Embryology and Histology of Pituitary and Adrenal gland

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Pituitary gland, is a pea-sized gland that sits in a protective bony enclosure called the sella turcica and covered by a dural fold, diaphragma sellae. It is composed of anterior, small intermediate and posterior lobes.

1- The anterior lobe of pituitary (adenohypophysis) is fleshy part of the gland; its endocrine cells are controlled by regulatory hormones released by neurosecretory cells in the hypothalamus (hypothalamic releasing hormones). Hypothalamic secretion passes in capillaries leading to infundibular blood vessels, which in turn lead to a second capillary bed in the anterior pituitary. This vascular relationship constitutes the hypothalamo-hypophyseal portal system.
Diffusion of the hypothalamic releasing hormones out of the second capillary bed takes place; these hypothalamic hormones binds to anterior pituitary endocrine cells and stimulating or depressing their release of hormones. The capillaries in this gland are fenestrated, to enable passage of hormones from the secretory cells into the bloodstream.

Portal system: is a system starts in capillaries and ends in capillaries.
2- **Intermediate lobe (pars intermedia)** is a narrow area lies between the anterior and posterior lobes of the pituitary. It is the smallest lobe and its function is to produce and secrete melanocyte-stimulating hormone.

3- **The posterior pituitary (neurohypophysis)** is a lobe of the gland that is functionally connected to the hypothalamus by the median eminence via a small tube called the **pituitary stalk** (also called the infundibular stalk or the infundibulum). The Posterior pituitary hormones are synthesized by neurosecretory cells of the **supraoptic and paraventricular nuclei**, these nuclei are located in the hypothalamus. Axons of these cells project down the infundibulum to the posterior pituitary.
The release of pituitary hormones by the anterior, intermediate, and posterior lobes is under the control of the hypothalamus.

The anterior pituitary contains several different types of cells that synthesize and secrete hormones. Usually there is one type of cells for each major hormone formed.

Hormones secreted by the anterior lobe
1- growth hormone' (GH),
2- Thyroid-stimulating hormone (TSH)
3- Adrenocorticotropic hormone (ACTH)
4- Prolactin (PRL)
5- Gonadotropin hormone:
a- includes Follicle-stimulating hormone (FSH) and
b- Luteinizing hormone (LH)

Hormones secreted by the intermediate lobe
1- Melanocyte–stimulating hormone (MSH)
The posterior pituitary stores and secretes
1- Antidiuretic hormone (ADH, also known as vasopressin and arginine vasopressin AVP). This hormone is released from the supraoptic nucleus in the hypothalamus.
2- Oxytocin hormone, it is released from the paraventricular nucleus in the hypothalamus. It stimulates uterine contraction.
Histology of the pituitary gland

1- **The anterior lobe** shows two types of chromophils cells (cells which take up stain), they are **acidophils** and **basophils**

<table>
<thead>
<tr>
<th>Type of chromophil</th>
<th>Secretory Product</th>
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<tbody>
<tr>
<td>Acidophil</td>
<td>growth hormone (GH, also known as somatotrophin, STH)</td>
</tr>
<tr>
<td></td>
<td>prolactin (PRL)</td>
</tr>
<tr>
<td>Basophil</td>
<td>ACTH (Adrenocorticotrophic hormone,) also known as corticotrophin.</td>
</tr>
<tr>
<td></td>
<td>TSH (thyroid stimulating hormone), also known as thyrotrophin</td>
</tr>
<tr>
<td></td>
<td>gonadotrophins: FSH (follicle stimulating hormone) and LH (Lutenising hormone).</td>
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This is a magnified image of the anterior pituitary, stained with H&E showing two types of chromophils; pink - **acidophils**, which are more common, and purple - **basophils**. (Occasionally, you may be able to identify a third type, which are poorly stained, these are resting/degranulated chromophils.)
2- The Intermediate lobe contains three types of cells - basophils (secrete melanocyte stimulating hormone), chromophobes (does not stain readily), and colloid-filled cysts. The cysts are the remainder of Rathke’s pouch.
3- The posterior lobe contains specialized neuroglial cells (assisting in the storage and release of the hormones) and nerve fibres (non-myelinated axons). The cell bodies of these axons are located in the hypothalamus.
Embryology of the pituitary gland

