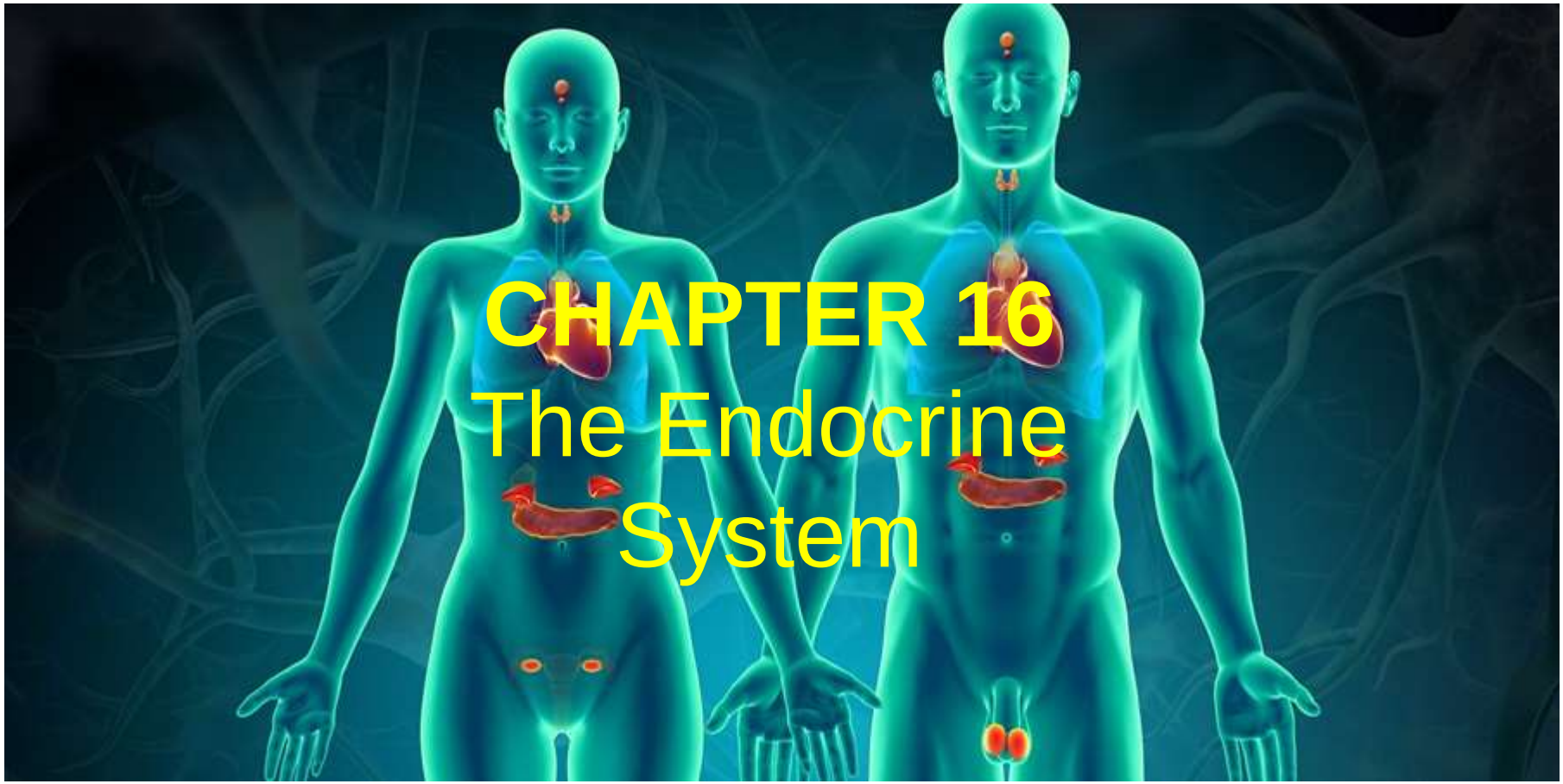

CHAPTER 16
The Endocrine System

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Introduction

- Endocrinology
- Hormones

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Introduction to Hormonal Regulation, Secretion, and Concentration
Interactions Animation

- Introduction to Hormonal Regulation, Secretion, and Concentration

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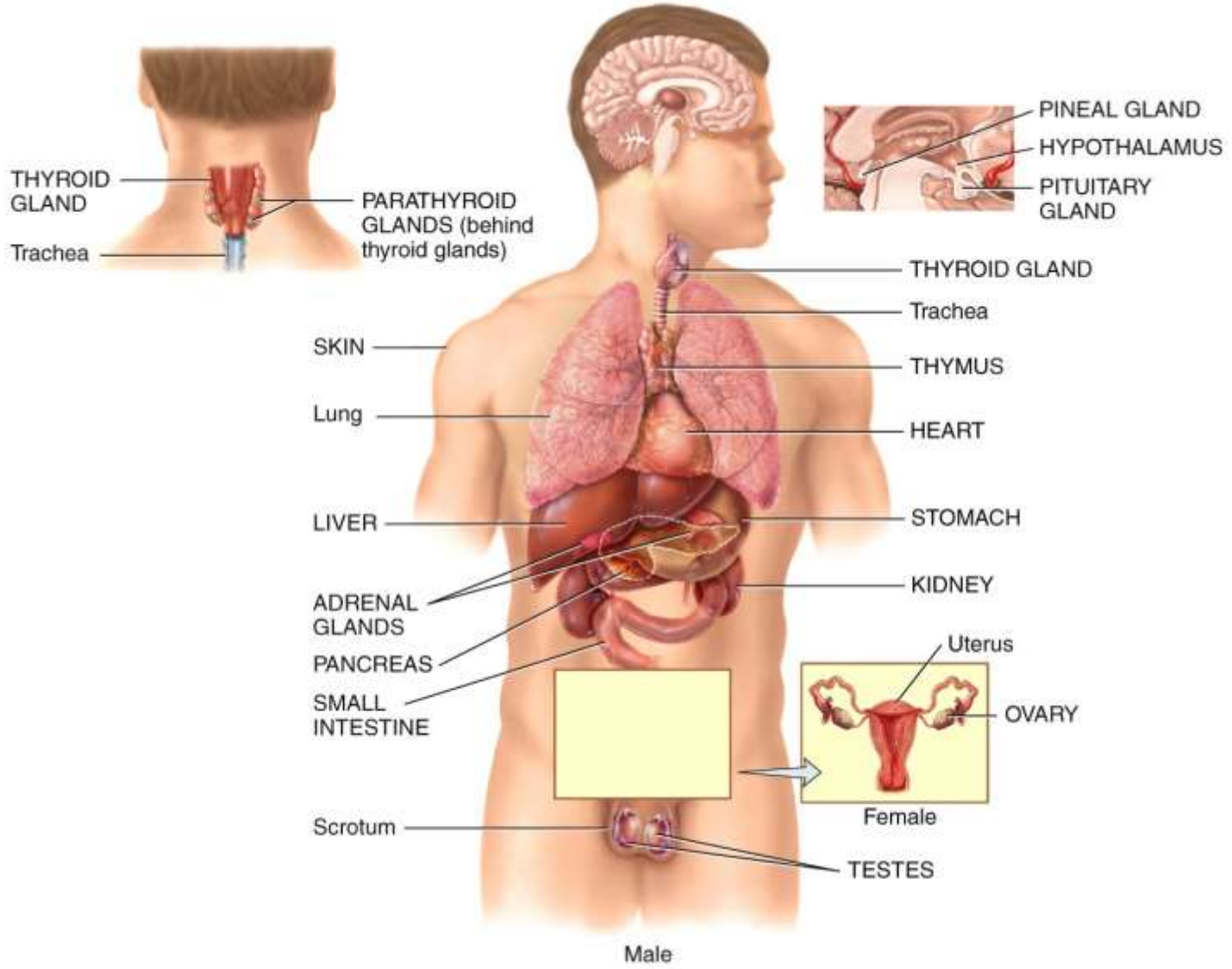
Location of Many Endocrine Glands



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Hormones

- Target cells
- Receptors

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Mechanisms of Hormone Action
Interactions Animation

- Mechanisms of Hormone Action

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Hormonal Cycles
Interactions Animation

- Hormonal Cycles

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Clinical Connection

- Blocking hormone receptors

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Hypothalamus and Pituitary Gland

- Hypothalamus
- Infundibulum
- Anterior pituitary cells secrete
  - Human growth hormone (hGH)
  - Thyroid-stimulating hormone (TSH)
  - Follicle-stimulating hormone (FSH)
  - Prolactin (PRL)
  - Adrenocorticotropic hormone (ACTH)

