

## I. Thyroid:

- 1) definition: butterfly-shaped endocrine gland located in the neck. It produces two types of hormones
  - a) **tri-iodothyronine (T3)** and **thyroxine (T4)**: are amino acid derivatives that bind to nuclear thyroid hormone receptor proteins, stimulate transcription of many genes, result in a generalized increase in cellular metabolism.
    - i) These act to increase the growth rate in the young, facilitate mental processes, and stimulate endocrine gland activity
    - ii) These hormones are stored in the colloid of the **thyroid follicles** bound to a large secretory glycoprotein called **thyroglobulin**
    - iii) When released, the glycoprotein is endocytosed and the hormone is cleaved by lysosomal proteases
  - b) **Calcitonin**: is a peptide hormone which inhibits bone resorption by osteoclasts and stimulating osteoblast activity thereby lowering blood calcium levels
    - i) Secreted by the **parafollicular cells** which are found individually or in clusters around the periphery of the follicle.
    - ii) Control of secretion is dependent only on blood calcium levels
- 2) Synthesis of T3 and T4
  - a) **Thyroglobin** synthesized and released into the colloid of the **thyroid follicle**
  - b) **Iodine** is actively transported into the follicular cells, activated, and released into the colloid where it can iodinate tyrosine residues of the thyroglobin
  - c) After endocytosis, iodinated residues are cleaved from thyroglobulin by proteases and are transferred into the cytosol as free thyroid hormones.
  - d) **TSH** stimulates the follicular cells to secrete T3 and T4 into the blood
- 3) Histological appearance/features
  - a) **Thyroid follicle**: spherical structures composed of a single layer of cuboidal epithelial cells, surrounding an inner colloid center, bounded by a basement membrane.
    - i) Composed of two cell types
      - (1) **Thyroid cells proper** synthesize colloid and are responsible for converting it to active hormone-appear squamous to low columnar in shape depending on their activity level, cytoplasm is basophilic and they have a dark-staining nucleus. Use pseudopods to phagocytose parts of the colloid
      - (2) **Calcitonin cells** (aka C cells, parafollicular cells)- larger than the thyroid cells and are pale staining. They do not reach the lumen of the follicles. Cytoplasmic extensions of thyroid cells partially surround the C cells
    - ii) **Follicular epithelium** low cuboidal in inactive follicles; cuboidal-columnar during active secretion and surrounded by blood vessels, lymphatics and nerves

## II. Parathyroid

- 1) Definition/location: Small ovoid structures; four in number; located on the posterior surface of the thyroid gland
  - a) Secrete **parathyroid hormone (PTH)** which raises calcium levels in three ways is stimulated by a decrease in blood calcium levels
    - i) Directly acting on the bone to increase the rate of osteoclast resorption and promoting breakdown of the bone matrix
    - ii) Direct action on kidney by increasing renal tubular resorption of calcium ions and inhibiting the reabsorption of phosphate ions (decreases calcium loss)
    - iii) Promotion of absorption of calcium from the small intestine by indirectly regulating production of vitamin D in the kidney
  - b) Cell types
    - i) **Principal (chief) cell** - numerous; secrete parathyroid hormone; arranged in cords or clusters
    - ii) **Oxyphil cell** - acidophilic staining due to presence of abundant mitochondria; do not secrete PTH. Are the inactive stage of the chief cell
  - c) Differentiate from the thyroid gland by the absence of follicles

### III. Adrenal gland

- 1) Definition/location: small flattened endocrine glands located at the upper pole of the kidneys. Contain two functionally different types of endocrine tissue
  - a) **Adrenal cortex** is the outer 80-90% of organ is composed of three layers:
    - (1) **Zona Glomerulosa** (13%) - arranged in clumps. Concentrically arranged cells surrounded by a stroma containing capillaries
    - (2) **Zona Fasciculata** (80%) - arranged in cords. Polygonal cells arranged in columns perpendicular to the capsule. Lipid droplets apparent in cells
    - (3) **Zona Reticularis** (7%) - arranged in an irregular network. Acidophilic due to abundant lysosomes
  - ii) secretes steroid hormones all derived from cholesterol
    - (1) **Mineralcorticoids**- secreted by the zona glomerulosa; include aldosterone and some deoxycorticosterone; stimulated by angiotensin II and ACTH; stimulate absorption of sodium; targets include distal convoluted tubules of the kidney, gastric mucosa, salivary glands, and sweat glands.
    - (2) **Glucocorticoids** secreted by the zona fasciculata; include hydrocortisone (cortisol) and corticosterone; stimulated by ACTH; anabolic effect in liver and catabolic effect in other tissues; suppress the immune response at above normal levels
    - (3) **Sex hormones (androgens)** secreted by the zona reticularis; include dehydroepiandrosterone and androstenedione; weak masculinizing effect.
  - iii) Is derived from the mesoderm (similar to the gonads) and appears yellowish
- b) **Adrenal medulla** secretes **epinephrine/norepinephrine** in response to pain/stress; increase oxygen consumption, increase heat production, mobilize fat for energy, increase blood pressure; prepare body for "fight or flight".
  - i) is embryonically similar to the sympathetic nervous system (neuroectodermal origin) and appears reddish
  - ii) Chief cell type is the **chromaffin cells** so called because the stored catecholamines are oxidized to a brown color

- (1) Arranged in clusters
- (2) Surrounded by venous sinusoids
- iii) Secretion of catecholamines are controlled by the preganglionic neurons of the sympathetic nervous system and act on adrenergic receptors throughout body but particularly in the heart, blood vessels, bronchioles and skeletal muscles.
  - (1) norepinephrine is stored in large granules with a dense core
  - (2) epinephrine is stored in smaller granules with a less dense core

#### IV. Clinical Correlations

- 1) **Graves Disease** is an autoimmune disease where IgG binds to the TSH receptors in the thyroid follicles and causes hyperplasia
  - a) Causes an over-activity of the thyroid (aka **hyperthyroidism**) which leads to a reduction in body weight, tachycardia, tiredness and muscle tremor
  - b) Also can cause **exophthalmos** - protrusion of the eyeballs.
  - c) Demonstrate a low TSH level and elevated T3/T4 level
- 2) **Simple Goiter** usually occurs when the thyroid gland is not able to produce enough thyroid hormone to meet the body's requirements. The thyroid gland compensates by enlarging, which usually overcomes mild deficiencies of thyroid hormone.
  - a) Associated with insufficient dietary intake of iodine
- 3) **Hypothyroidism** insufficient production of thyroid hormones characterized by fatigue, sleeping for 14-16 hours a day, muscular sluggishness, slowed heart rate, mental sluggishness, constipation, and loss of hair growth.
  - a) May also cause
    - i) **Myxedema** - bagginess under the eyes and a swollen face, due to infiltration of excess glycosaminoglycans and proteoglycans into the extracellular matrix.
    - ii) **Cretinism** - extreme hypothyroidism in fetal life through childhood; failure of growth and mental retardation