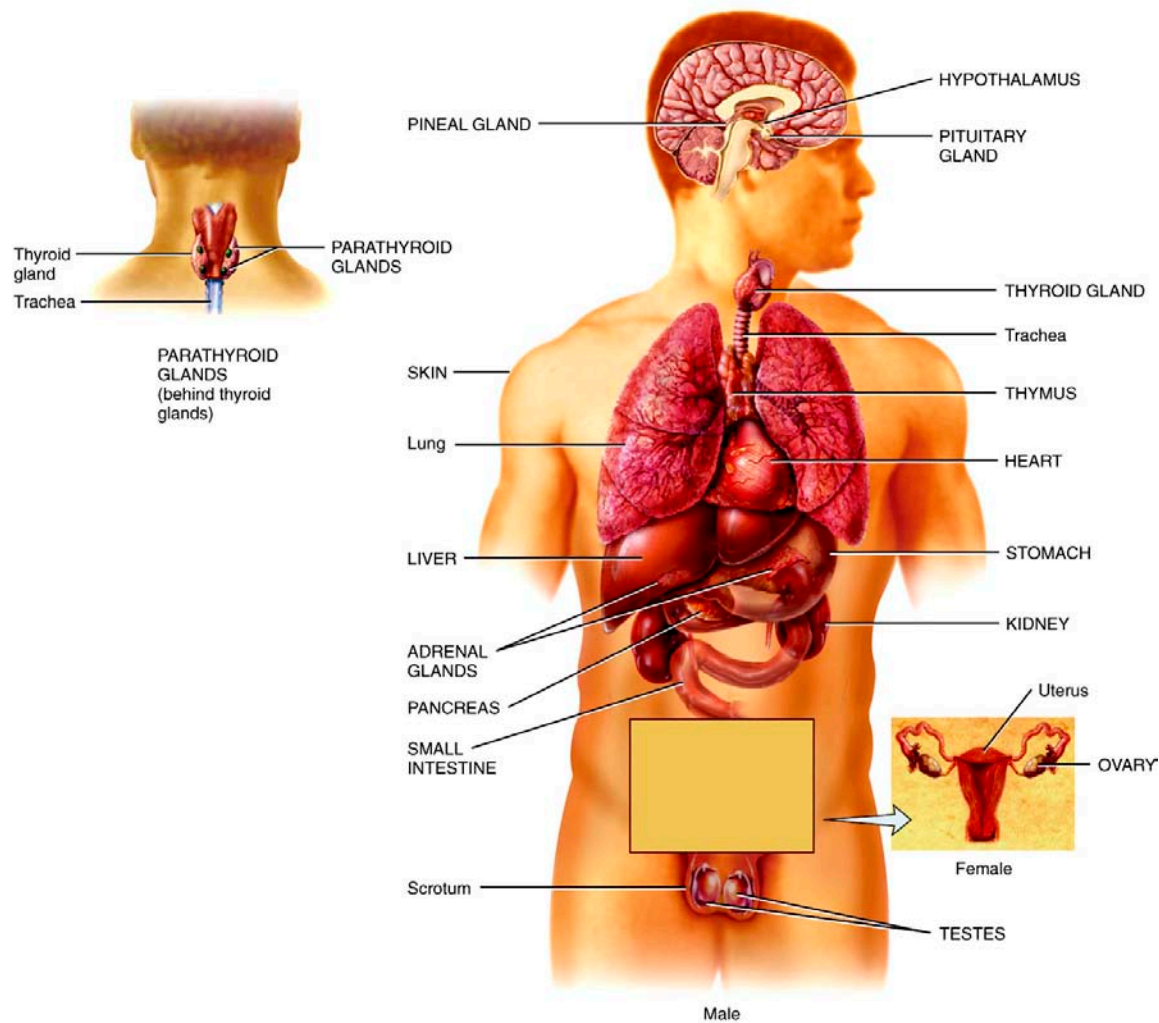
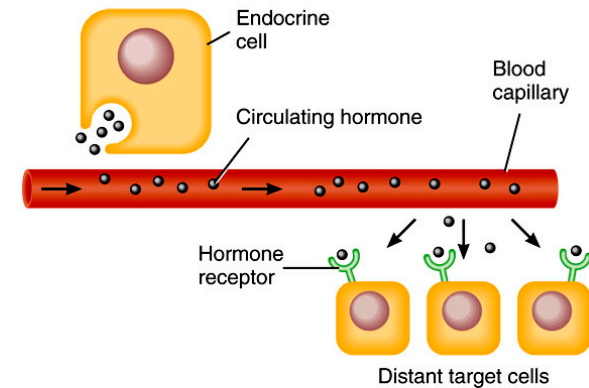


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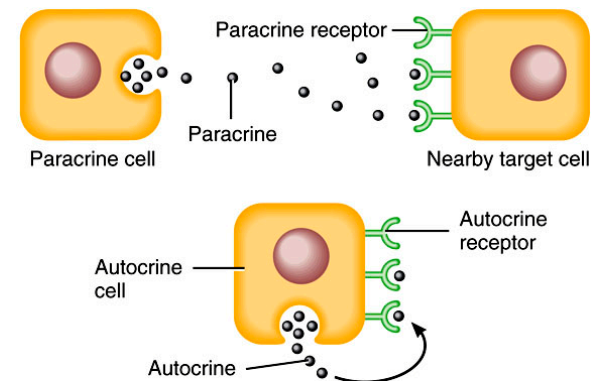
Hormone Activity

- Hormones affect only specific target tissues with specific receptors
- Receptors constantly synthesized and broken down
 - Down-regulation
 - Up-regulation

- Hormone types
 - Circulating – circulate in blood throughout body
 - Local hormones – act locally
 - Paracrine – act on neighboring cells
 - Autocrine – act on the same cell that secreted them



(a) Circulating hormones



(b) Local hormones (paracrine and autocrine)

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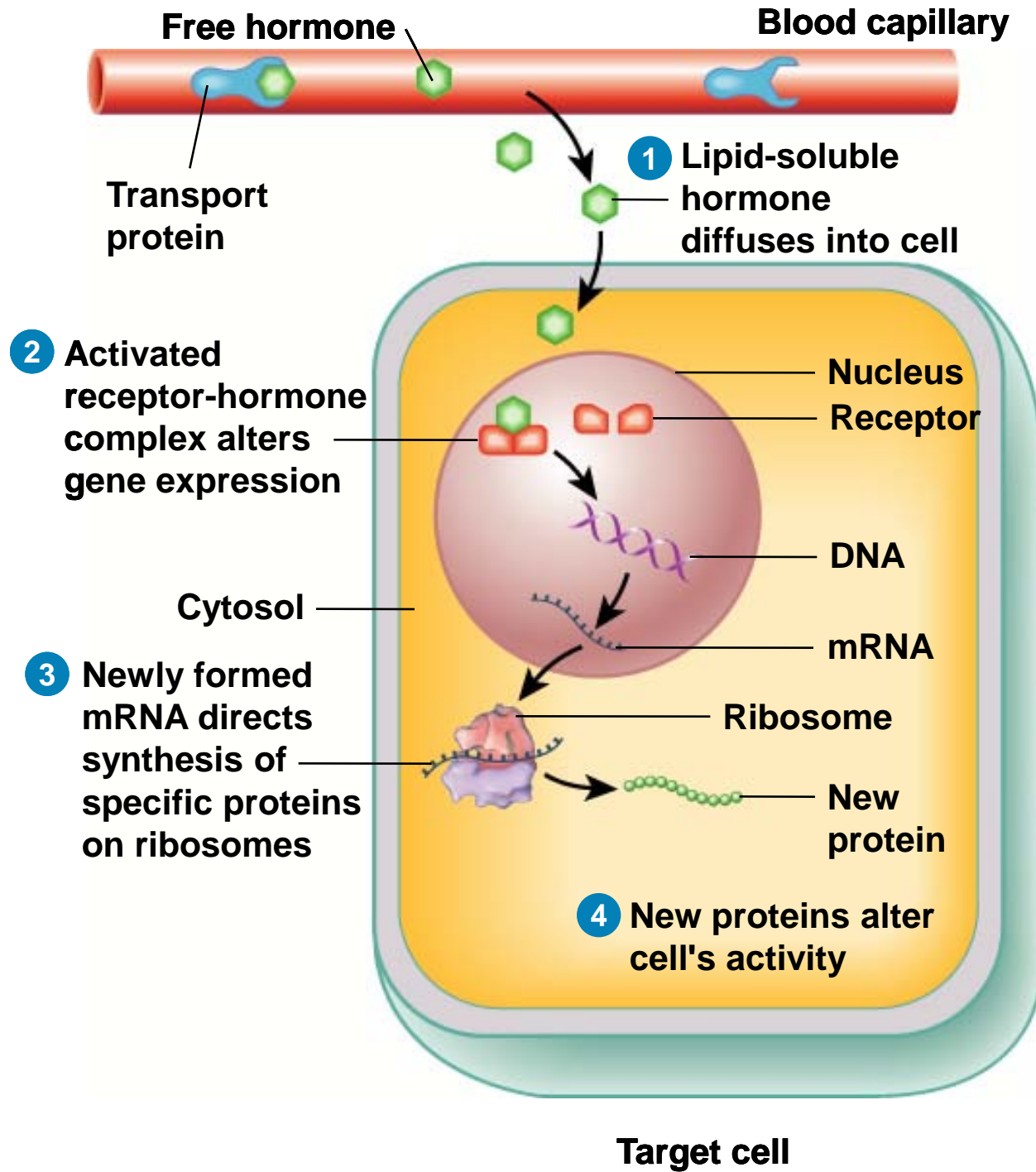
Chemical classes of hormones

