ENDOCRINE SYSTEM

The endocrine system, the nervous system and the immune system are the main control/regulatory systems of the body. Together they are responsible for maintaining a balance within the body of functions and chemical composition of fluids (homeostasis). Interactions between the three are numerous.

Endocrine cells act by secreting chemical messenger substances (hormones) into connective tissue spaces and adjacent blood capillaries, which carry the substances often to distant target organs. Endocrine cells are found in three distinct anatomic distributions: 1) gathered together in one specialized organ as an endocrine gland (e.g., pituitary, adrenal glands), 2) forming discrete clusters in another specialized organ (e.g., pancreatic islets), and 3), dispersed widely among the lining epithelial cells of certain organs, particularly the gut and respiratory tracts, as the diffuse neuroendocrine system (e.g., G cells of gastric mucosa).

In this laboratory we concentrate on the first category, the major endocrine glands. Note that these glands, unlike exocrine glands, are ductless and very richly vascularized, often with fenestrated capillaries. Think about why they might be fenestrated.

PITUITARY GLAND (hypophysis)

Recall that this gland has a dual embryonic origin: oral cavity ectoderm (Rathke’s pouch) and neuroectoderm (hypothalamic infundibular process). The former gives rise to the adenohypophysis (anterior lobe), the latter to the neurohypophysis (posterior lobe). The secretions of the two are remarkably different in origin and function.

The anterior pituitary (pars distalis) is largely composed of blood sinusoids (which are the second capillary bed in the hypothalamo-hypophyseal portal system), and the
characteristic secretory cells: **acidophils, basophils, and chromophobes**. Acidophils release growth hormone and prolactin. Basophils release ACTH, TSH and the gonadotrophins. Chromophobes are non-secreting and may represent a pool of reserve cells.

The posterior pituitary (pars nervosa) is the terminus of the hypothalamo-hypophysial tracts. These nerve fibers store neurosecretory substance (Herring bodies). Most of the nuclei in this region are those of specialized glial cells ("pituicytes").

**THYROID GLAND**

The secretory cells of this endocrine gland also are of two different embryonic origins. The thyroid is unusual in that the precursor of its major secretory products, *tetra iodothyronine (thyroxine, T4)* and *triiodothyronine, (T3)* are stored extracellularly in large quantity until needed. Be familiar with the biosynthetic and release pathways for these hormones.

The thyroid gland is composed of follicles. These are epithelial parenchymal cells surrounding a central storage vacuole. The storage material is a highly eosinophilic secretory product called **colloid**. The colloid consists mainly of **thyroglobulin** (a protein). This is the storage form of the hormones $T_3$ and $T_4$. The size of the follicles varies with the physiological activity of the gland as well as with the plane of histologic sectioning. The follicular epithelial cells are mostly cuboidal. In general, the higher the epithelium the greater the activity of the gland. When colloid is actively being processed to release thyroid hormone, there are "reabsorption lacunae" (see drawing above), indicating an active follicle. **Parafollicular ("C") cells** may occur singly among the follicular epithelial cells, inside the follicular basal lamina but not making contact with the colloid. They also may occur in clusters outside the follicles. These cells secrete a hormone that lowers blood levels of calcium.
The thyroid has a relatively delicate capsule of fibroelastic connective tissue, which penetrates between the follicles to form the stroma of the gland. Typical of endocrine glands, the stroma is well vascularized.

PARATHYROID GLANDS

The parathyroid gland consists mostly of closely-packed cords or clumps of small, basophilic, secretory chief (principal) cells. The gland has a connective tissue capsule of its own. Connective tissue stroma is minimal but contains many blood capillaries. There are also clusters of larger, eosinophilic oxyphil cells. These cells usually do not appear until after puberty, and increase in numbers with age.

ADRENAL (SUPRARENAL) GLANDS

These are endocrine glands with two structural-functional components of different embryonic origins: cortex-mesoderm, medulla-neural crest. Review their gross anatomical location and blood supply.