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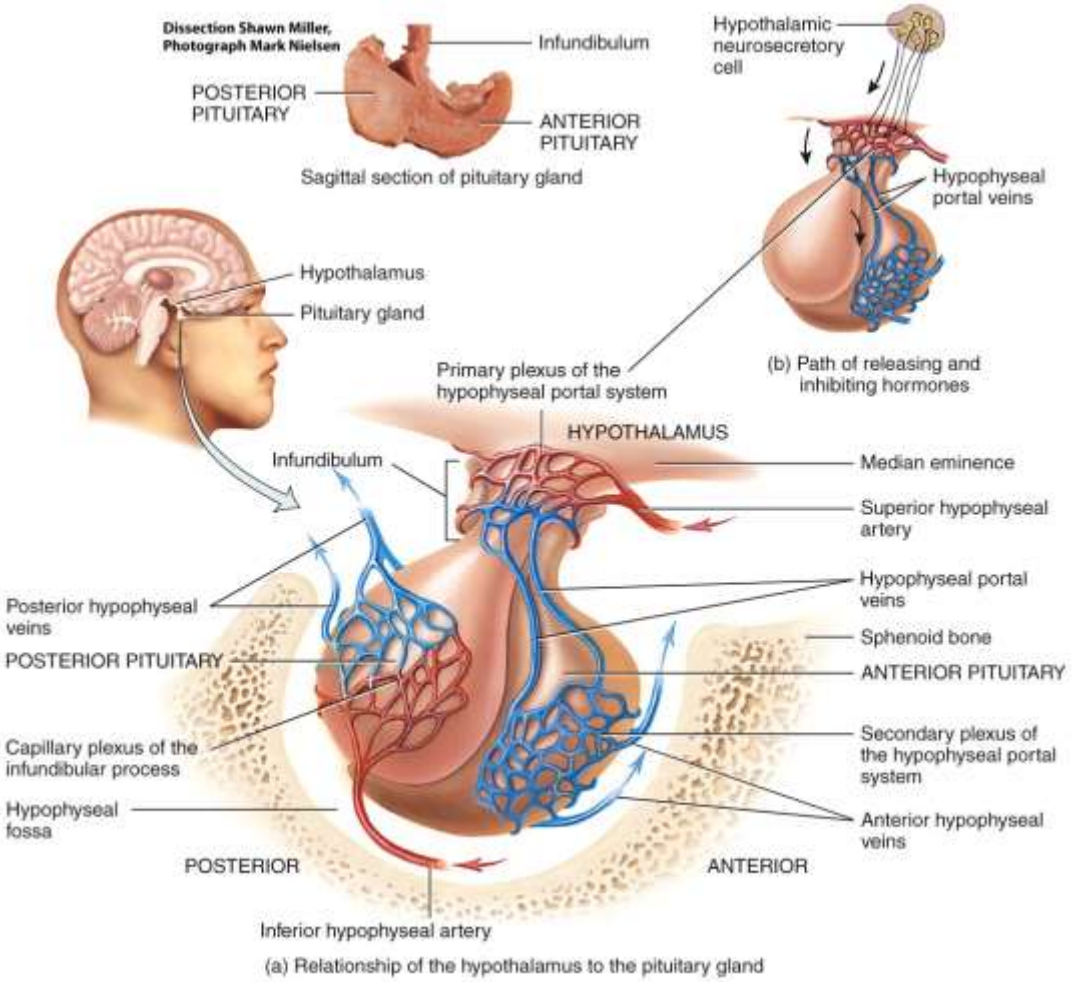
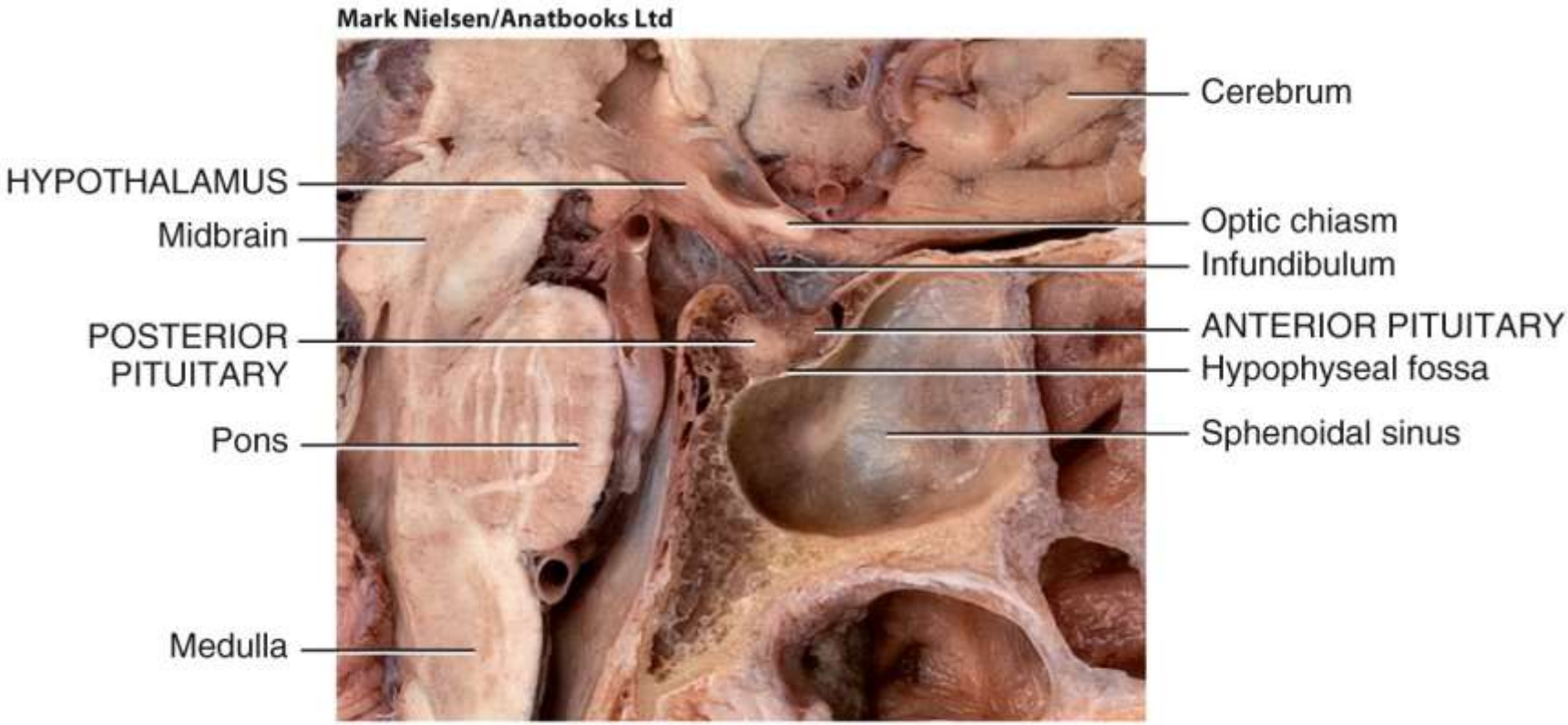
Hypothalamus and Pituitary Gland, and Their Blood Supply



Hypothalamus and Pituitary Gland, and Their Blood Supply



(c) Sagittal section of hypothalamus and pituitary gland of adult

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Posterior Pituitary

The posterior pituitary stores and releases these hormones:

- **Oxytocin (OT):** is a peptide hormone and neuropeptide. It is normally produced in the hypothalamus and released by the posterior pituitary. It plays a role in social bonding, sexual reproduction, childbirth, and the period after childbirth
- **Antidiuretic hormone (ADH), also called vasopressin:** It is normally produced in the hypothalamus and released by the posterior pituitary.
- It helps to control blood pressure by acting on the kidneys and the blood vessels. Its most important role is to conserve the fluid volume of your body by reducing the amount of water passed out in the urine

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Clinical Connection

- **Disorders of the endocrine system**
  - **Pituitary dwarfism:** or growth hormone deficiency, is a condition in which the pituitary gland does not make enough growth hormone. This results in a child's slow growth pattern and an unusually small stature (below average height)
  - **Giantism:** is a rare condition that causes abnormal growth in children. This change is most notable in terms of height, but girth "measurement around the middle especially a person's waist." is affected as well. It occurs when your child's pituitary gland makes too much growth hormone, which is also known as somatotropin.
  - **Acromegaly:** is a hormonal disorder that develops when your pituitary gland produces too much growth hormone during adulthood. When this happens, your bones increase in size, including those of your hands, feet and face. Acromegaly usually affects middle-aged adults

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Pineal Gland and Thymus

- **Melatonin:** The hormone melatonin plays a role in your natural sleep-wake cycle. Natural levels of melatonin in the blood are highest at night
- **Seasonal affective disorder (SAD):** is a type of depression that's related to changes in seasons — SAD begins and ends at about the same times every year. If you're like most people with SAD, your symptoms start in the fall and continue into the winter months, sapping your energy and making you feel moody. Less often, SAD causes depression in the spring or early summer.