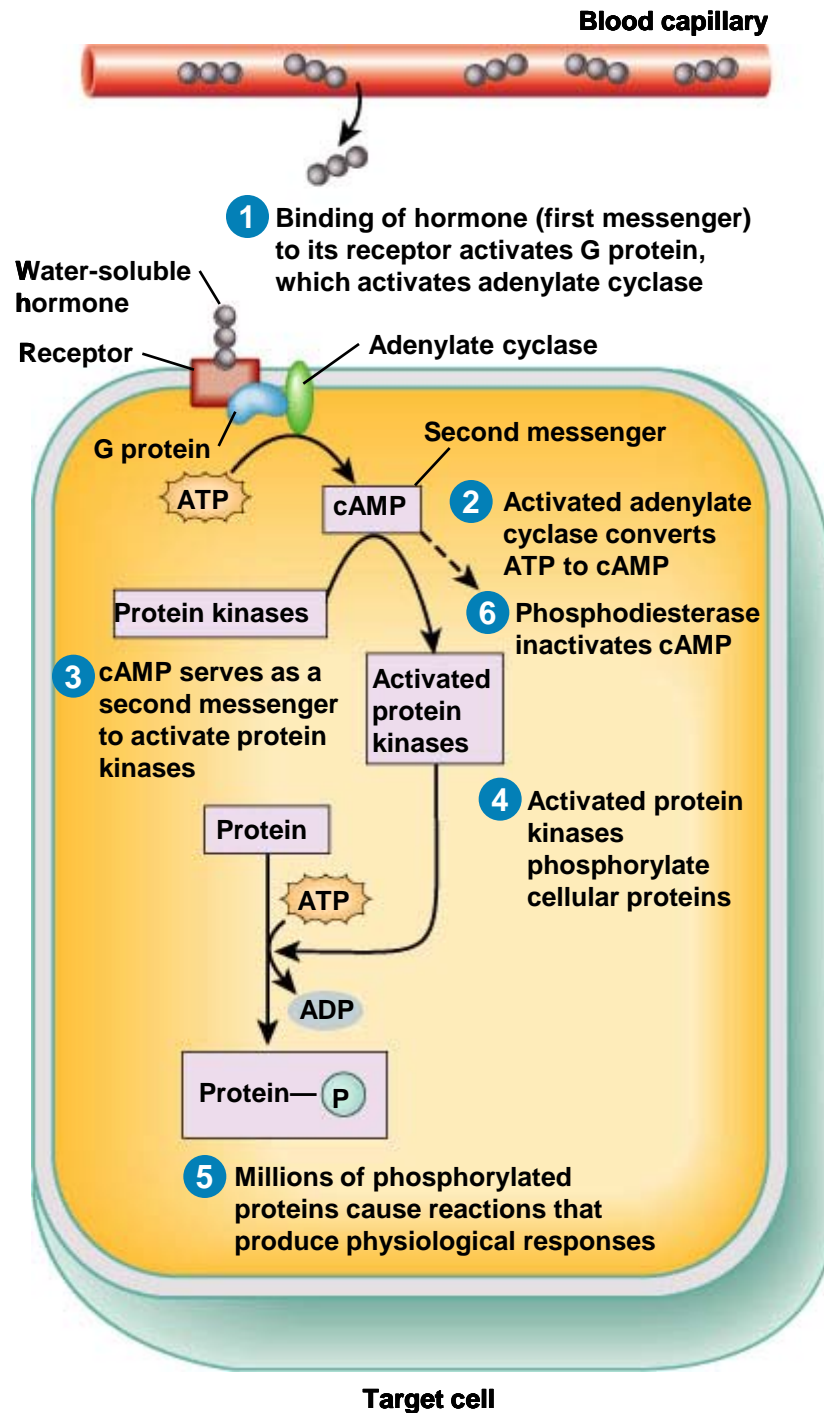
- Lipid-soluble – use transport proteins
 - Steroid
 - Thyroid
 - Nitric oxide (NO)
- Water-soluble – circulate in “free” form
 - Amine
 - Peptide/ protein
 - Eicosanoid

Mechanisms of Hormone Action

- Response depends on both hormone and target cell
- Lipid-soluble hormones bind to receptors inside target cells
- Water-soluble hormones bind to receptors on the plasma membrane
 - Activates second messenger system
 - Amplification of original small signal
- Responsiveness of target cell depends on
 - Hormone's concentration
 - Abundance of target cell receptors
 - Influence exerted by other hormones
 - Permissive, synergistic and antagonistic effects

Lipid-soluble and Water-soluble Hormones





Control of Hormone Secretion

- Regulated by
 - Signals from nervous system
 - Chemical changes in the blood
 - Other hormones
- Most hormonal regulation by negative feedback
 - Few examples of positive feedback

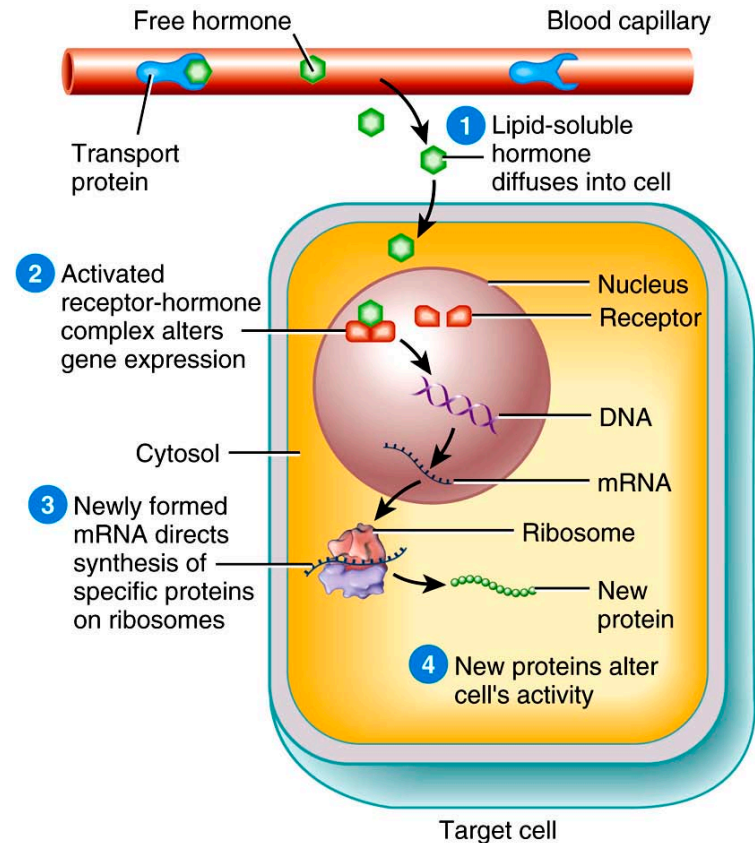


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Hypothalamus and Pituitary Gland

