Endocrine System
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Endocrine System Lecture Objectives

• Describe the location, histologic components, and embryologic origin of the pituitary gland.

• List the hormones produced by the anterior and posterior pituitary and know their general function.

• Describe the location, histologic components, and embryologic origin of the thyroid gland.

• List the hormones made by the thyroid gland and know their general function.

• Describe the location, cell types and hormone of the parathyroid glands.
Endocrine System Lecture Objectives

- Describe the location, cortical layers, and medulla of the adrenal glands.
- List the hormones made in the cortex and medulla, and know their general function.
- Describe the location of the pancreas, and the structure and cellular components of a typical pancreatic islet.
- List the hormones made by the islet cells and know their general function.
- Describe the location, cell types, and hormone produced by the pineal gland.
Endocrine System Lecture Outline

• Introduction
• Pituitary
• Thyroid
• Parathyroid
• Adrenal
• Pancreas
• Pineal
Endocrine System Lecture Outline

• Introduction
Endocrine organs secrete hormones through the blood (no ducts!).

Hormones travel elsewhere and have effects on different tissues.

The classical endocrine system consists of all the organs we will discuss in this lecture.

Male and female reproductive systems also have endocrine functions (we’ll discuss these later).
Endocrine System in a Nutshell

Hypothalamus

Pituitary

Endocrine organ (for example, thyroid)
Endocrine System in a Nutshell

- Hypothalamus
- Pituitary
- Endocrine organ (thyroid)

The hypothalamus tells the pituitary what to do.

The pituitary tells the endocrine organ what to do.

The endocrine organ releases hormone.
Endocrine System in a Nutshell

The hypothalamus is like a CEO but we don’t talk about it much (not many diseases there)

The pituitary is like a COO. It basically tells everyone what to do.

The endocrine organ is the worker drone. Poor guy.
There are negative feedback loops that tell the system when to stop producing hormone.
Endocrine System Lecture Outline

- Introduction
- Pituitary
Pituitary Gland

• Located in the sella turcica (Turkish saddle) in the sphenoid bone.
• Connected to the hypothalamus
• Two lobes:
  • Anterior (adenohypophysis)
  • Posterior (neurohypophysis)
Diencephalon

Cerebral vesicle

Hypophyseal diverticulum (Rathke’s pouch)

Stomatodeum

Notochord

Neurohypophyseal diverticulum

Forming pituitary gland

Former site of buccopharyngeal membrane

Development of the Pituitary Gland
Development of the Pituitary Gland

Also called craniopharyngeal duct

Floor of diencephalon
Neurohypophyseal diverticulum
Infundibulum
Hypophysial diverticulum
Oral ectoderm

Pars intermedia
Anterior lobe

Infundibular stem
Pars tuberalis (anterior lobe)
Optic chiasm
Median eminence

Developing sphenoid bone
Former site of hypophysital stalk
Pharyngeal roof

Colloid-containing vesicles
Intracranial, intraosseus, and pharyngeal accessory anterior lobe tissue

Pars nervosa (posterior lobe)

Recessing stalk of hypophysial diverticulum

Development of the Pituitary Gland
Ugh! Just give me the bottom line.

Anterior pituitary: derived from oral ectoderm. Posterior pituitary: derived from floor of developing brain. This makes sense, given what the lobes look like (anterior = glandular epithelium, posterior = neural tissue).
Anterior and posterior pituitary
Anterior and posterior pituitary
Anterior Pituitary (Adenohypophysis)

- Composed of cords of glandular epithelial cells separated by capillaries.
- Makes and secretes a bunch of hormones.
- Subdivisions
  - Pars distalis (biggest and most important part)
  - Pars tuberalis (superior extension of pars distalis)
  - Pars intermedia (separates pars distalis from pars nervosa)
Anterior pituitary

<table>
<thead>
<tr>
<th>Anterior pituitary</th>
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<tbody>
<tr>
<td>Pars tuberalis</td>
</tr>
<tr>
<td>Pars intermedia</td>
</tr>
<tr>
<td>Pars distalis</td>
</tr>
</tbody>
</table>