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Thyroid Gland and Parathyroid Glands

- Thyroid
  - Lateral lobes connected by isthmus
  - Follicular cells produce two hormones:
    - Triiodothyronine (T_3)
    - Thyroxine, also called Tetraiodothyronine (T_4)

    Together, these hormones regulate your body's temperature, metabolism, and heart rate. *Most of the T3 in your body binds to protein*

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Clinical Connection

- **Thyroid gland disorders**
  - Congenital hypothyroidism
  - Graves disease – AUTOIMMUNE HYPERTHYROIDISM
    - Exophthalmos
  - Hashimoto's thyroiditis – AUTOIMMUNE HYPOTHYROIDISM
  - Goiter: enlargement of the gland, could be associated with hypo, hyper or normal thyroid function.

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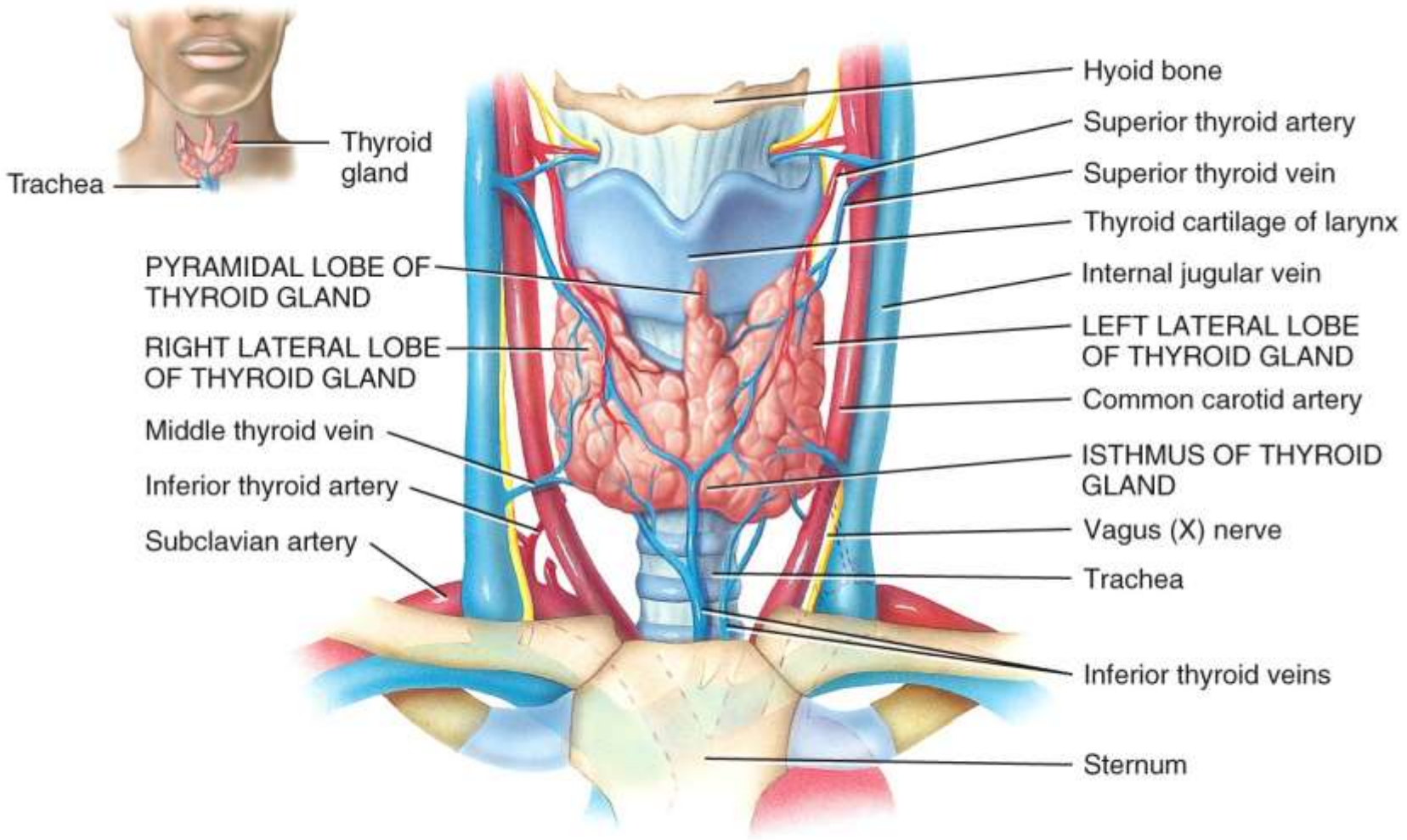
The Thyroid Gland



(a) Anterior view of thyroid gland

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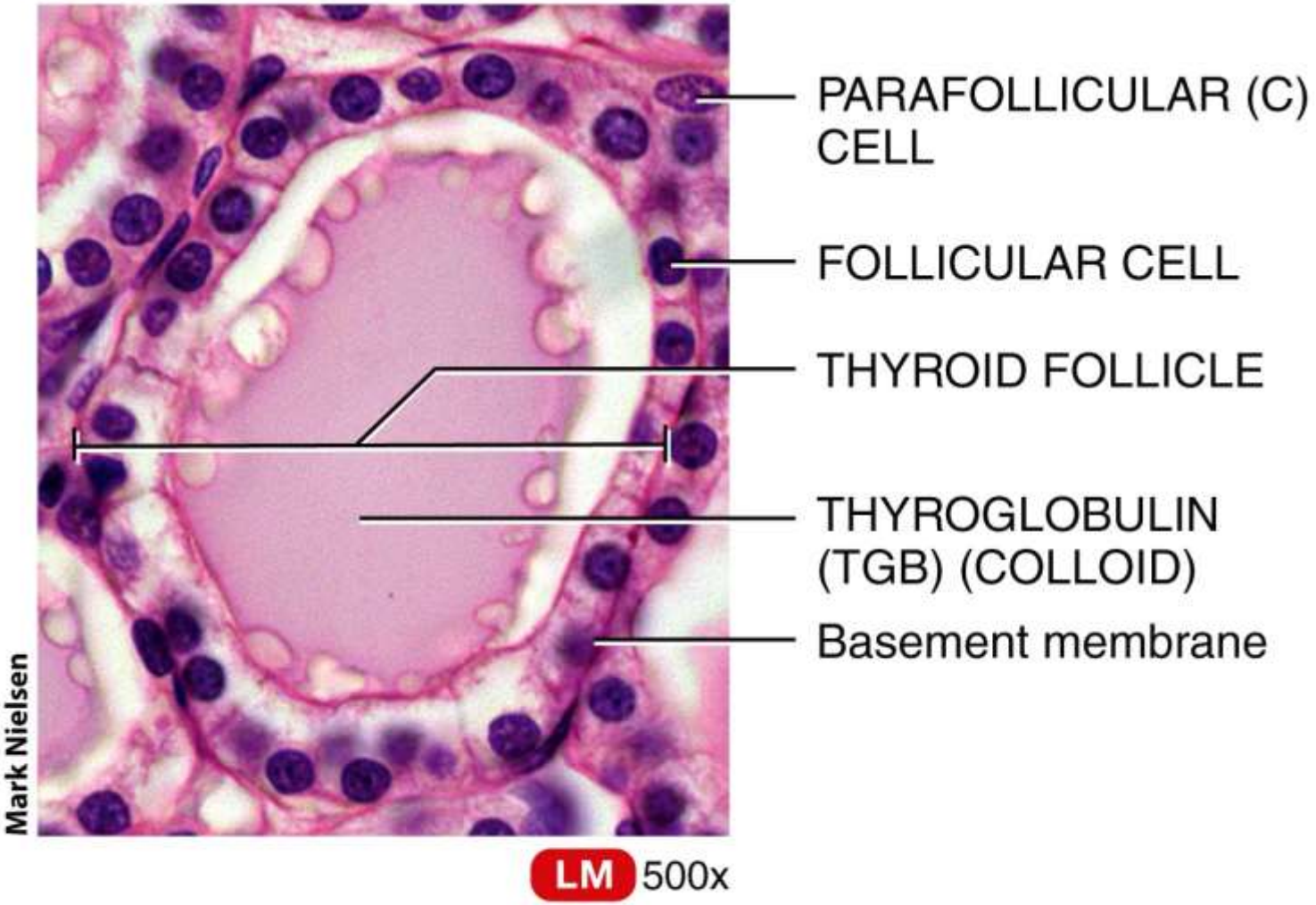
The Thyroid Gland