- Hypothalamus is a major link between nervous and endocrine system
- Pituitary attached to hypothalamus by infundibulum
 - Anterior pituitary or adenohypophysis
 - Posterior pituitary or neurohypophysis

Hypothalamus and Pituitary Gland

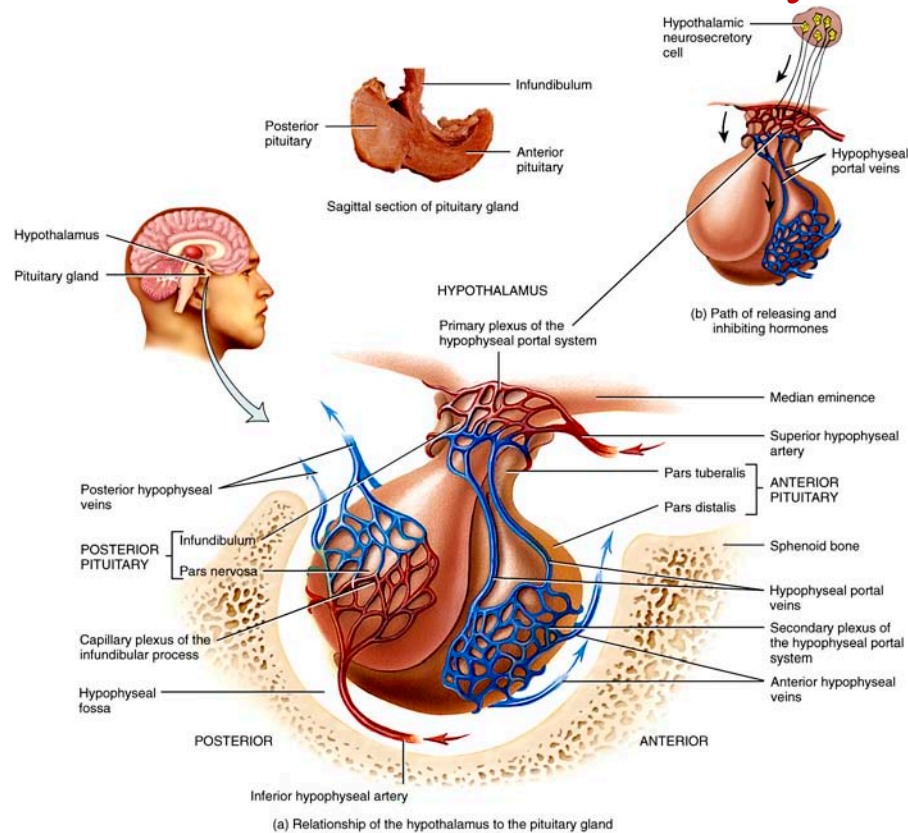


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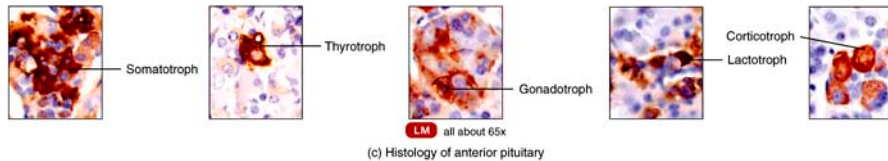


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Anterior pituitary

- ❑ Release of hormones stimulated by releasing and inhibiting hormones from the hypothalamus
- ❑ Also regulated by negative feedback
- ❑ Hypothalamic hormones made by neurosecretory cells transported by hypophyseal portal system
- ❑ Anterior pituitary hormones that act on other endocrine systems called tropic hormones

Hormones of the Anterior Pituitary

- Human growth hormone (hGH) or somatostatin
 - Stimulates secretion of insulin-like growth factors (IGFs) that promote growth, protein synthesis
- Thyroid-stimulating hormone (TSH) or thyrotropin
 - Stimulates synthesis and secretion of thyroid hormones by thyroid
- Follicle-stimulating hormone (FSH)
 - Ovaries initiates development of oocytes, testes stimulates testosterone production
- Luteinizing hormone (LH)
 - Ovaries stimulates ovulation, testes stimulates testosterone production

Hormones of the Anterior Pituitary

- Prolactin (PRL)
 - Promotes milk secretion by mammary glands
- Adrenocorticotrophic hormone (ACTH) or corticotropin
 - Stimulates glucocorticoid secretion by adrenal cortex
- Melanocyte-stimulating Hormone (MSH)
 - Unknown role in humans

Negative Feedback Regulation

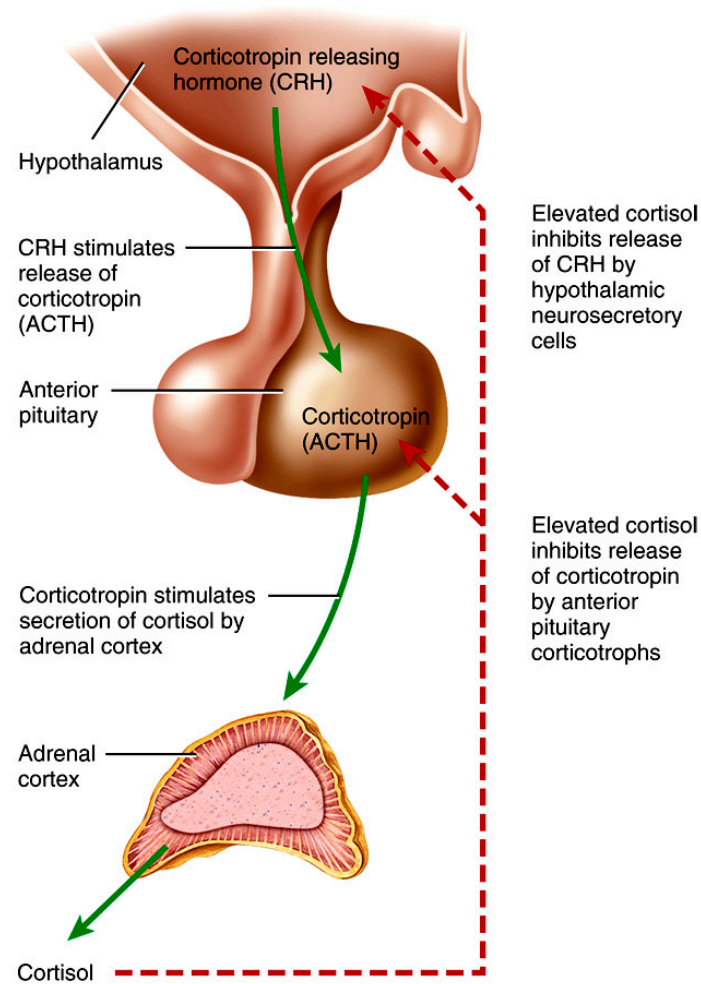
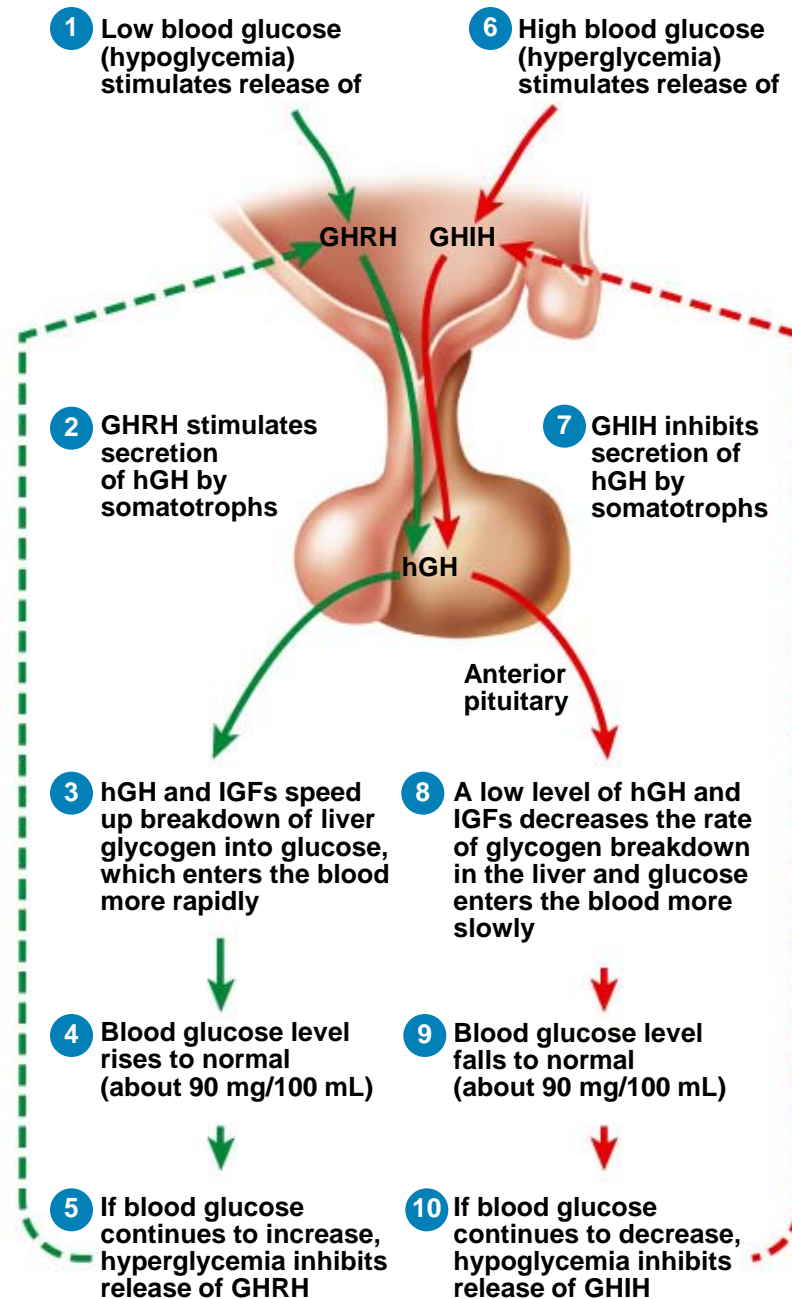