Optic chiasm

Hypophyseal fossa in sella turcica of sphenoid bone

Anterior pituitary
Posterior lobe

Anterior lobe

Pituitary: super low-power view
Pituitary: super low-power view

- Pars distalis (PD)
- Pars intermedia (PI)
- Pars tuberalis (PT)
- Infundibular stalk (IS)
- Pars nervosa (PN)
Anterior pituitary: acidophils, basophils, chromophobes
Hormones of the Anterior Pituitary

Anterior pituitary makes and secretes:

- Growth hormone (GH)
- Prolactin (PL)
- Follicle-stimulating hormone (FSH)
- Luteinizing hormone (LH)
- Adrenocorticotropic hormone (ACTH)
- Thyroid stimulating hormone (TSH)
# ROS* of Anterior Pituitary Hormones

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Stimulates</th>
</tr>
</thead>
<tbody>
<tr>
<td>GH</td>
<td>Growth of bones and many other functions</td>
</tr>
<tr>
<td>PL</td>
<td>Milk secretion</td>
</tr>
<tr>
<td>FSH</td>
<td>Females: ovarian follicle development</td>
</tr>
<tr>
<td></td>
<td>Males: spermatogenesis</td>
</tr>
<tr>
<td>LH</td>
<td>Females: ovarian follicle development</td>
</tr>
<tr>
<td></td>
<td>Males: testicular hormone secretion</td>
</tr>
<tr>
<td>ACTH</td>
<td>Secretion of hormones of the adrenal cortex</td>
</tr>
<tr>
<td>TSH</td>
<td>Secretion of thyroid hormone</td>
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</tbody>
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* Ridiculously Oversimplified Summary
Acidophils
GH
PL
Basophils
FSH
LH
ACTH
TSH
Posterior Pituitary (Neurohypophysis)

- Composed of neural tissue (mostly axons).
- Subdivisions
  - Pars nervosa (biggest and most important part)
  - Median eminence (floor of the hypothalamus)
  - Infundibulum and infundibular stalk (axons traveling from hypothalamus to pars nervosa)
Hypothalamus

Posterior pituitary

- Mammillary body
- Median eminence
- Infundibulum
- Infundibular stalk
- Pars nervosa

Posterior pituitary
Pituitary: super low-power view

- Pars distalis (PD)
- Pars tuberalis (PT)
- Pars intermedia (PI)
- Infundibular stalk (IS)
- Pars nervosa (PN)
Posterior pituitary
Posterior pituitary: axons and pituicytes (glial cells)
Hormones of the Posterior Pituitary

• Posterior pituitary doesn’t make hormones! It secretes hormones made by the hypothalamus.

• Herring bodies are dilated portions of axons containing hormone-filled vesicles.

• Hormones:
  • Antidiuretic hormone (ADH) (also called vasopressin)
  • Oxytocin
Posterior pituitary: Herring body
**BAHS* of Posterior Pituitary Hormones**

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Stimulates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antidiuretic hormone</td>
<td>Water reabsorption in the kidney</td>
</tr>
<tr>
<td>Oxytocin</td>
<td>Contraction of uterine smooth muscle in labor. Contraction of breast cells to allow milk let down.</td>
</tr>
</tbody>
</table>

* Boring as heck summary
# VIS* of Oxytocin

<table>
<thead>
<tr>
<th>Situation</th>
<th>Stimulates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interpersonal connection</td>
<td>Trust</td>
</tr>
<tr>
<td>Orgasm</td>
<td>Pleasure AND connection with that particular person</td>
</tr>
<tr>
<td>Intimate relationship</td>
<td>Monogamy</td>
</tr>
<tr>
<td>Sports teams</td>
<td>Better performance</td>
</tr>
</tbody>
</table>

* Very interesting summary
Hypothalamo-hypophyseal portal system

- Neurons of the supraoptic and paraventricular nuclei
- Neurons of the dorsal medial, ventral medial and infundibular nuclei
- Stem
- Infundibulum
- Median eminence
- Primary capillary plexus
- Superior hypophyseal artery
- Inferior hypophyseal artery
- Pars distalis
- Pars nervosa
- Secondary capillary plexus
- Endocrine cells
- Collecting vein

Hormones produced in the hypothalamus and released in the pars nervosa
- Stimulating (or inhibiting) hormones produced in the hypothalamus
- Hormones produced in the pars distalis
Hypothalamus
The hypothalamus produces and releases hormones that stimulate or (less commonly) inhibit hormone secretion from the anterior pituitary.