(b) Thyroid follicles

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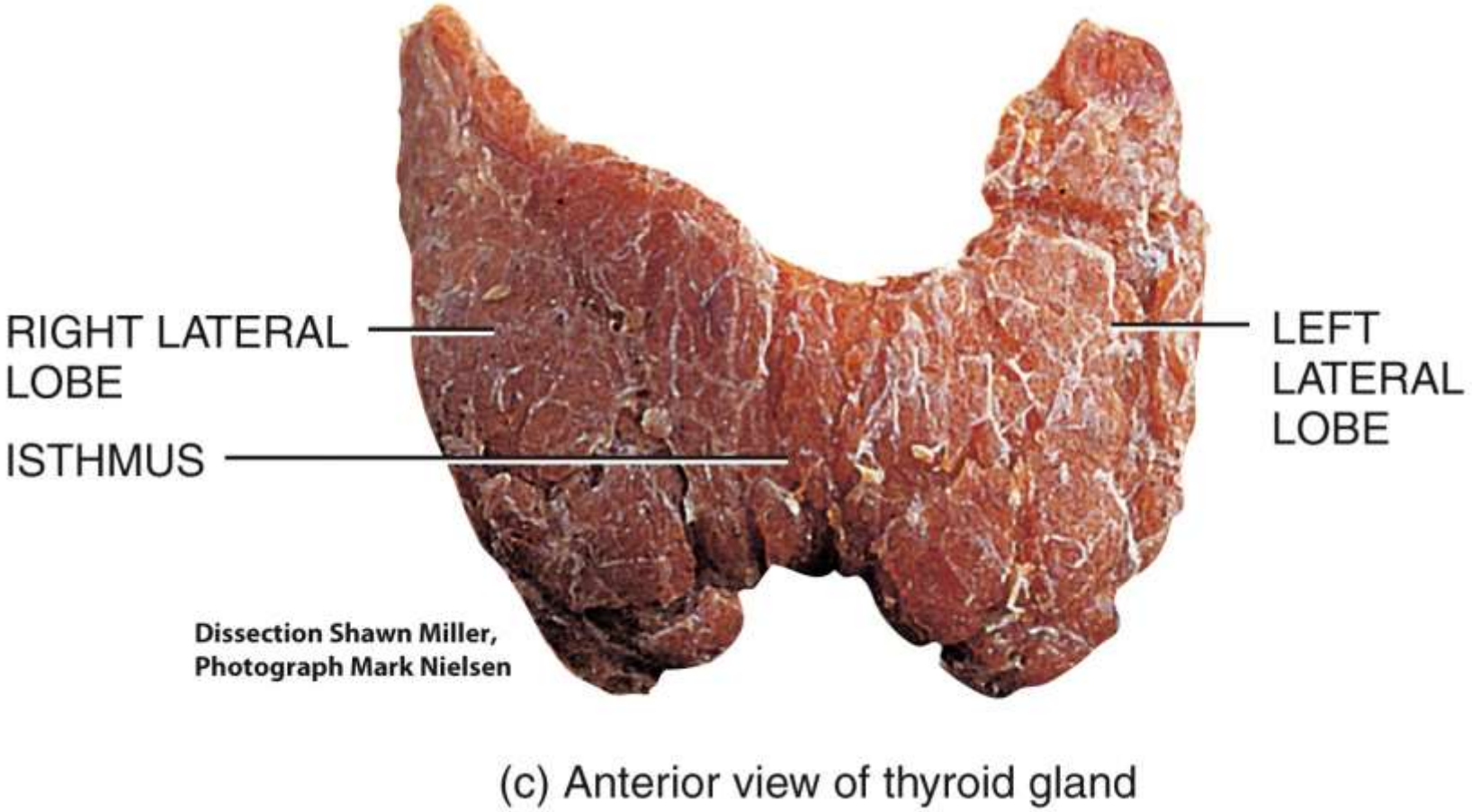
The Thyroid Gland



(c) Anterior view of thyroid gland

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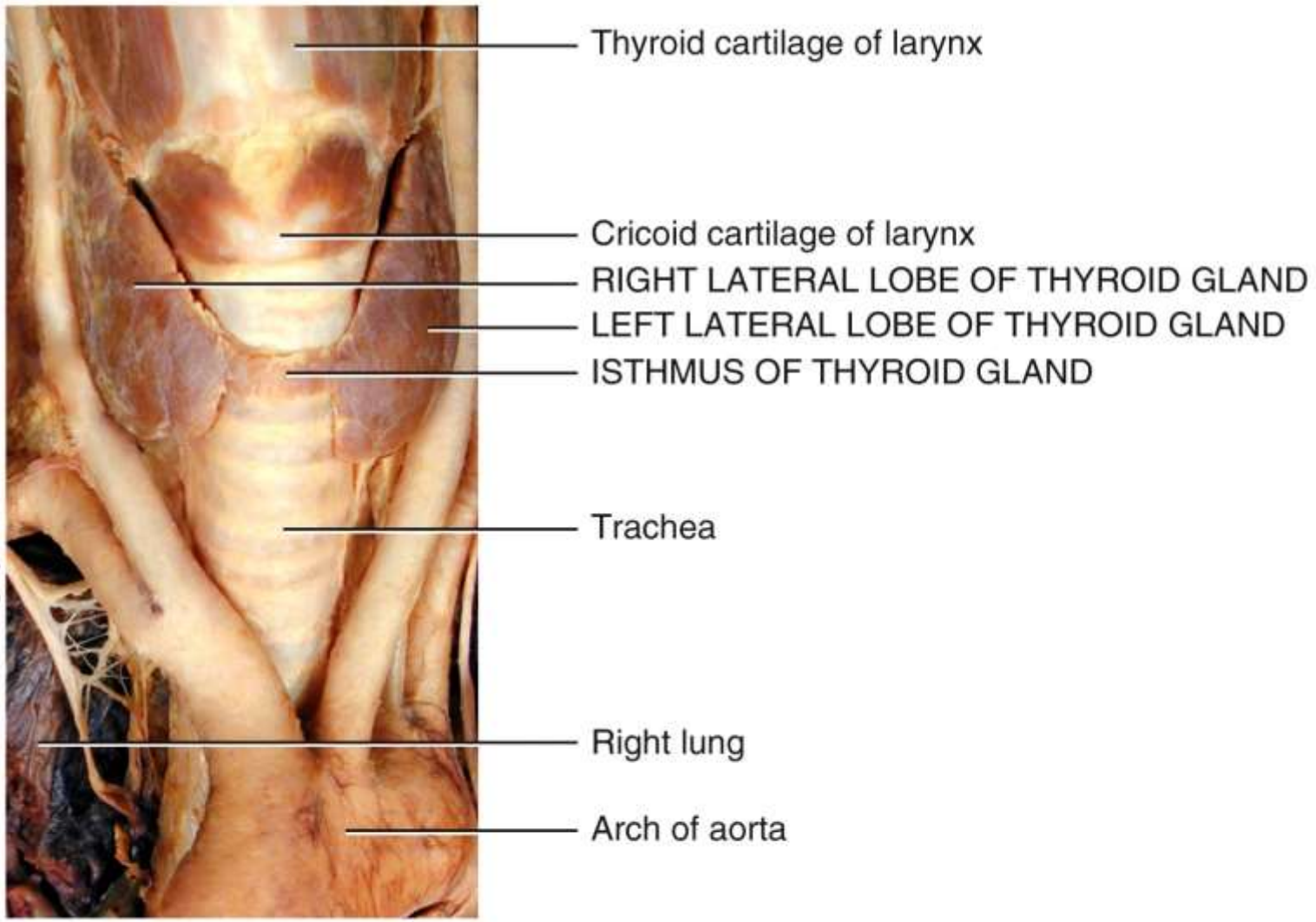
The Thyroid Gland



(d) Anterior view

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Parathyroid Glands

- **Parathyroid**
  - **Parathyroid hormone (PTH) :** also called parathormone or parathyrin, is a hormone secreted by the parathyroid glands that regulates the serum calcium through its effects on bone, kidney, and intestine

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Clinical Connection

- Thyroid gland disorders and parathyroid gland disorders
  - **Hypoparathyroidism:** is the state of decreased secretion or activity of parathyroid hormone (PTH). This leads to decreased blood levels of calcium (hypocalcemia) and increased levels of blood phosphorus (hyper-phosphatemia)
  - **Hyperparathyroidism:** is a condition in which one or more of the parathyroid glands become overactive and secrete too much parathyroid hormone (PTH). This causes the levels of calcium in the blood to rise, a condition known as hypercalcemia.