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Effects of hGH and IGFs



Posterior pituitary

- ❑ Does not synthesize hormones
- ❑ Stores and releases hormones made by the hypothalamus
 - Transported along hypothalamohypophyseal tract
- ❑ Oxytocin (OT)
- ❑ Antidiuretic hormone (ADH) or vasopressin

Hypothalamohypophyseal tract

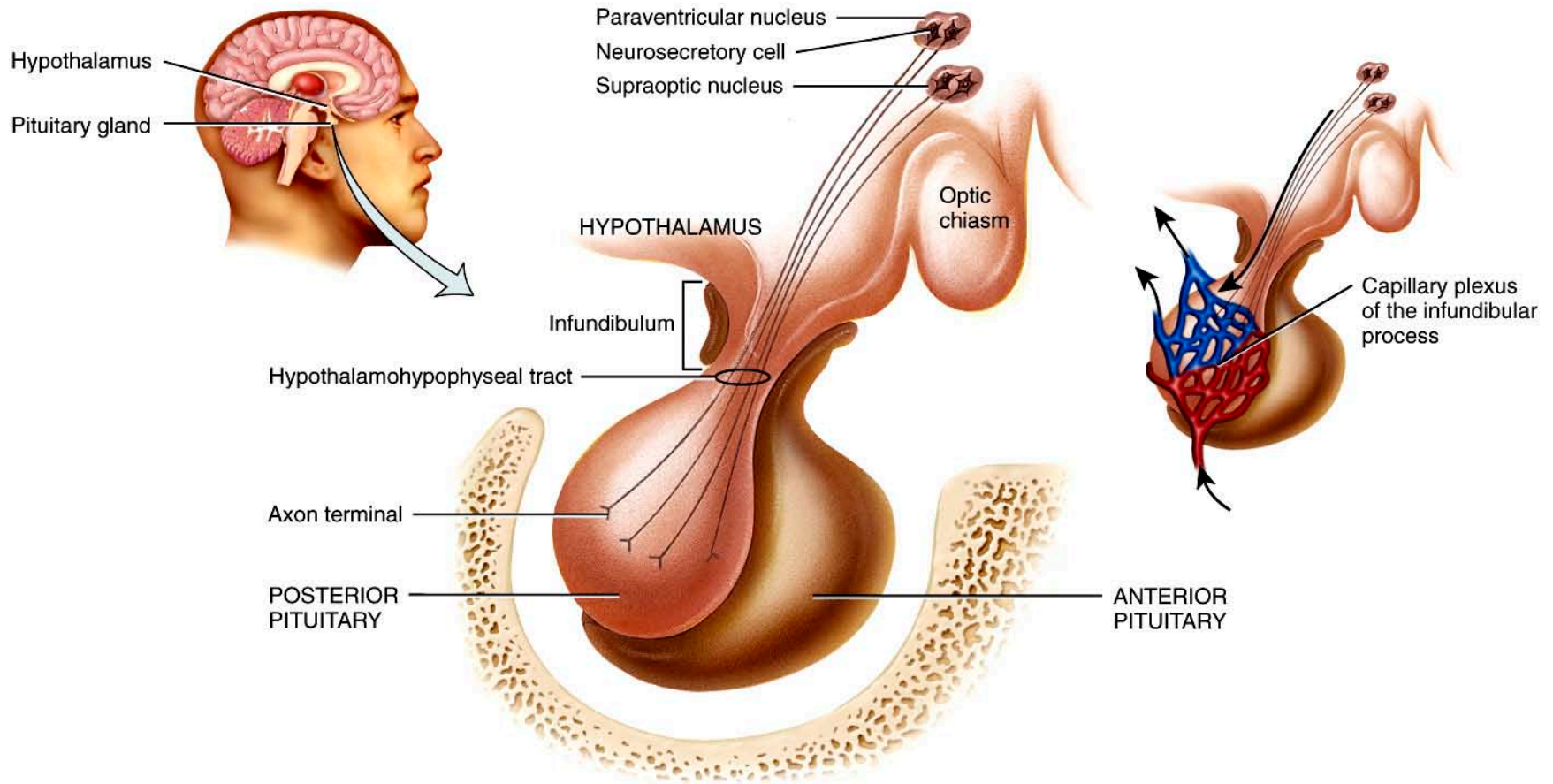


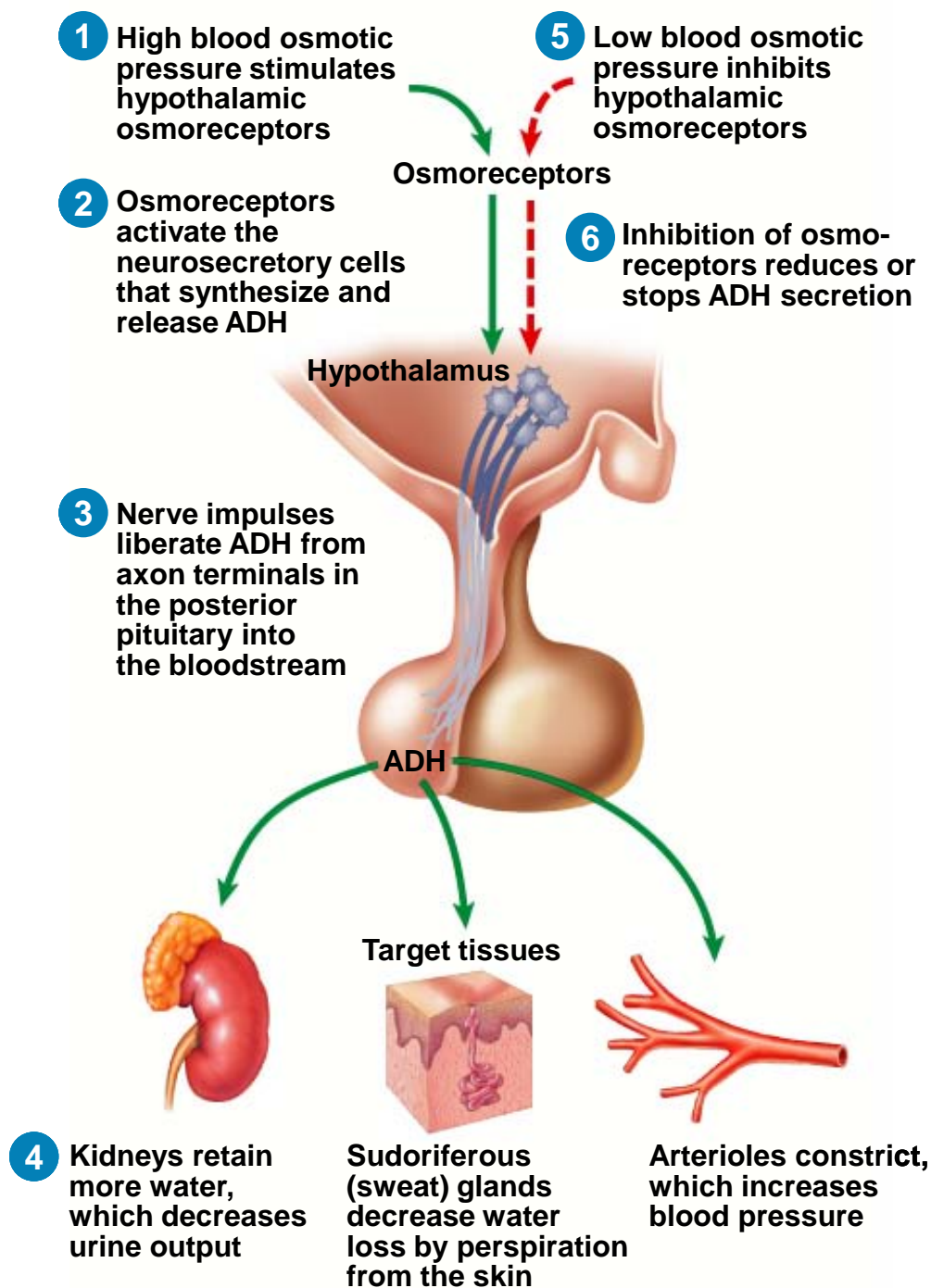
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Oxytocin (OT)

