Endocrine system

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Learning objectives

• Describe the organization and function of endocrine tissues, including the key endocrine organs as well as diffuse endocrine cells.
• Distinguish the different types of pituitary cells using the light microscope and electron microscope.
• Name and describe the different layers of the adrenal gland, as well as the blood supply to this gland.
• Explain what is unique about the structure of the thyroid gland.
• Recognize the differences among thyroid, adrenal gland and pituitary gland.
Endocrine system

Endocrine glands: thyroid gland, adrenal gland, pituitary gland

Endocrine components distributed in other organs – heart, stomach, intestine, pancreas, kidney, ovary and testis
Endocrine organs

✓ No duct
✓ Fenestrated cap./Sinus
✓ Cells are arranged into groups, cords, network or follicles
✓ Secret hormone
Ways of Secretion

Endocrine vs. Neuronal secretion

Ways of Secretion
Nitrogen-secreting cell
RER: synthesize hormone
Golgi complex: release hormone
Membrane-bound granules: store granules

Steroid-secreting cells
SER: synthesize cholesterol
Mitochondria: synthesize steroid
lipid droplet: storage of cholesterol
Steroid-secreting cells
SER: synthesize cholesterol
Mitochondria: synthesize steroid
lipid droplet: storage of cholesterol
Thyroid Gland

- Found at 2nd through 4th cartilages of the trachea
- Small gland with four parathyroid glands attached to the posterior surface
- Structure
  - **Capsule**: D.C.T
  - **Parenchyma**: follicle, reticular tissue

C: capsule, S: septa
Simple follicular epithelium cells

- Inactive/active: squamous/cuboidal/columnar
- Less CT: rich in fenestrated capillary

Follicle cavity: colloid

- A jelly-like substance:
- Inactive/active: much/less

Thyroid follicle

Inactive

Active

fenestrated capillary
Follicular cell

Microvillus, RER, Golgi complex, secreting granules, Pinocytosis vesicles, lysosome

T: follicular thyrocytes
L: lumen
Production of Thyroid Hormone

1. production of thyroglobulin (RER, Golgi apparatus)
2. Uptake of iodide (Na/I symporters, iodide/chloride transporter, peroxidase)
3. Iodination of tyrosyl residues
4. Formation of pre-T3 and pre-T4
5. Endocytosis of iodinated thyroglobulin (lysosome)
6. Secretion of T4 and T3
Parafollicular cell

✓ Between the follicles
✓ Cells are bigger and lightly stained
✓ Secrete calcitonin
✓ Calcitonin functions to reduce calcium levels in the blood by actively reducing breakdown of bone and inhibiting re-absorption of calcium in digestive system.

T: follicular thyrocytes  C: parafollicular cell
Parafollicular cell

Well-developed organelles: Golgi complex, RER, Secreting granules with calcitonin

Ultrastructure of thyroid follicular and parafollicular cells
Thyroid Gland Functions

- Thyroid hormones increase the number and size of mitochondria and stimulate mitochondrial protein synthesis, helping to enhance metabolic activity.
  - It controls the metabolism of the body.
  - It controls the heart beat.
  - It regulates the temperature in the body.
- Thyroid hormones regulate the development of nervous system.
Adrenal gland

- Capsule: CT
- Parenchyma: cortex + medulla
Adrenal cortex

Cortex: secreting cells, sinus, connective tissue

Three zones: Zona glomerulosa, Zona fasciculata, Zona reticularis
Zona glomerulosa:
- Smaller cells, darkly-stained
- Cells are arranged in rounded clumps
- Cells secrete mineralcorticoids including aldosterone.
- Aldosterone which helps to control electrolyte and water balance.

Zona fasciculata
- Bigger cells
- Cells are arranged into cords
- Cells secrete glucocorticoids including cortisone and hydrocortisone.
- These hormones help to regulate glucose metabolism and important in inflammation reactions and immunologic response.