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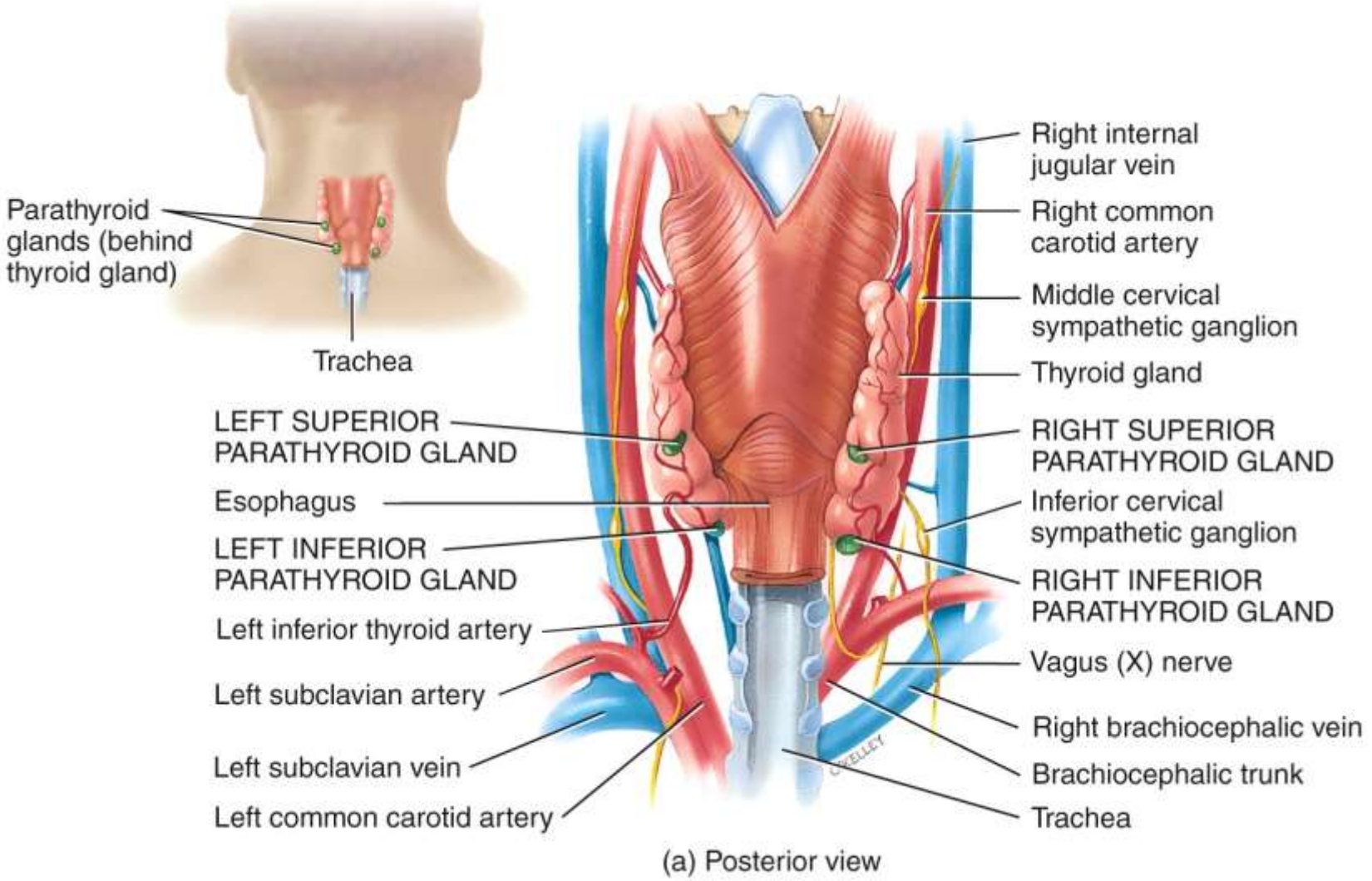
The Parathyroid Glands



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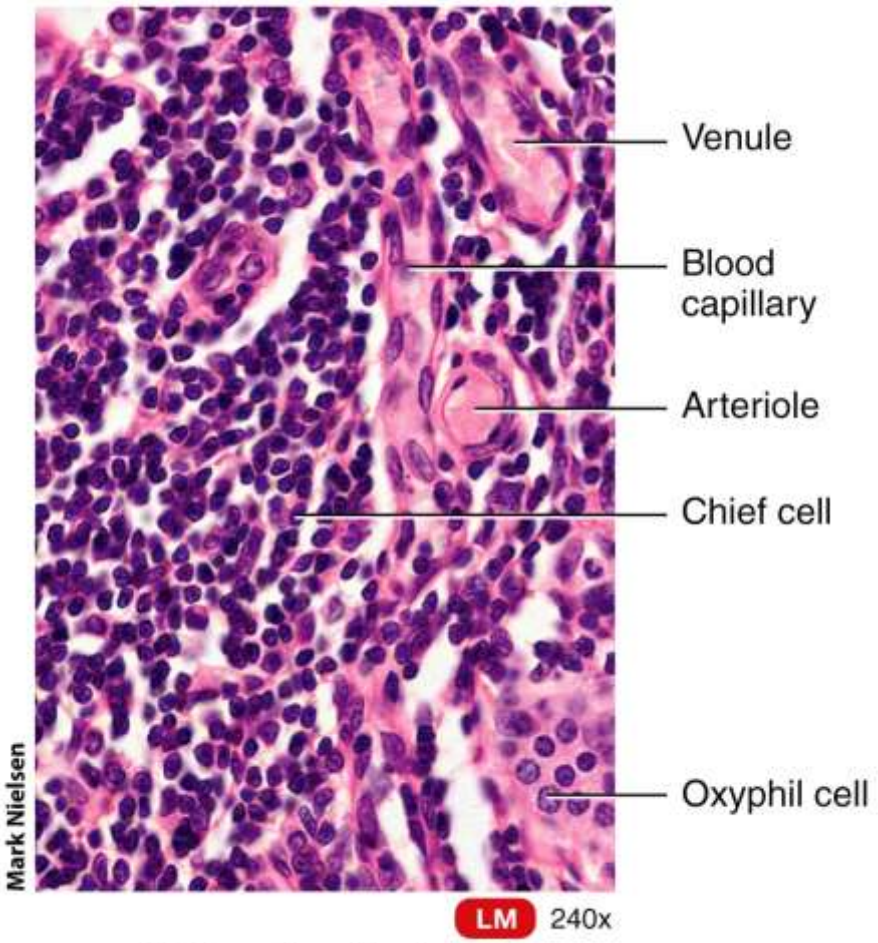
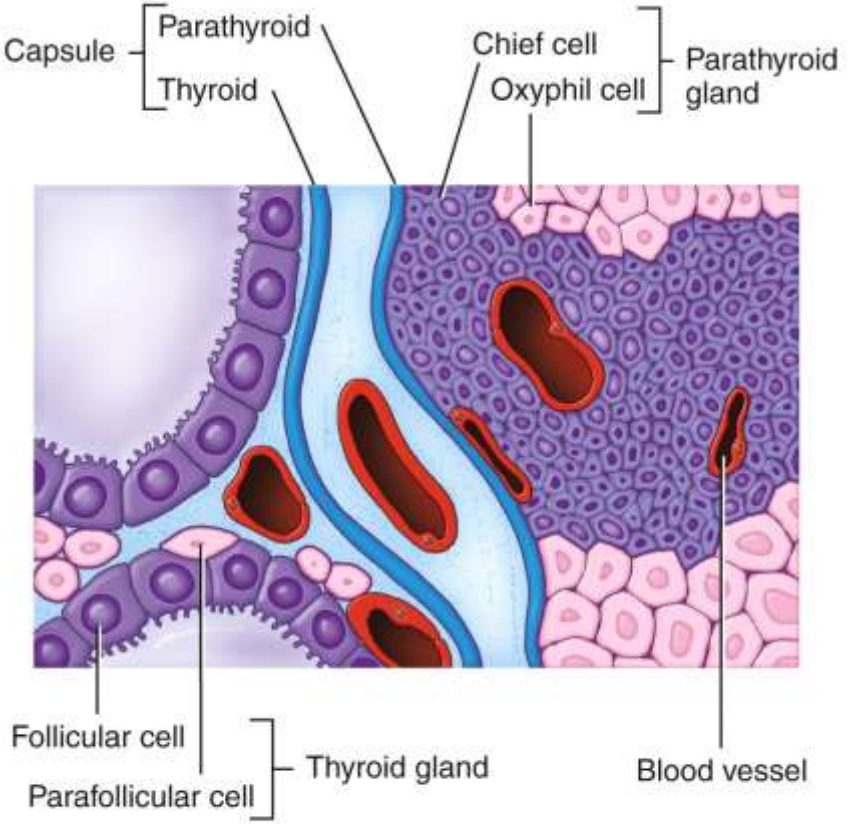
The Parathyroid Glands



(b) Parathyroid gland



(c) Portion of the thyroid gland (left) and parathyroid gland (right)