- ❑ During and after delivery of baby affects uterus and breasts
- ❑ Enhances smooth muscle contraction in wall of uterus
- ❑ Stimulates milk ejection from mammary glands

Antidiuretic Hormone (ADH)

- ❑ Decreases urine production by causing the kidneys to return more water to the blood
- ❑ Also decreases water lost through sweating and constriction of arterioles which increases blood pressure (vasopressin)



Thyroid Gland

- Located inferior to larynx
- 2 lobes connected by isthmus
- Thyroid follicles produce thyroid hormones
 - Thyroxine or tetraiodothyronine (T_4)
 - Triiodothyronine (T_3)
 - Both increase BMR, stimulate protein synthesis, increase use of glucose and fatty acids for ATP production
- Parafollicular cells or C cells produce calcitonin
 - Lowers blood Ca^{2+} by inhibiting bone resorption

Thyroid Gland

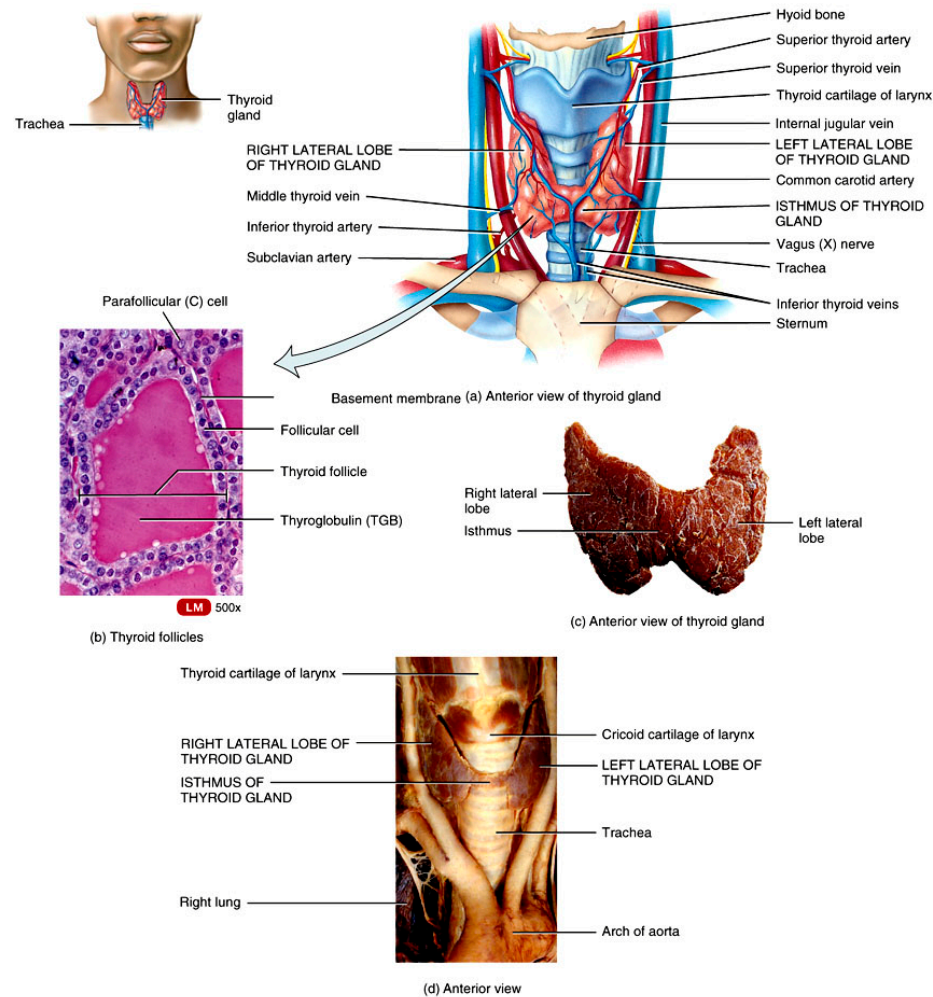
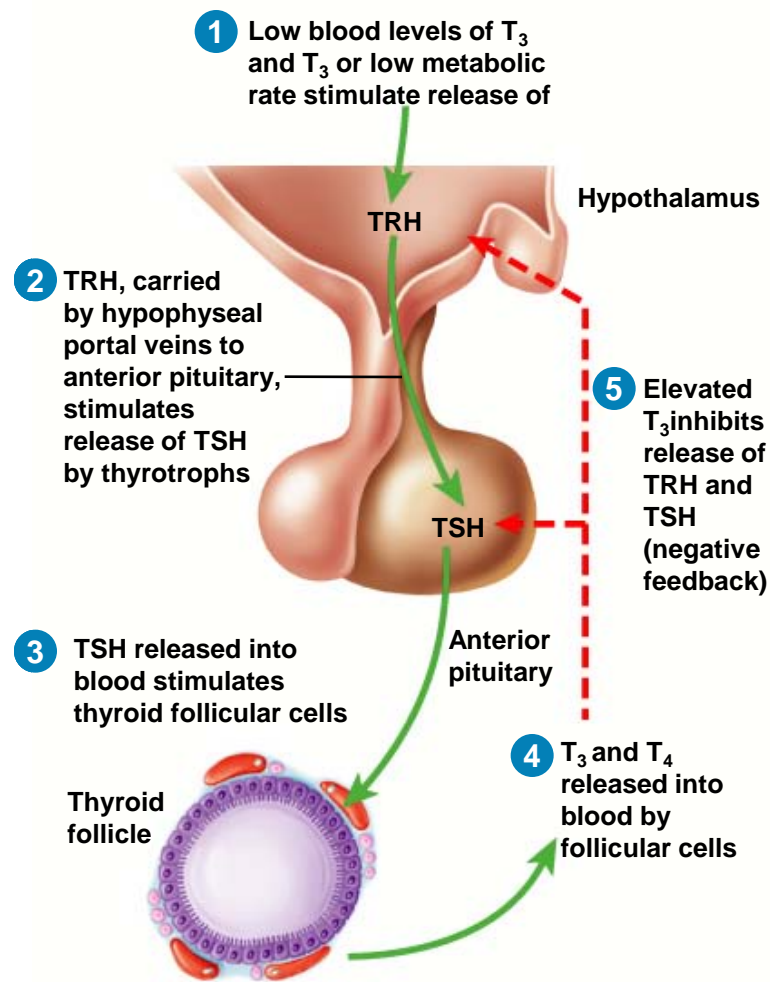