Target organs
Hormones produced by target organs exert negative feedback on both the hypothalamus and the anterior pituitary. Too much hormone turns off production/secretion for a while. Nice!
Endocrine System Lecture Outline

• Introduction
• Pituitary
• Thyroid
Development of the Thyroid Gland

Originates from foramen cecum; descends along thyroglossal duct (which later disappears), in front of the hyoid and larynx, to its position in front of the trachea (by week 7).
Thyroglossal duct cyst

Developmental abnormalities of the thyroid
Thyroid gland gross anatomy
Thyroid follicles containing colloid
Thyroid Gland

- Composed of round follicles lined by simple squamous to cuboidal epithelium and filled with colloid.
- Follicular cells synthesize thyroid hormones (T3 and T4) and secrete them into the blood.
- Hypothalamus releases TRH (thyrotropin releasing hormone), which makes pituitary release TSH (thyroid stimulating hormone), which makes thyroid release thyroid hormone.
Uptake of colloid by endocytosis. Lysosome & colloid droplet fuse. Digestion by enzymes releases thyroid hormones (T3, T4).

Synthesis and Iodination of Thyroglobulin
- Iodinated thyroglobulin
- In colloid
- Apical vesicle containing thyroglobulin
- Mannose incorporation
- Thyroglobulin synthesis
- Amino acids
- Iodide

Release of Thyroid Hormone
- Uptake of colloid by endocytosis
- Lysosomes
- Digestion by enzymes releases thyroid hormones (T3, T4)
- Thyroid-stimulating hormone bound to receptor
- Lysosomal enzyme synthesis
- (T3, T4)
What Does Thyroid Hormone Do?

- Quick answer: increase growth and metabolism.
- More detailed answer: stimulate mitochondrial protein synthesis, increase absorption of carbohydrates, regulate fat metabolism, promote cell growth.
- Bottom line: it increases basal metabolic rate and revs up most bodily functions (increases heart rate, raises body temperature, increases nervous reactivity, increases GI motility...the list goes on).
Parafollicular Cells (C Cells)

- Derived from neural crest ectoderm.
- Located between follicular cells and between follicles.
- Parafollicular cells are larger cells with clear cytoplasm and small secretory granules containing calcitonin.
- Calcitonin is made in response to high blood calcium (it’s not regulated by the pituitary!).
- Calcitonin lowers blood calcium levels by inhibiting osteoclastic resorption.
Parafollicular (C) cell
Endocrine System Lecture Outline

• Introduction
• Pituitary
• Thyroid
• Parathyroid
Parathyroid glands gross anatomy
Parathyroid Glands

• Four glands on posterior surface of thyroid.
• Main function: secrete parathyroid hormone (PTH) to regulate calcium levels.
• PTH raises calcium levels in response to low serum calcium (it’s not regulated by the pituitary!).
• Two main cell types: chief cells (secrete PTH) and oxyphils (function unknown).
Parathyroid gland: super low-power view
Parathyroid gland: adipose tissue
Parathyroid gland: chief cells
Parathyroid gland: oxyphil cells
Endocrine System Lecture Outline

• Introduction
• Pituitary
• Thyroid
• Parathyroid
• Adrenal
Adrenal gland gross anatomy
The Adrenal Cortex and Medulla

Adrenal cortex is on the outside
  • Originates from mesoderm
  • Produces steroids (mineralocorticoids, glucocorticoids, and sex steroids)

Adrenal medulla is on inside
  • Originates from neural crest
  • Produces epinephrine and norepinephrine
Cranial nerves
Bones and connective tissue of the head
Pharyngeal arches
Adrenal medulla