Zona reticularis
- Smaller cells, darkly-stained
- Cells form and network of interlinking cells.
- Secrete sex hormones mainly androgens, estrogen. Usually in small proportions if too many can cause bearded lady.
Ultra-structure of cortical adrenalocytes

- Lipid droplets
- Mitochondria with tubular and vesicular cristae
- Abundant SER

L: Lipid droplets
G: Golgi apparatus
N: Nuclei
A: Autophagosomes
M: Mitochondria
Medulla:
Connective tissue, Sinus, Central vein, Richly innervated by pre-ganglionic sympathetic fibers

Cell types:

• **ganglion cell**: few, bigger cell, *lightly-stained nuclei*, obvious nucleolus

• **Medulla cells/chromaffin cells**: polygonal, *basophilic cytoplasm*, modified sympathetic postganglionic neurons that have become secretory cells,
  ✓ epinephrine cell: 80%, less electron-dense, smaller
  ✓ norepinephrine cell: 20%, electron-dense

1 Cords of chromaffin medullary cells
2 Medullary veins
3 Multipolar ganglion cells
4 Cushion of smooth muscle cells, smooth muscle prominence

Stain: alum hematoxylin-eosin; magnification: × 40
Epinephrine: Epinephrine increases heart rate, dilates bronchioles and dilates arteries of cardiac and skeletal muscle.

Norepinephrine: constricts vessels of the digestive system and skin, increasing blood flow to the heart, muscles and brain.

Part of the bodies response to an emergency or the fight or flight response.
Most of blood passes from cortex to medulla, and glucocorticoid in the cortex activates the phenylethanolamine methyltransferase in the medulla cells and converts norepinephrine into epinephrine.
Pituitary gland/Hypophysis

Master gland

✓ Secretes hormones that regulate other endocrine glands
✓ Controlled by hypothalamus
腺垂体来自胚胎口凹的外胚层上皮，神经垂体由间脑底部的神经外胚层向腹侧突出的神经垂体芽发育而成。
Hypophysis

Staining: adenohypophysis >> neurohypophysis
Capsule: connective tissue
Pars distalis

✓ 75% of the mass of the hypophysis
✓ Sinusoid
✓ Cells are arranged by cords/groups
  • Chromophobe
  • Chromophil: basophils and acidophils
• Acidophils: 40%, acidophilia granules
• Basophils: 10%, basophilia granules
• Chromophobes: 50%, pale-staining
<table>
<thead>
<tr>
<th>Cell Type</th>
<th>% of Total Cells</th>
<th>Hormone Produced</th>
<th>Major Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Somatotrophs</td>
<td>50</td>
<td>Somatotropin (growth hormone, GH), a 22-kDa protein</td>
<td>Stimulates growth in epiphyseal plates of long bones via insulin-like growth factors (IGFs) produced in liver</td>
</tr>
<tr>
<td>Lactotrophs (or mammotrophs)</td>
<td>15-20</td>
<td>Prolactin (PRL), a 22.5-kDa protein</td>
<td>Promotes milk secretion</td>
</tr>
<tr>
<td>Gonadotrophs</td>
<td>10</td>
<td>Follicle-stimulating hormone (FSH) and luteinizing hormone (LH; interstitial cell-stimulating hormone [ICSH] in men), both 28-kDa glycoprotein dimers, secreted from the same cell type</td>
<td>FSH promotes ovarian follicle development and estrogen secretion in women and spermatogenesis in men; LH promotes ovarian follicle maturation and progesterone secretion in women and interstitial cell androgen secretion in men</td>
</tr>
<tr>
<td>Thyrotrophs</td>
<td>5</td>
<td>Thyrotropin (TSH), a 28-kDa glycoprotein dimer</td>
<td>Stimulates thyroid hormone synthesis, storage, and liberation</td>
</tr>
<tr>
<td>Corticotrophs</td>
<td>15-20</td>
<td>Adrenal corticotropin (ACTH), a 4-kDa polypeptide</td>
<td>Stimulates secretion of adrenal cortex hormones</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lipotropin (LPH)</td>
<td>Helps regulate lipid metabolism</td>
</tr>
</tbody>
</table>
**Somatotrophs:** the most ubiquitous cells of the anterior pituitary and have a distinct appearance because they have abundant secretory granules.

**Mammatrophs:** secretory granules vary with pregnancy and lactation.

**Thyrotrophs:** many granules, but they tend to be limited more to the periphery of the cells.

**Gonadotrophs** are larger and have granules of different sizes although there are typically fewer of these granules than in the somatotrophs and thyrotrophs.