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Control of thyroid hormone secretion

- ❑ Thyrotropin-releasing hormone (TRH) from hypothalamus
- ❑ Thyroid-stimulating hormone (TSH) from anterior pituitary
- ❑ Situations that increase ATP demand also increase secretion of thyroid hormones



Actions of Thyroid Hormones:

- Increase basal metabolic rate**
- Stimulate synthesis of Na^+/K^+ ATPase**
- Increase body temperature (calorigenic effect)**
- Stimulate protein synthesis**
- Increase the use of glucose and fatty acids for ATP production**
- Stimulate lipolysis**
- Enhance some actions of catecholamines**
- Regulate development and growth of nervous tissue and bones**

Parathyroid Glands

- Embedded in lobes of thyroid gland
- Usually 4
- Parathyroid hormone (PTH) or parathormone
 - Major regulator of calcium, magnesium, and phosphate ions in the blood
 - Increases number and activity of osteoclasts
 - Elevates bone resorption
- Blood calcium level directly controls secretion of both calcitonin and PTH via negative feedback

Parathyroid Glands

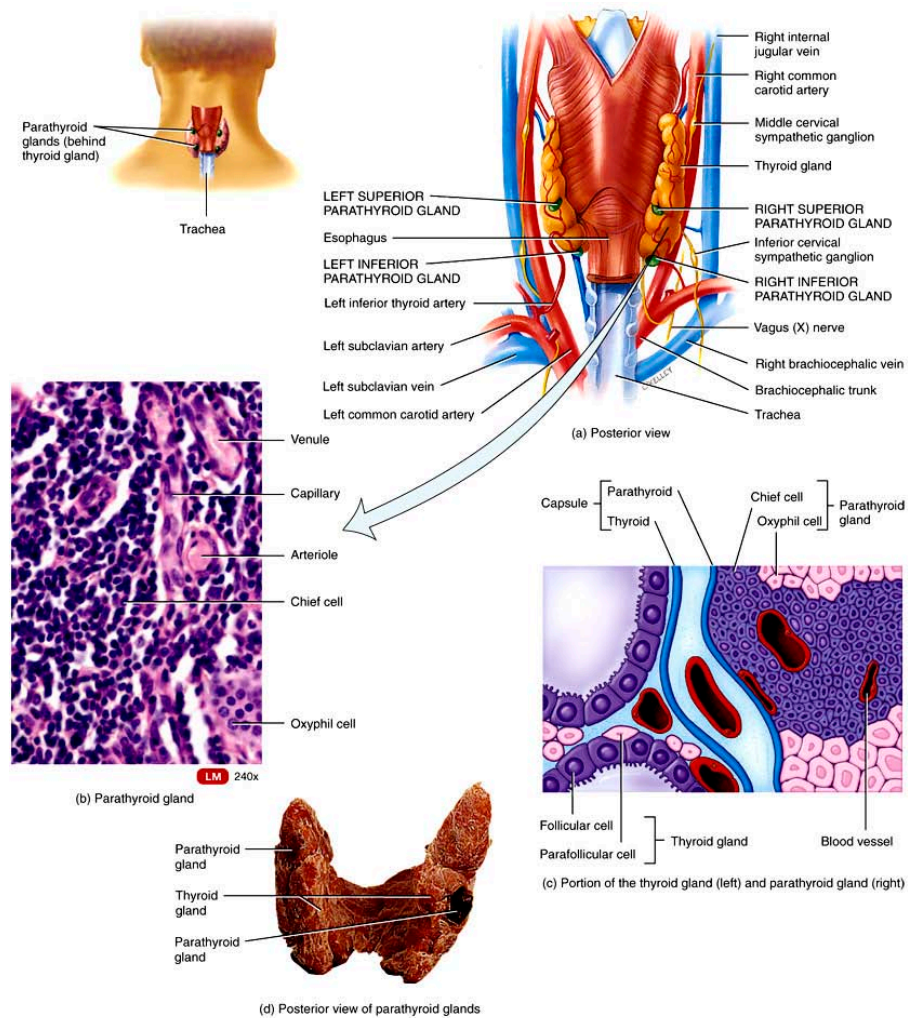
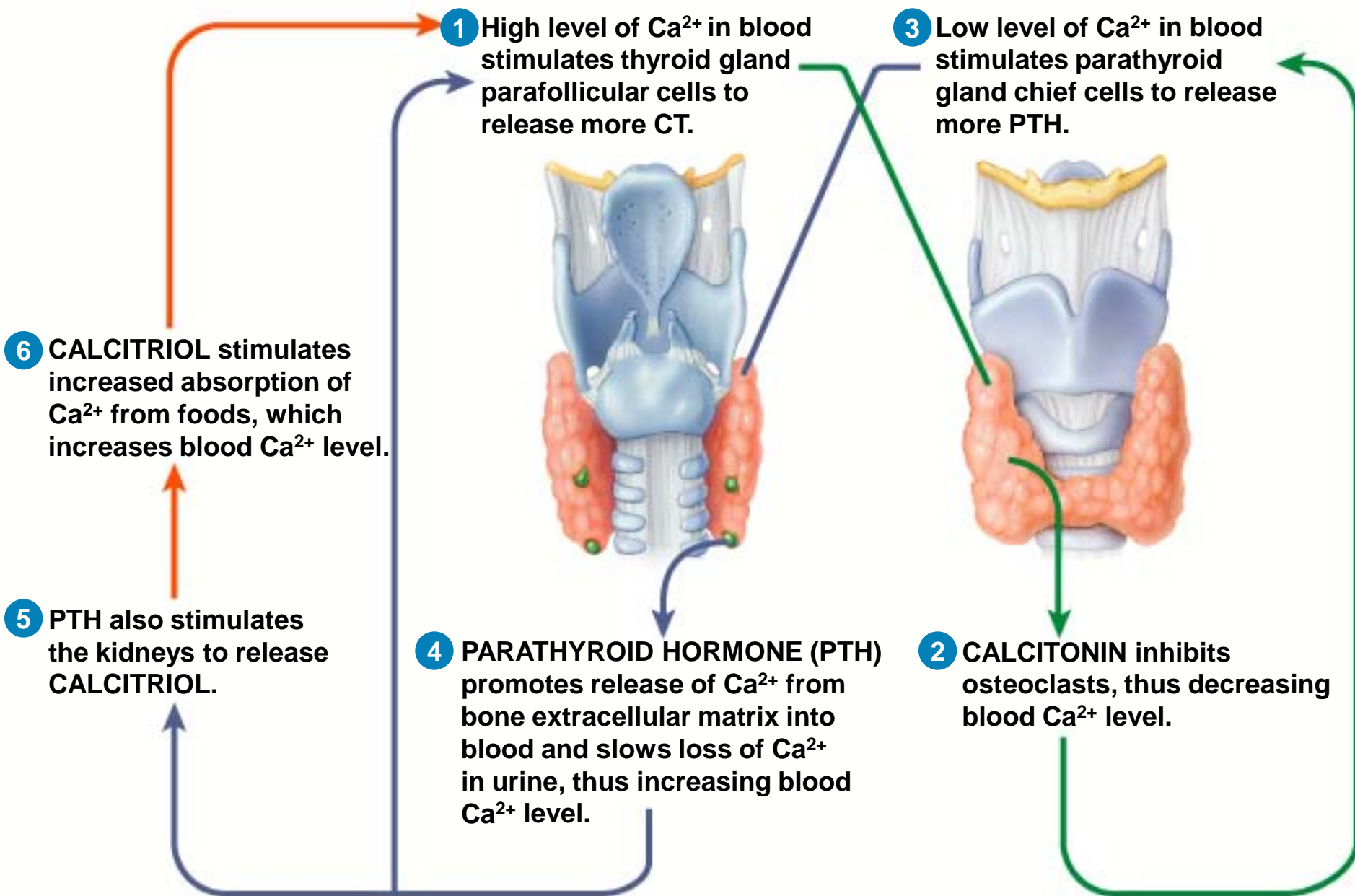


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Roles of Calcitonin, Parathyroid hormone, Calcitriol in Calcium Homeostasis