The adrenal gland has a connective tissue capsule, which surround a cortex and medulla. The cortex is divided into zones, distinguished by the organization of cells. From outer to inner: zona glomerulosa, zona fasciculata, zona reticularis (see figure). There are intervening blood sinuoids. The zona glomerulosa is mostly making aldosterone; the fasciculate is mostly making glucocorticoids and the reticularis is mostly making sex hormones.

The parenchyma of the medulla is mostly comprised of chromaffin cells (modified sympathetic ganglion cells), with intervening blood sinuoids. Arterial blood enters the gland in the capsule. The medulla has a dual blood supply:
• Medullary arterioles traverse the trabeculae of the cortex bringing arterial blood directly to the medulla
• Arterial blood first percolates through the cortex and drains into medullary capillary sinusoids exposing the medulla to high levels of steroid hormones (glucocorticoids are necessary to induce the enzyme methyltransferase, essential for the conversion of norepinephrine to epinephrine).

Venous drainage is from a single vein that drains from the medulla.

**PANCREATIC ISLETS (of Langerhans)**

The endocrine cells of the pancreas are aggregated into small, spherical clusters known as islets (of Langerhans), which are scattered among the exocrine acini and ducts. The cells of the islets are arranged into compact anastomosing cords that are extensively vascularized by fenestrated capillaries. In contrast to the exocrine pancreas, there are no ducts associated with the islets. Each islet cell is closely apposed to a capillary so that the hormones are released directly into pericapillary spaces.

Alpha and beta cells represent 20 and 75 percent of the islet cell population respectively. Alpha cells produce glucagon and beta cells produce insulin. There are a smaller number of somatostatin secreting delta cells and clear cells without stainable granules. Another islet cell type located preferentially in the head region secretes, in response to food ingestion, pancreatic polypeptide (PP), a hormone that stimulates gastric secretion while inhibiting bile secretion and intestinal peristalsis.

**PINEAL**

The pineal gland is an organ that is comprised of modified retinal cells (pinealocytes) and glial cells. The pinealocytes release melatonin into the circulation in a circadian fashion, under the control of the sympathetic nervous system. The most striking histological features of the pineal are the concretions surrounded by parenchymal cells of the pineal gland, known as pinealocytes, together with their supporting glial cells.
CHECK LIST

Understand endocrine, paracrine and autocrine secretory patterns.

PITUITARY GLAND: Know the embryonic origin of the anterior lobe (Rathe’s pouch) and the posterior lobe (neuroectoderm). Understand the difference in the cellular architecture, vasculature and the mode of secretion in the anterior and posterior pituitary. Identify:
- pars distalis (adenohypophysis, anterior pituitary)
  - basophils  - acidophils  - chromophobes
- pars nervosa (neurohypophysis, posterior pituitary)
  - pituicytes  - Herring bodies (special stain only)
- pars intermedia

THYROID GLAND: Understand the architecture of this gland and its stimulation, storage and release mechanisms. Understand what is meant by:
- follicles  - colloid (thyroglobulin)
- follicular cells  - reabsorption lacunae
- parafollicular (“C”) cells

PARATHYROID GLAND: Understand the architecture of this gland and its relationship to the thyroid gland. Know the physiological effects of the hormone secreted by the gland and its effect on calcium metabolism.
- chief (principal cells)  - oxyphil cells

ADRENAL GLANDS: Understand the different embryonic origins of cortex and medulla. Know the structural/functional relationships and the hormones produced by each region.
- capsule
- cortex
  - zona glomerulosa  - zona fasciculata
  - zona reticularis  - blood supply
- EM of steroid-secreting cells
- medulla
  - chromaffin cells  - blood supply

PANCREATIC ISLETS: Review the difference between endocrine and exocrine secretion in this mixed organ.
- alpha cells  - beta cells