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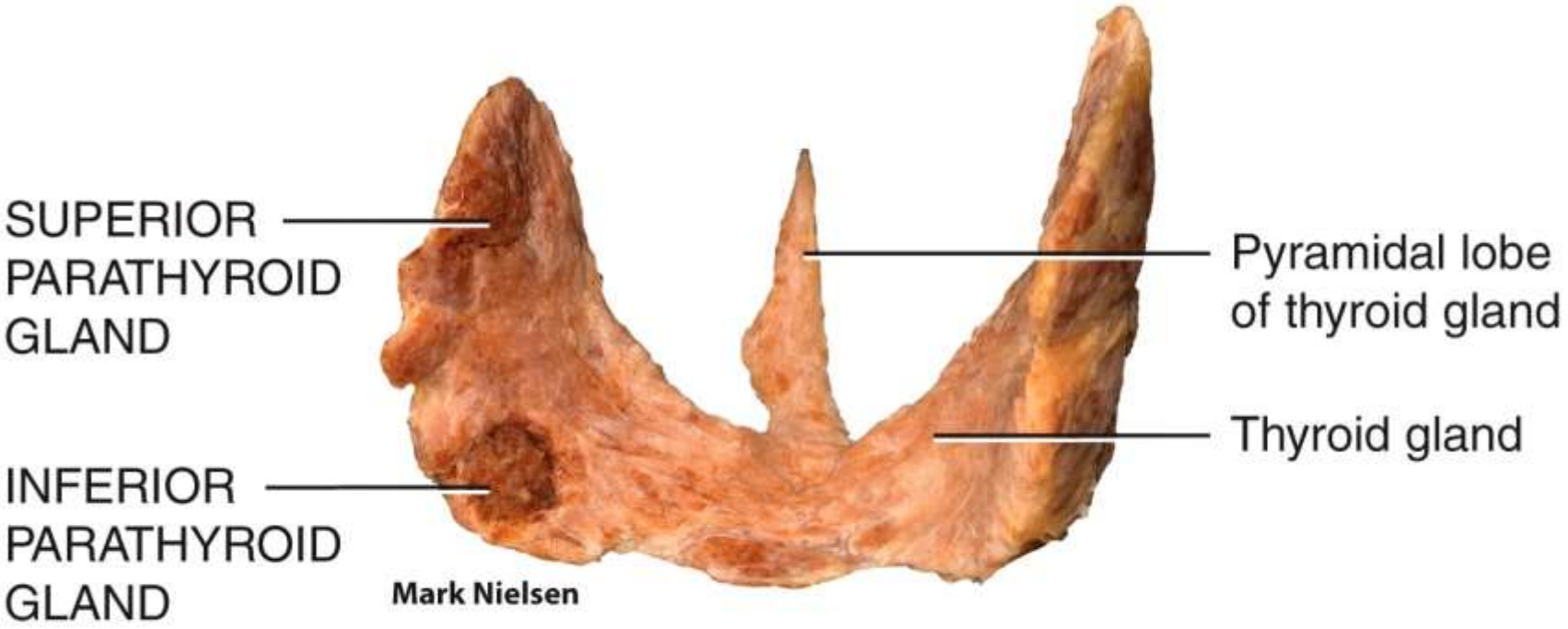
The Parathyroid Glands



(d) Posterior view of parathyroid glands

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Adrenal Glands

- Lie superior to each kidney
- Adrenal cortex
- Adrenal medulla
  - Inner region of the adrenal gland
  - Produces two hormones:
    - Epinephrine
    - Norepinephrine

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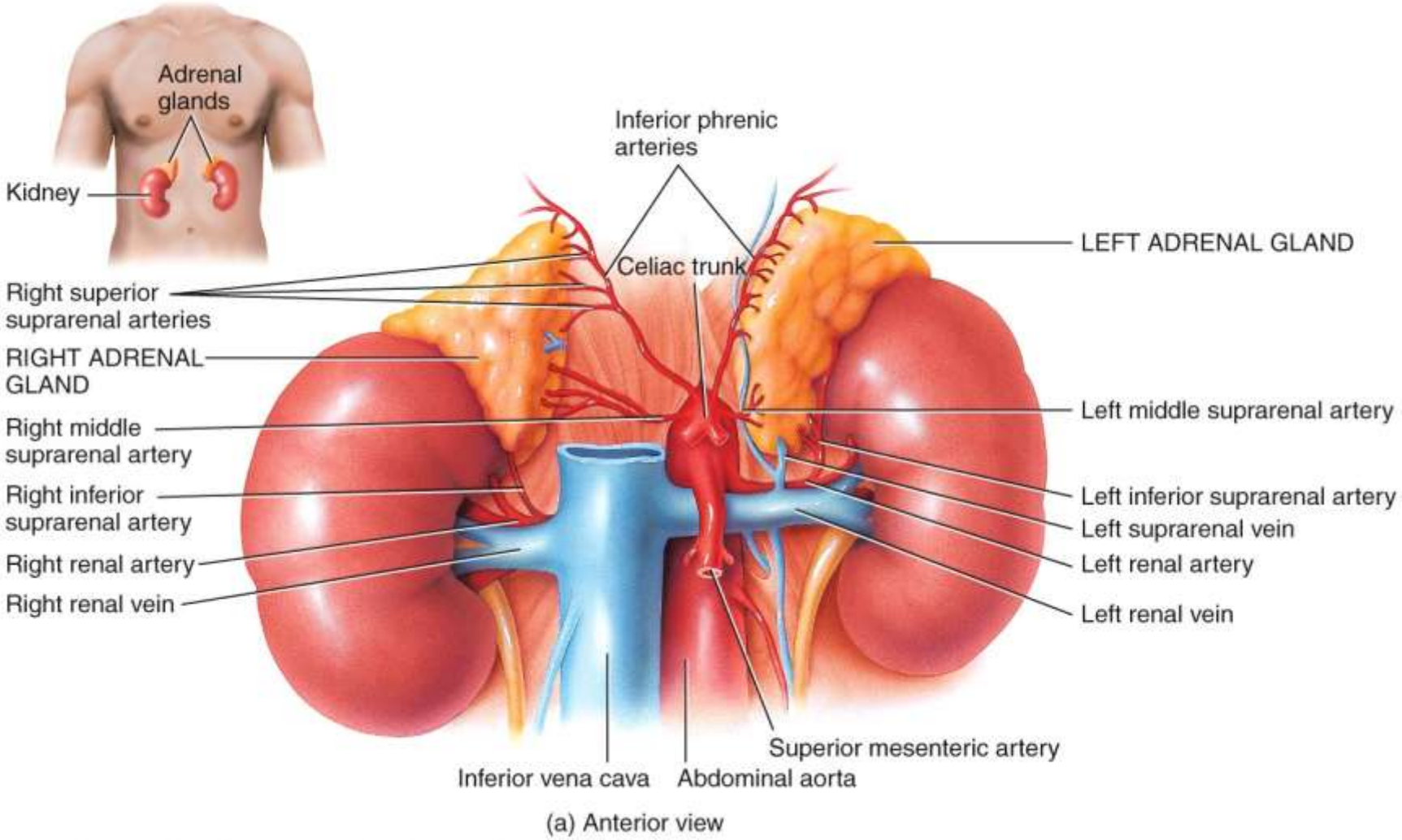
The Adrenal (Suprarenal) Glands