Adrenal Glands

- 2 structurally and functionally distinct regions
 - Adrenal cortex
 - Mineralocorticoids affect mineral homeostasis
 - Glucocorticoids affect glucose homeostasis
 - cortisol
 - Androgens have masculinizing effects
 - Dehydroepiandrosterone (DHEA) only important in females
 - Adrenal medulla
 - Modified sympathetic ganglion of autonomic nervous system
 - Intensifies sympathetic responses
 - Epinephrine and norepinephrine

Adrenal Glands

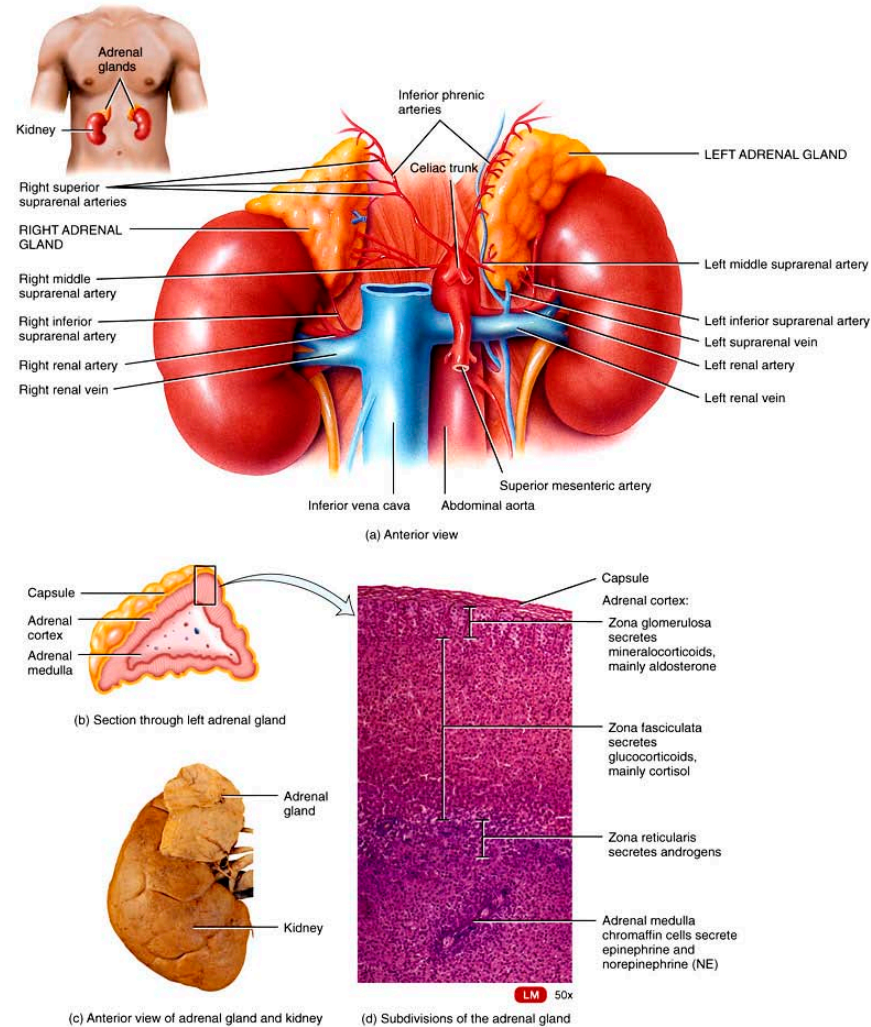


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Pancreatic Islets

- Both exocrine and endocrine gland
- Roughly 99% of cells produce digestive enzymes
- Pancreatic islets or islets of Langerhans
 - Alpha or A cells secrete glucagon – raises blood sugar
 - Beta or B cells secrete insulin – lowers blood sugar
 - Delta or D cells secrete somatostatin – inhibits both insulin and glucagon
 - F cells secrete pancreatic polypeptide – inhibits somatostatin, gallbladder contraction, and secretion of pancreatic digestive enzymes

Pancreas

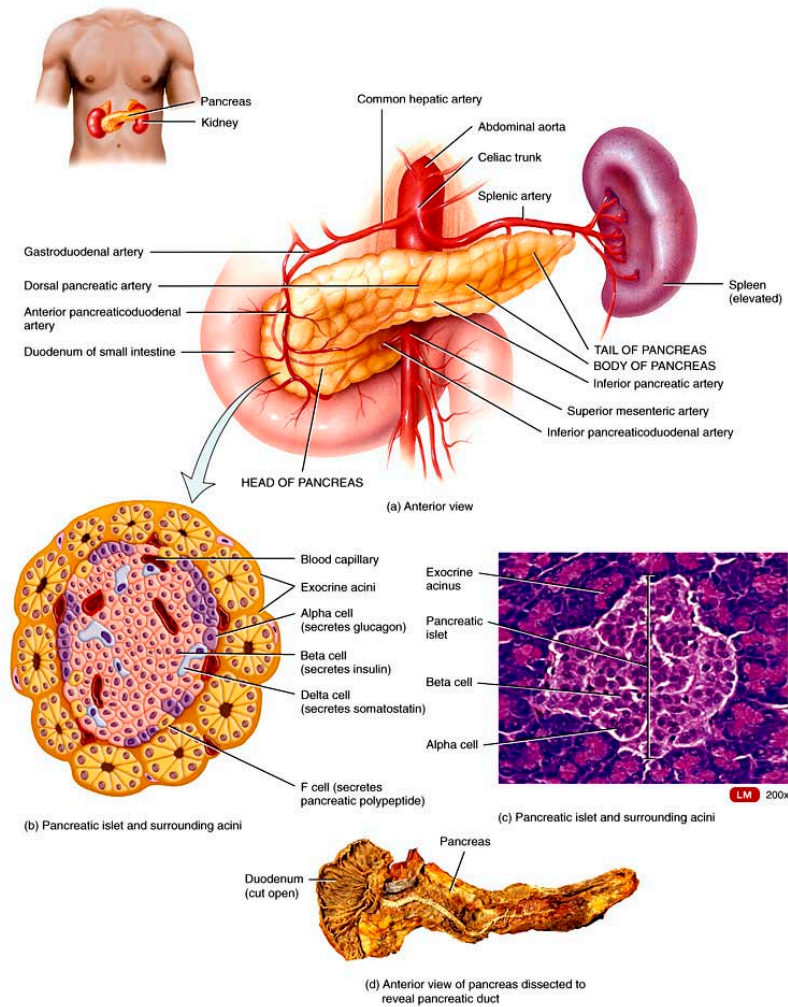
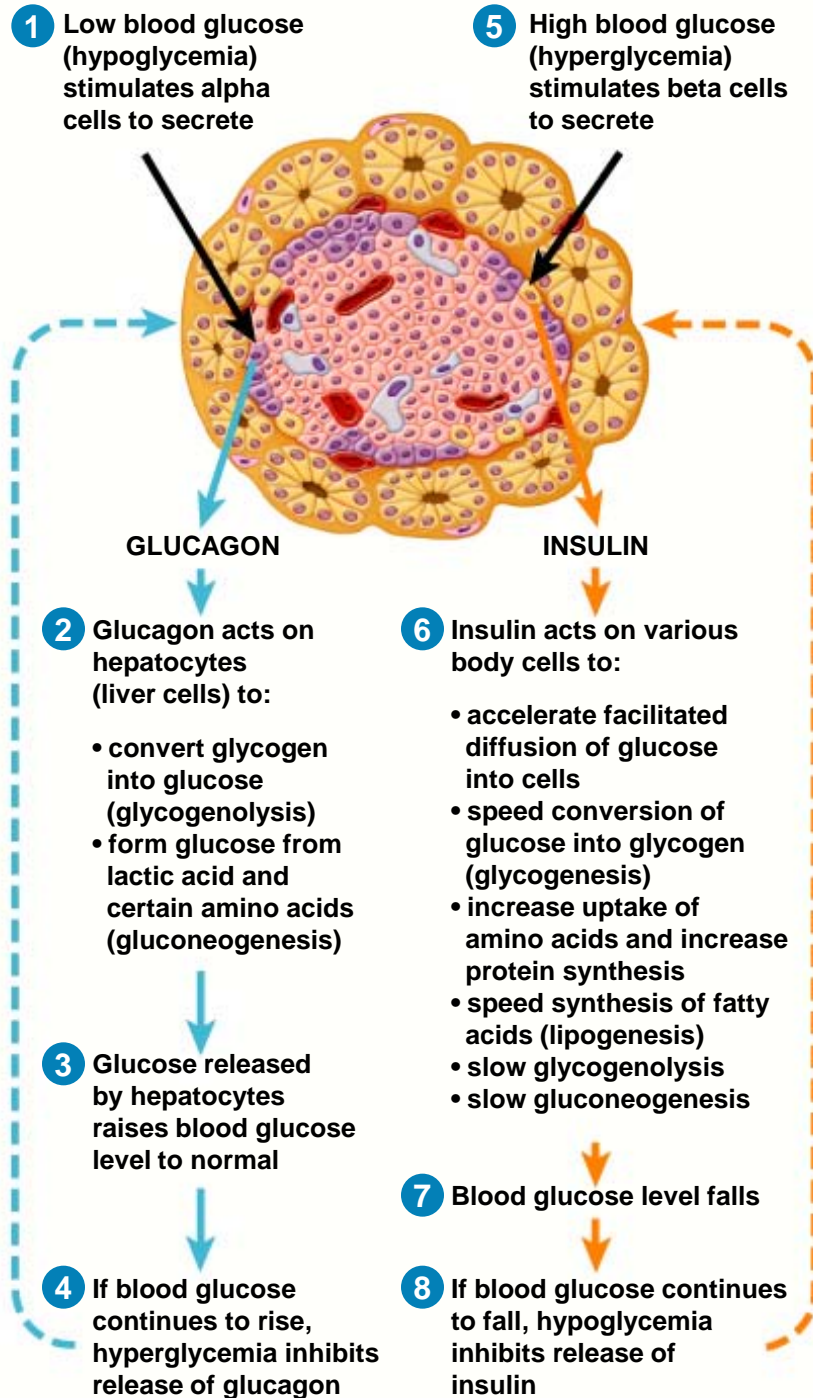