Central nervous system
Posterior pituitary

Neuroectoderm

Urogenital system
Intermediate plate mesoderm

Lateral plate mesoderm
Paraxial mesoderm

Surface ectoderm

Epidermis, hair, and nails
Anterior pituitary

Endoderm

Lining of GI tract

Bones of most of the body
(everything except the head)
Muscles of the body and head
Pharyngeal arches
Connective tissue

Heart
Hematopoietic system
Pharyngeal arches
Connective tissue
Adrenal cortex
Adrenal gland histology

Cortex

Medulla

Adrenal gland histology
Zones of the Adrenal Cortex

- **Zona glomerulosa**
  - *glomerulus* = little ball of yarn

- **Zona fasciculata**
  - *fascis* = bundle

- **Zona reticularis**
  - *reticulum* = little net
Zona Glomerulosa

- Outermost zone. Cells arranged in little clusters.
- Cells produce mineralocorticoids (mostly aldosterone).
- Aldosterone stimulates sodium reabsorption by the kidney (leading to an increase in blood pressure).
- Aldosterone release is stimulated mostly by angiotensin II (only slightly by ACTH).
Adrenal cortex: glomerulosa
Zona Fasciculata

• Middle zone. Cells arranged in straight bundles.
• Cells make glucocorticoids (mostly cortisol), and a small amount of androgens.
• Cortisol is a long-term “stress” hormone
  • Mobilizes resources (increases blood glucose)
  • Shuts down stuff you don’t need (digestion, growth, immune response, reproduction)
• Cortisol release is stimulated by ACTH.
Zona Reticularis

- Innermost zone. Cells form an irregular network.
- Cells make sex steroids (androgens).
- Androgens have weak masculinizing characteristics.
- Androgen release is stimulated by ACTH.
Adrenal cortex: fasciculata and reticularis
Adrenal medulla

- Contains chromaffin cells (modified sympathetic neurons lacking axons and dendrites) and a few sympathetic ganglion cells.
- Chromaffin cells produce catecholamines (mostly epinephrine and a little norepinephrine) when stimulated by preganglionic sympathetic neurons.
- Catecholamines are the “fight or flight” hormones. They increase blood glucose, increase heart rate, increase blood flow to heart and skeletal muscle, and decrease blood to non-essential organs.
Adrenal medulla: ganglion cell and chromaffin cells
Hormones:
- Mineralocorticoids
- Glucocorticoids
- Sex hormones

Capsule:
- Zona glomerulosa
- Zona fasiculata
- Zona reticularis

Adrenal gland hormones:
- Salt
- Sugar
- Sex

Adrenalin
Noradrenalin
Endocrine System Lecture Outline

- Introduction
- Pituitary
- Thyroid
- Parathyroid
- Adrenal
- Pancreas
Pancreas

• The pancreas has both exocrine (ducts) glands and endocrine (ductless) glands.

• The exocrine glands produce digestive enzymes; we’ll discuss these in the Pancreas, Liver and Gallbladder lecture.

• The endocrine glands produce hormones that regulate blood glucose: glucagon, insulin, and somatostatin. They also produce pancreatic polypeptide, which helps regulate the digestive system.
Pancreatic islets (of Langerhans)
Pancreatic islet (of Langerhans)
Main Islet Cells and Hormones

A (alpha) cells
• Secrete glucagon when blood glucose is low
• Glucagon raises blood glucose

B (beta) cells
• Secrete insulin when blood glucose is high
• Insulin decreases blood glucose by making cells take up glucose and making the liver synthesize glycogen
Other Islet Cells and Hormones

D (delta) cells
- Secrete somatostatin
- Somatostatin inhibits release of insulin and glucagon

F cells
- Secrete pancreatic polypeptide
- Pancreatic polypeptide inhibits release of digestive enzymes
- Also causes relaxation of gallbladder and decreases secretion of bile
Endocrine System Lecture Outline

- Introduction
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- Pineal
Pineal Gland

- Located in brain near posterior third ventricle
- Two main cell types: pinealocytes and glial cells
- Pinealocytes occur in clusters and produce melatonin (which helps induce sleep) in response to light.
- “Brain sand” (corpora arenacea) are globules of basophilic calcified material that can be seen radiologically.
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