Pituitary gland develops from two different parts

1- An ectodermal bulge from the stomodeum (depression forming the mouth) immediately in front of the oropharyngeal membrane. This bulge is called **Rathke’s pouch**

2- A downward extension from the hypothalamus known as the **Infundibulum**

On the 3rd week, **Rathke’s pouch** appears as an outgrowth from the oral cavity. It grows dorsally toward the infundibulum. By the end of the second month, it loses its connection with the mouth and comes in contact with the infundibulum. **Anterior cells of the Rathke’s pouch** multiply rapidly forming the **anterior lobe** of pituitary (adenohypophysis). A small extension of the anterior lobe, the **pars tuberalis** (part of the anterior lobe), grows along the stalk of the infundibulum and surrounds it.
The posterior wall of the Rathke’s pouch develops into the Pars intermedia (middle lobe). The infundibulum gives rise to the stalk and the posterior lobe of the pituitary (neurohypophysis) which contains neuroglial cells and nerve fibres coming down from cell bodies in the hypothalamus.
Development of suprarenal gland
Suprarenal gland
Adrenal gland

Adrenal gland has outer adrenal cortex and inner adrenal medulla

All the hormones secreted by **adrenal cortex** are **steroid hormones**, which are all based on cholesterol. **Secretory cells contain triglyceride droplets.** The cortex can be divided into three regions:

• Zona glomerulosa
• Zona fasciculata
• Zona reticularis

**Hormones secreted from adrenal medulla** are Adrenaline and Noradrenaline
Histology of the Adrenal cortex

Adrenal gland

Cortex

Medulla

Connective tissue capsule

Zona glomerulosa (adrenal cortex)

Zona fasciculata (adrenal cortex)

Zona reticularis (adrenal cortex)

Adrenal medulla

Superior surface of kidney
1. **Zona glomerulosa**, the outermost zone of the adrenal cortex secretes **mineralcorticoids**. These hormones are important for fluid homeostasis. These include **aldosterone**, which regulates absorption/uptake of K+ and Na+ levels in the kidney.

The secretory cells are arranged in irregular **ovoid clusters** that are **surrounded by trabeculae** which contain capillaries. The nuclei stain strongly, and the cytoplasm is less pale than that of the next zone, the **zona fasciculata**, as there are fewer lipid droplets in these cells.
2. Zona fasciculata, the middle zone of the adrenal cortex secretes glucocorticoids which are important for carbohydrate, protein and lipid metabolism. An example is cortisol which raises blood glucose and cellular synthesis of glycogen. Its secretion is controlled by a hormone from the pituitary - ACTH. The secretory cells are arranged in cords, often one cell thick, surrounded by fine strands of supporting tissue. The nuclei of these cells stain strongly, and the cytoplasm is rich in Smooth Endoplasmic Reticulum, mitochondria and lipid droplets. The cytoplasm looks pale and foamy due to the presence of lipid droplets.

Zona fasciculata
Zona fasciculata
3. Zona reticularis, the innermost layer of the cortex. It secretes sex hormones (androgens), and small amounts of glucocorticoids. Some brown pigment is seen in some of these cells - this is lipofuscin, probably an insoluble degradation product of organelle turnover - an 'age' pigment. The cytoplasm of the cells in this region stains more darkly, and contains fewer lipid droplets.
Histology of the Adrenal medulla

Adrenal medulla contains columnar basophilic staining cells, with non granular cytoplasm (no granules) and no stored lipid. It also contains many venous channels which drain blood from the sinusoids of the cortex, pass through the medulla, and drain into the medullary vein. Cells are actively secreting the peptide (amino acid) based hormones – nor-adrenaline and adrenalin (catecholamines), which are stored in the granules.