**Corticotrophs** have the least abundant granules.

Note also the capillary that is present.
Somatotropic cells

Ultrastructure and immunohistochemistry of somatotropic cells

(a) Ultrastructurally, cytoplasm of all chromophil cells is shown to have well-developed Golgi complexes (G), euchromatic nuclei (N), and cytoplasm filled with secretory granules, as seen here in a somatotroph, the most common acidophil. The arrow indicates the cell membrane. Specific chromophils are more easily identified using immunohistochemistry and antibodies against the hormone products. (X10,000)

(b) The micrograph shows somatotrophs stained using an antibody against somatotropin. (X400; Hematoxylin counterstain)
嗜色细胞

嗜酸性细胞

生长激素细胞（50%）

↑骨骼肌、骨

催乳激素细胞（15-20%）

↑乳腺发育、乳汁分泌

促甲状腺激素细胞（5%）

↑甲状腺素合成分泌

促碱性细胞

促性腺激素细胞（10%）

卵泡刺激素

女：卵泡发育、雌激素分泌
男：精子发生

黄体生成素

女：卵泡成熟、孕激素分泌
男：雄激素分泌

促肾上腺皮质激素

促脂素

↑脂肪细胞甘油三酯分解
Pars intermedia

✓ A narrow zone lying between pars distalis and pars nervosa
✓ Basophils/Chromophobes/colloid-filled cysts derived from the lumen of the embryonic hypophyseal pouch

PI: pars intermedia  PD: pars distalis  PN: pars nervosa  B: basophils
C: colloid-filled cysts
Pars tuberalis

✓ A smaller funnel-shaped region surrounding the infundibulum of the neurohypophysis
✓ Capillaries are very rich
✓ Cells are arranged into cords
✓ Most of the cells are Chromophobes.
✓ Most of cells could secret FSH and LH.
### Pituitary-related disease

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Hyper-secretion</th>
<th>Hypo-secretion</th>
</tr>
</thead>
<tbody>
<tr>
<td>GH</td>
<td>Gigantism acromegaly</td>
<td>Dwarf (children)</td>
</tr>
<tr>
<td>Prolactin</td>
<td>No catamenia</td>
<td>More mammary-gland</td>
</tr>
<tr>
<td>ACTH</td>
<td>Cushing syndrome</td>
<td>----</td>
</tr>
<tr>
<td>FSH</td>
<td>Reproductive system</td>
<td>Reproductive system</td>
</tr>
<tr>
<td>LH</td>
<td>Reproductive system</td>
<td>Reproductive system</td>
</tr>
<tr>
<td>TSH</td>
<td>Hyperthyroid condition</td>
<td>Cretinism myxedema</td>
</tr>
</tbody>
</table>

- **Gigantism**
- **Dwarf**
- **acromegaly**
- **Cushing syndrome**
- **Cretinism**
Neurohypophysis

- The extension of the hypothalamus
- Unmyelinated nerve fiber, branched glial cells (pituicytes) and fenestrated capillaries
- **NOT** produce any hormones but does secrete two hormones produced by the hypothalamus: Oxytocin and ADH
- Herring body: neurosecretory bodies, the accumulation of hormones, faintly eosinophilic structures

C: capillary
P: pituicytes
NB: Herring body
Oxytocin and ADH

Oxytocin (OT): regulates uterine muscle contraction and mammary glands stimulating milk flow

ADH: increases water retention by the kidney
Hypothalamic-hypophyseal tract & blood supply

- Adenohypophysis: Superior hypophyseal arteries---hypothalamic-hypophyseal portal system
- Neurohypophysis: Inferior hypophyseal arteries
下丘脑结节区

Tuberous area of hypothalamus
A stimulus (e.g., low body temperature) causes the hypothalamus to secrete thyrotropin-releasing hormone (TRH), which acts on the anterior pituitary. Hypothalamic thyrotropin-releasing hormone (TRH) stimulates secretion of thyroid-stimulating hormone or thyrotropin (TSH), which stimulates synthesis and secretion of thyroid hormone (TH). In addition to their effects on target organs, TH inhibits TSH secretion from the pars distalis and TRH secretion from the hypothalamus by negative feedback.
Questions

1. Which region are epinephrine produced from? A, B, C, or D?
2. Name the cell by arrow and describe its structure and function.
3. Which of area to regulate the following activity?

3.1. To regulate thyroid activity?
3.2. To regulate adrenal activity?
3.3. To regulate renal tubule activity?
4. Please describe the difference of follicular cell and Parafollicular cell? (microstructure and ultrastructure and function)

5. Secretion, chemical modification and storage, reuptake, and digestion of a protein occur in epithelial cells of what endocrine tissue?
   a. Neurohypophysis
   b. Adrenal medulla
   c. Adenohypophysis
   d. Thyroid gland
   e. Neuroendocrine cells in the duodenum