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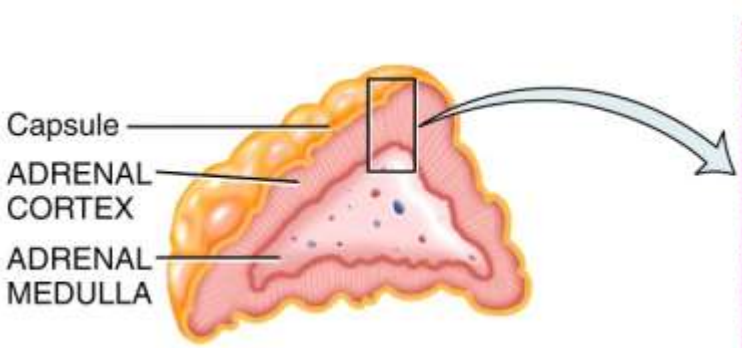
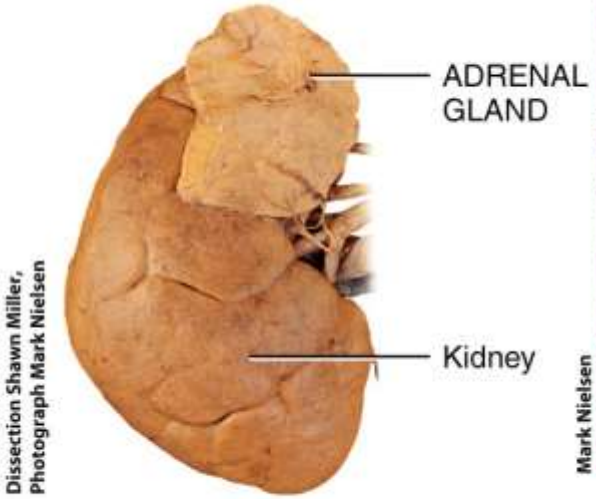
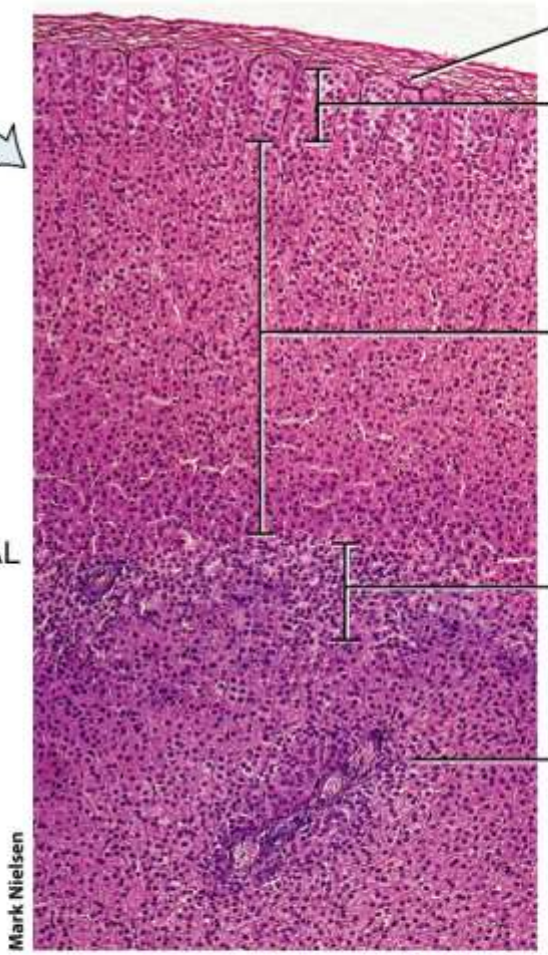
The Adrenal (Suprarenal) Glands



(b) Section through left adrenal gland



(c) Anterior view of adrenal gland and kidney



(d) Subdivisions of the adrenal gland

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Clinical Connection

- **Adrenal gland disorders**
  - **Congenital adrenal hyperplasia (CAH):** is a form of adrenal insufficiency in which 21-hydroxylase, the enzyme that produces two important adrenal steroid hormones, cortisol and aldosterone, is deficient. Because cortisol production is impeded, the adrenal gland over-produces androgens (male steroid hormones)
  - **Cushing's syndrome:** is a disorder that occurs when your body makes too much of the hormone cortisol over a long period of time. Cortisol is sometimes called the "stress hormone" because it helps your body respond to stress.
  - **Addison's disease:** also known as primary adrenal insufficiency and hypocortisolism, is a long-term endocrine disorder in which the adrenal glands do not produce enough steroid hormones. Symptoms generally come on slowly and may include abdominal pain, weakness, and weight loss.
  - **Pheochromocytomas:** is a rare tumor of adrenal gland tissue. It results in the release of too much epinephrine and norepinephrine, hormones that control heart rate, metabolism, and blood pressure

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Pancreas

- **Islets of Langerhans**
  - **Alpha cells** or **α-cells:** They make up to 20% of the human islet cells synthesizing and secreting the peptide hormone glucagon, which elevates the glucose levels in the blood.
  - **Beta cells:** they constitute the predominant type of cell. The beta cells make and release insulin, a hormone that controls the level of glucose (sugar) in the blood.
  - **Delta cells, δ-cells or D cells :** are somatostatin-producing cells. They can be found in the stomach, intestine and the pancreatic islets, it serves to block the secretion of both insulin and glucagon from adjacent cells. Insulin, glucagon, and somatostatin act in concert to control the flow of nutrients into and out of the circulation.
  - **F cells, Pancreatic polypeptide cells (PP cells):** or formerly as gamma cells, or F cells, are cells which produce pancreatic polypeptides in the pancreatic islets (Islets of Langerhans) of the pancreas. They are very few in number and are polygonal in shape

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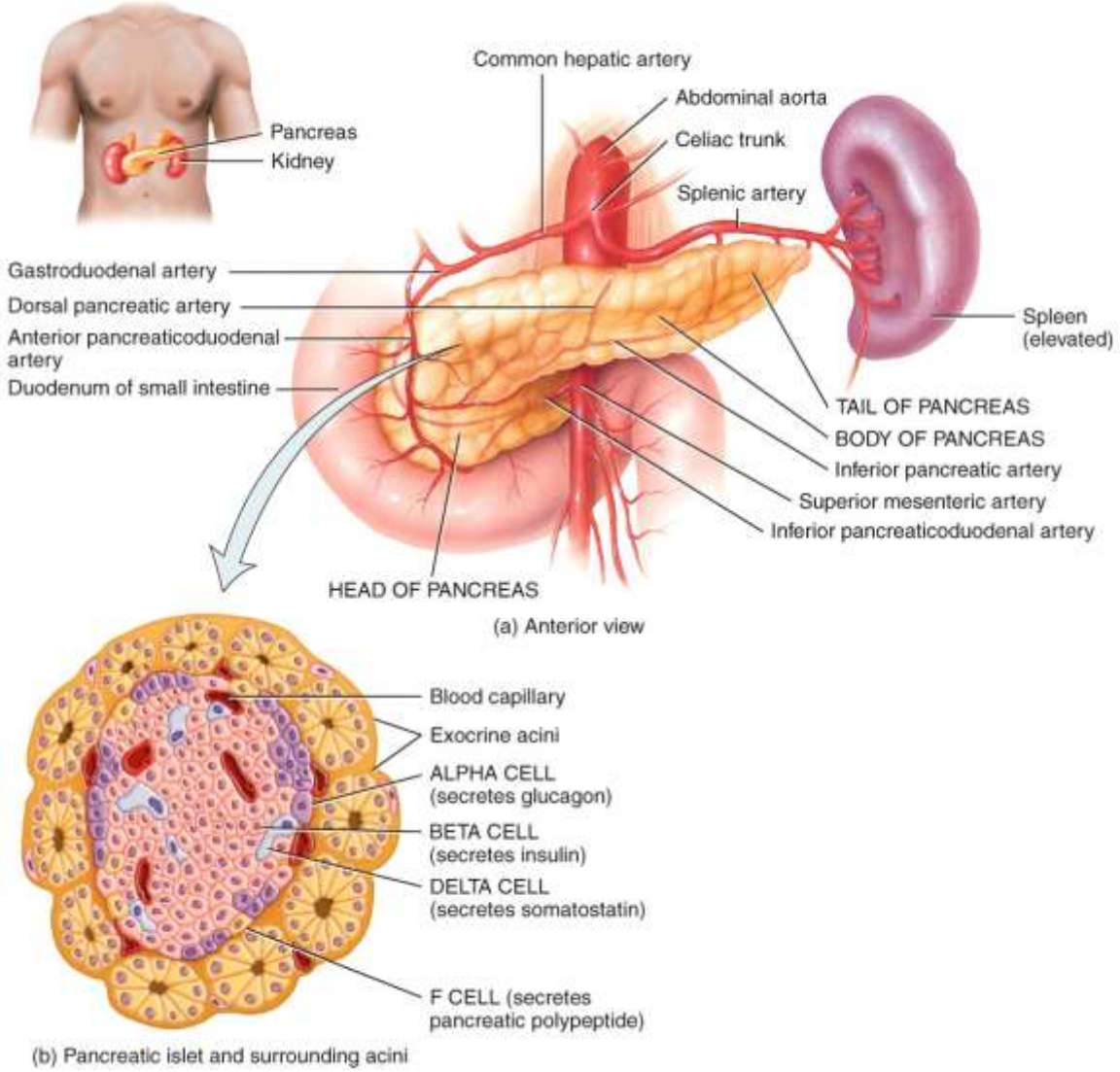
The Pancreas