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Negative Feedback Regulation of Glucagon and Insulin



Ovaries and Testes

- Gonads – produce gametes and hormones
- Ovaries produce 2 estrogens (estradiol and estrone) and progesterone
 - With FSH and LH regulate menstrual cycle, maintain pregnancy, prepare mammary glands for lactation, maintain female secondary sex characteristics
 - Inhibin inhibits FSH
 - Relaxin produced during pregnancy
- Testes produce testosterone – regulates sperm production and maintains male secondary sex characteristics
 - Inhibin inhibits FSH

Pineal Gland

- Attached to roof of 3rd ventricle of brain at midline
- Masses of neuroglia and pinealocytes
- Melatonin – amine hormone derived from serotonin
- Appears to contribute to setting biological clock
- More melatonin liberated during darkness than light

Thymus and Other Endocrine Tissues

■ Thymus

- ❑ Located behind sternum between the lungs
- ❑ Produces thymosin, thymic humoral factor (THF), thymic factor (TF), and thymopoietin
- ❑ All involved in T cell maturation

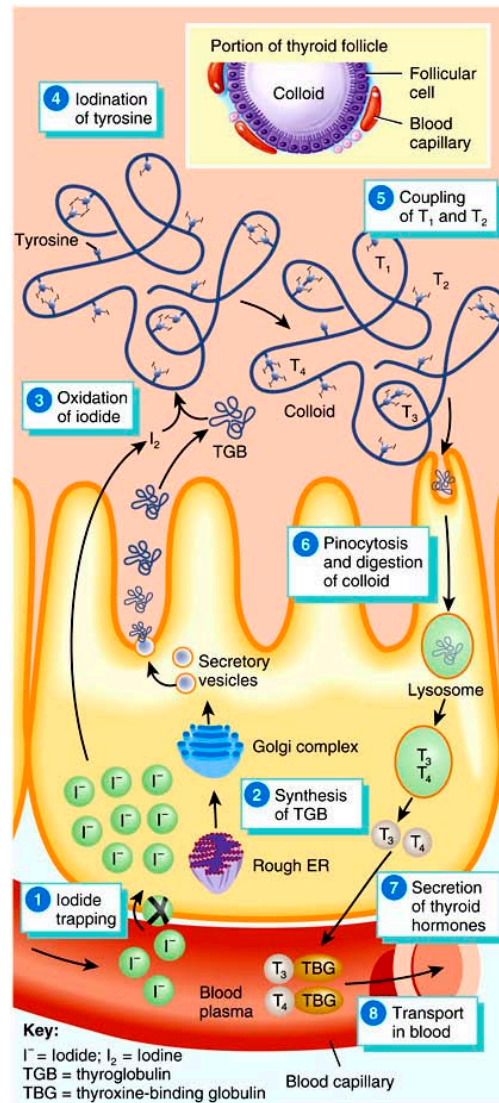


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The Stress Response

- Eustress is helpful stress / Distress is harmful
- Body's homeostatic mechanisms attempt to counteract stress
- Stressful conditions can result in stress response or general adaptation syndrome (GAS)
 - 3 stages – initial flight-or-fight, slower resistance reaction, eventually exhaustion
 - Prolonged exposure to cortisol can result in wasting of muscles, suppression of immune system, ulceration of GI tract, and failure of pancreatic beta cells

Stress Response

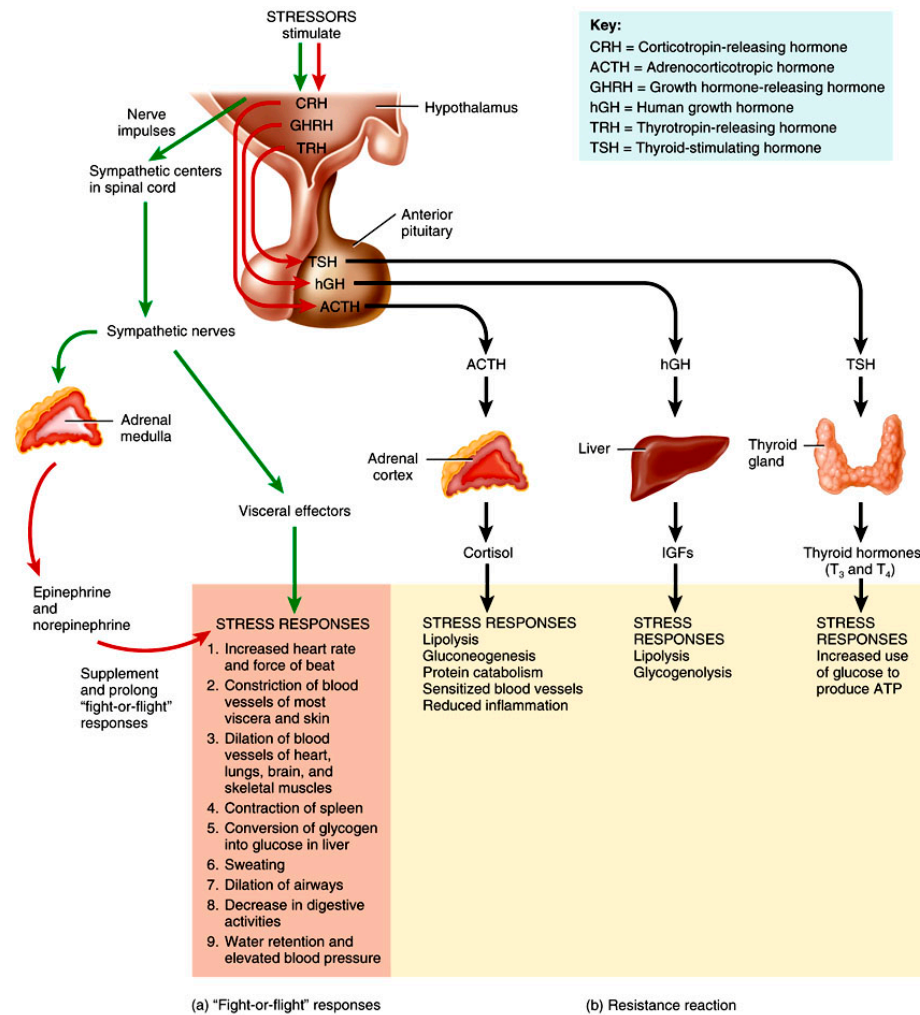


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End of Chapter 18

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