Secretion of these hormones is controlled by the sympathetic nervous system. The targets of these hormones are the adrenergic receptors in the heart, blood vessels, bronchioles, visceral muscle, skeletal muscle, and in the liver, where they promote glycolysis (breakdown of glycogen).
adrenal medulla contains **basophilic staining cells**, with a granular cytoplasm and no stored lipid. It also contains many venous channels.
Embryology of the Suprarenal gland

- **Lie on the superior aspect of the kidneys**

- **Consist of two endocrine organs**
  a. Inner adrenal medulla
  b. Outer adrenal cortex

- **Distinct embryological origins**
  a. **Medulla** - chromaffin cells derived from the ectodermal cells of the neural crest
  b. **Cortex** - mesodermal origin
On the beginning of 2\textsuperscript{nd} month (8 mm fetus) and under the induction by mesonephric duct, the mesothelial (coelomic epithelial) cells proliferate and penetrate the underlying mesenchym. They multiply quickly and \textbf{differentiate into large acidophilic cells} which surround the medullary primordium and form the \textbf{fetal (primitive) suprarenal cortex}. At the \textbf{end of the 3\textsuperscript{rd} month}, a \textbf{second wave} of cells from the coelomic epithelium (mesothelium) penetrates the mesenchyme and surrounds the original \textbf{acidophilic cell mass}. These smaller basophilic cells form the \textbf{definitive cortex of the gland}. The small basophilic cells will form the future \textbf{zona glomerulosa and zona fasciculata} of the definitive cortex.

After birth, the \textbf{fetal (primitive) cortex} regresses rapidly, except for its outer layer which differentiates into the \textbf{zona reticularis}.
Prior to the 5\textsuperscript{th} month of fetal life, the cortex appears to develop autonomously. After this time, its development depends on hypophyseal corticotrophic hormone (ACTH).
The medullary primordium occurs at about day 45 of gestation. Cells originating in the sympathetic system from the sympathetic chain (neural crest cells) in the region near the developing mesodermal cortical primordium. While the fetal cortex is forming, the sympathetic cells invade its medial aspect and are arranged in clusters and cords. These cells gives rise to the medulla of the suprarenal gland. These cells do not form nerve processes, They stain yellow-brown with chrome salts and are called chromaffin cells. The staining is probably due to the oxidation of epinephrine and norepinephrine within the cells by the staining chrome salts.
Development of the adrenal gland
Development of the adrenal gland

After birth

Adult cortex

Development of the adrenal gland
At birth, the medulla is only slightly developed and is not yet functional. 

Development of the definitive cortex and its physiologic activity is regulated by ACTH, and it is not completely differentiated until 18 to 21 months after birth.

The adrenal arteries take their major origin from the abdominal aortic system.

Innervation of the adrenal gland: The adrenal medulla consists of irregularly shaped cells grouped around blood vessels. These adrenal medullary cells are modified postganglionic neurons. These cells are intimately connected with the sympathetic nervous system. They secrete epinephrine and norepinephrine in the blood. The targets of these hormones are the adrenergic receptors on body organs.
The adrenal glands in a newborn baby are much larger as a proportion of the body size than in an adult. For example, at age three months the glands are four times the size of the kidneys. The size of the cortex decreases relatively by age of 1 year after birth, mainly because of shrinkage of the cortex. The fetal cortex regresses rapidly, except for its outer layer which differentiates into the zona reticularis of the cortex.

**Conclusion:** Fetal adrenal glands grow rapidly and at term are similar in weight to adult adrenals. From birth to 1 year their mass is reduced as they undergo a process of differentiation. Growth then remains slow until age 7 years. Thereafter, growth accelerates and the adrenals reach adult weight by the end of puberty.
Development of adrenal gland

- Sympathetic trunk
- Spinal cord: T₈–L₁
- Ventral root
- Thoracic splanchnic nerves
- Kidney
- Adrenal gland
- Adrenal medulla
- Epinephrine and norepinephrine
- Capillary

**A**
- 5th month
  - Adult cortex: 20%
  - Fetal cortex: 75%
  - Medulla: 5%

**B**
- Newborn
  - Adult cortex: 35%
  - Fetal cortex: 50%
  - Medulla: 15%

**C**
- Adult
  - z. glomerulosa
  - z. fasciculata
  - z. reticularis
  - Medulla: 20%
Thank You