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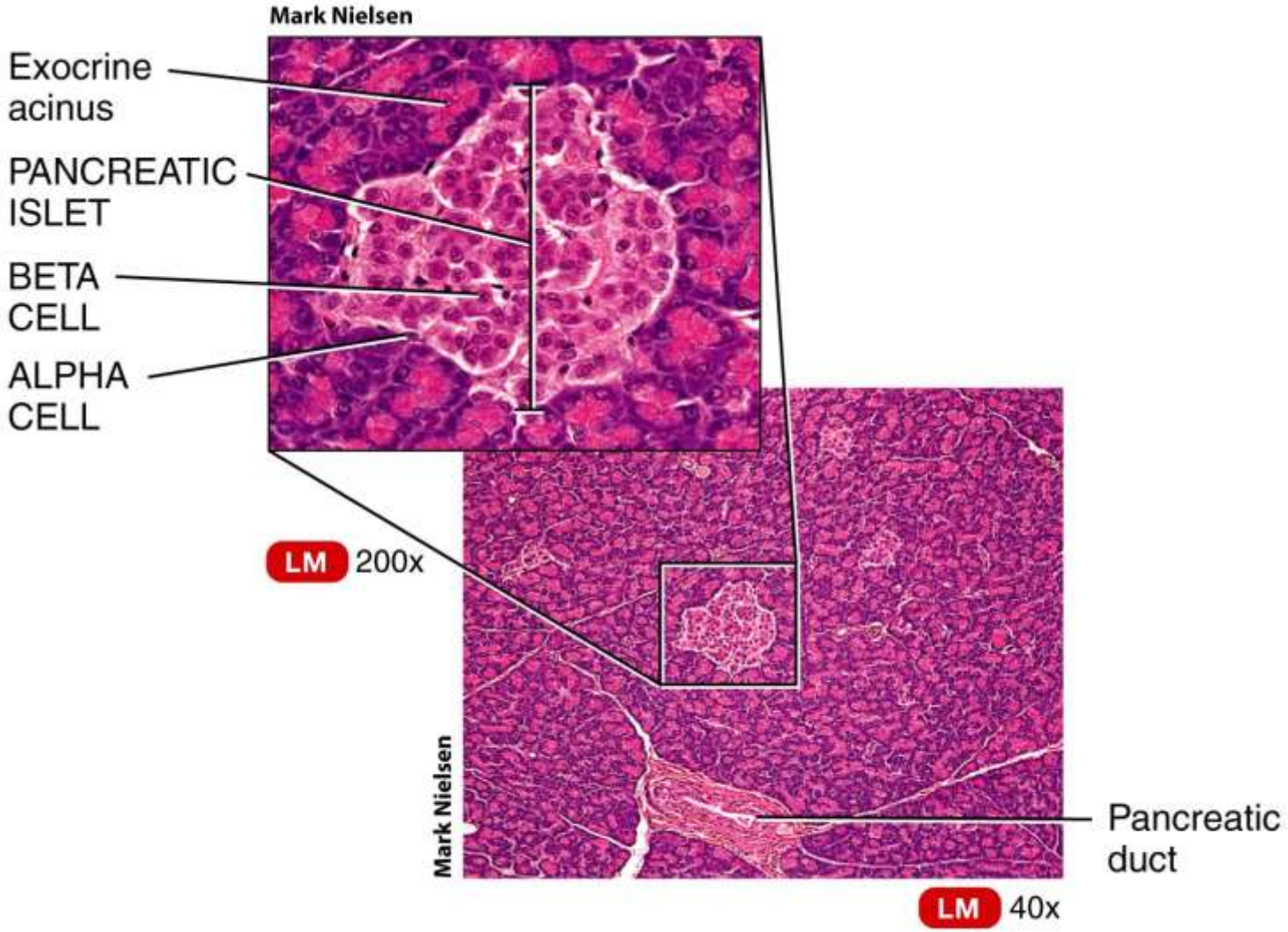
The Pancreas



(c) Pancreatic islet and surrounding acini

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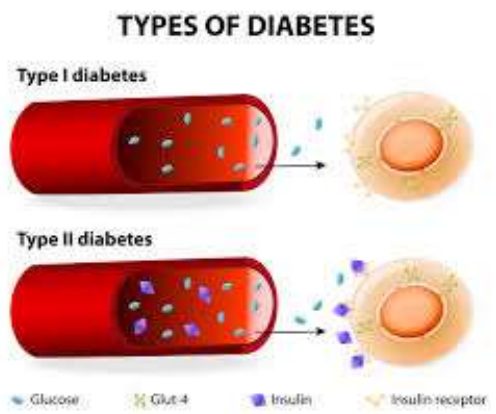
Clinical Connection

- **Diabetes mellitus**
  - **Type 1 diabetes (insulin-dependent diabetes):** once known as juvenile diabetes or is a chronic condition in which the pancreas produces little or no insulin. Insulin is a hormone needed to allow sugar (glucose) to enter cells to produce energy.
  - **Type 2 diabetes (non-insulin-dependent diabetes):** is an inherited metabolic disorder characterized by hyperglycemia with resistance to ketosis. The onset is usually after age 40 years.
  - Temporary insulin therapy may be needed during inter-current illness, surgery or pregnancy.



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Other Endocrine Tissues

- **Gastrointestinal tract**
  - **Gastrin:** is a peptide hormone that stimulates secretion of gastric acid (HCl) by the parietal cells of the stomach and aids in gastric motility. It is released by G cells in the pyloric antrum of the stomach, duodenum, and the pancreas
  - **Glucose-dependent insulinotropic peptide (GIP):** is a hormone produced by the small intestine in response to eating food. Its main action is to encourage the release of insulin into the bloodstream to control blood sugar levels.
  - **Secretin:** is a hormone that regulates water homeostasis throughout the body and influences the environment of the duodenum by regulating secretions in the stomach, pancreas, and liver. It is a peptide hormone produced in the S cells of the duodenum, which are located in the intestinal glands.
  - **Cholecystokinin (CCK):** move the bile-sac (gallbladder), is a peptide hormone of the gastrointestinal system responsible for stimulating the digestion of fat and protein.

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Clinical Connection

- *Stress, hormones, and disease*
  - Gastritis
  - Ulcerative colitis
  - Irritable bowel syndrome (IBS)
  - Hypertension
  - Asthma
  - Rheumatoid arthritis (RA)
  - Migraine headaches
  - Anxiety
  - Depression

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Other Endocrine Tissues

- **Kidneys**
  - **Renin:** primary function is therefore to eventually cause an increase in blood pressure, leading to restoration of perfusion pressure in the kidneys. Renin is secreted from juxtaglomerular kidney cells, which sense changes in renal perfusion pressure, via stretch receptors in the vascular walls.
  - **Erythropoietin (EPO):** also known as erythropoetin, haematopoietin, or haemopoietin, is a glycoprotein cytokine secreted mainly by the kidney in response to cellular hypoxia; it stimulates red blood cell production (erythropoiesis) in the bone marrow.
  - **Calcitriol:** is the active form of vitamin D, normally made in the kidney

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Other Endocrine Tissues

- **Heart**
  - **Atrial natriuretic peptide (ANP):** is a cardiac hormone which gene and receptors are widely present in the body. Its main function is to lower blood pressure and to control electrolyte homeostasis i.e. reduction in expanded extracellular fluid (ECF) volume by increasing renal sodium excretion

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Other Endocrine Tissues

- **LIVER**
- In the last 10 years, many new endocrine functions of the liver have been discovered.
- Advances in the classical endocrine functions include delineation of mechanisms of liver production of endocrine hormones [including 25-hydroxyvitamin D, insulin-like growth factor 1 (IGF-1), and angiotensinogen], hepatic metabolism of hormones (including thyroid hormones, glucagon-like peptide-1, and steroid hormones), and actions of specific binding proteins to glucocorticoids, sex steroids, and thyroid hormones.

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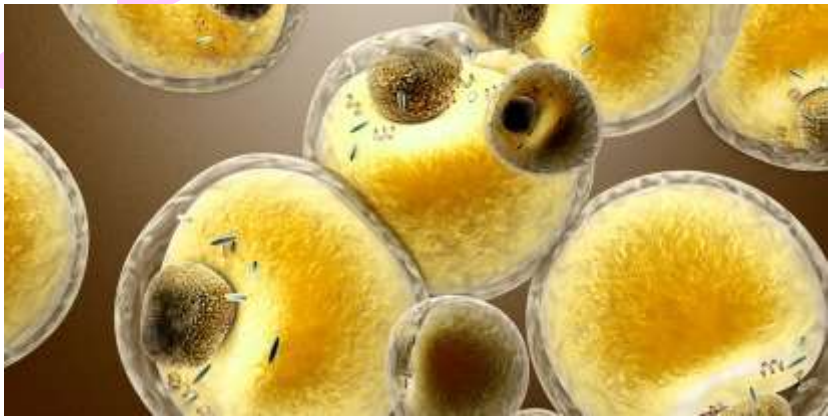
Other Endocrine Tissues

- **Adipose tissue**
  - **Leptin:** a hormone released from the fat cells located in adipose tissues, sends signals to the hypothalamus in the brain. This particular hormone helps regulate and alter long-term food intake and energy expenditure, not just from one meal to the next.
  - In recent years, leptin supplements have become quite popular. They claim to decrease appetite and make it easier for you to lose weight.



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