The Endocrine System

glands and disorders.

Major Endocrine Organs

- Pituitary gland
- Thyroid gland
- Parathyroid glands
- Adrenal glands
- Pineal gland
- Thymus gland
- Pancreas
- Gonads (Ovaries and Testes)
- Hypothalamus

Location of Major Endocrine Organs

Pituitary Gland

- Size of a pea
- Hangs by a stalk from the hypothalamus in the brain
- Protected by the sphenoid bone
- Has two functional lobes
  - Anterior pituitary—glandular tissue
  - Posterior pituitary—nervous tissue
- Often called the “master endocrine gland”

Hormones of the Anterior Pituitary

- Six anterior pituitary hormones
  - Two affect non-endocrine targets
    - Growth hormone
    - Prolactin
  - Four stimulate other endocrine glands (tropic hormones)
    - Thyroid-stimulating hormone (thyrotropic hormone)
    - Adrenocorticotropic hormone
    - Two gonadotropic hormones (FSH and LH)
Hormones of the Anterior Pituitary

- **Growth hormone**
  - General metabolic hormone
  - Major effects are directed to growth of skeletal muscles and long bones
  - Plays a role in determining final body size
  - Causes amino acids to be built into proteins
  - Causes fats to be broken down for a source of energy

- **Gigantism** results from hypersecretion of GH during childhood
- **Pituitary dwarfism** results from hyposecretion of GH during childhood
- **Acromegaly** results from hypersecretion of GH during adulthood

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**Prolactin (PRL)**
- Stimulates and maintains milk production following childbirth
- Function in males is unknown

**Adrenocorticotropic hormone (ACTH)**
- Regulates endocrine activity of the adrenal cortex

**Thyroid-stimulating hormone (TSH)**
- Influences growth and activity of the thyroid gland
Hormones of the Anterior Pituitary
- Gonadotropic hormones
  - Regulate hormonal activity of the gonads
    - Follicle-stimulating hormone (FSH)
      - Stimulates follicle development in ovaries
      - Stimulates sperm development in testes
    - Luteinizing hormone (LH)
      - Triggers ovulation of an egg in females
      - Stimulates testosterone production in males

Posterior pituitary
- Hypothalamus produces two hormones
  - Oxytocin
  - Antidiuretic hormone
  - These hormones are transported to neurosecretory cells of the posterior pituitary
  - The posterior pituitary is not strictly an endocrine gland, but does release hormones

Hormones of the Posterior Pituitary
- Oxytocin
  - Stimulates contractions of the uterus during labor, sexual relations, and breastfeeding
  - Causes milk ejection in a nursing woman
- Antidiuretic hormone (ADH)
  - Inhibits urine production by promoting water reabsorption by the kidneys
  - In large amounts, causes vasoconstriction leading to increased blood pressure
  - Also known as vasopressin

Thyroid Gland
- Found at the base of the throat
- Consists of two lobes and a connecting isthmus
- Produces two hormones
  - Thyroid hormone
  - Calcitonin

Thyroid Gland
- Figure 9.7a

Thyroid gland
- Common carotid artery
- Isthmus of thyroid gland
- Left subclavian artery
- Left lobe of thyroid gland
- Aorta
- Trachea
- Brachiocephalic artery
- Thyroid cartilage
- Left lobe of thyroid gland
### Thyroid Gland

- **Thyroid hormone**
  - Major metabolic hormone
  - Composed of two active iodine-containing hormones
    - Thyroxine (T<sub>4</sub>)—secreted by thyroid follicles
    - Triiodothyronine (T<sub>3</sub>)—conversion of T<sub>4</sub> at target tissues

### Thyroid Gland

- **Thyroid hormone disorders**
  - Goiters
    - Thyroid gland enlarges due to lack of iodine
    - Salt is iodized to prevent goiters
  - Cretinism
    - Caused by hyposecretion of thyroxine
    - Results in dwarfism during childhood

### Thyroid Gland

- **Thyroid hormone disorders (continued)**
  - Myxedema
    - Caused by hypothyroidism in adults
    - Results in physical and mental sluggishness
  - Graves’ disease
    - Caused by hyperthyroidism
    - Results in increased metabolism, heat intolerance, rapid heartbeat, weight loss, and exophthalmos

### Thyroid Gland

- Graves disease

### Myxedema
Thyroid abnormalities

Thyroid Gland
- Calcitonin
  - Decreases blood calcium levels by causing its deposition on bone
  - Antagonistic to parathyroid hormone
  - Produced by parafollicular cells
  - Parafollicular cells are found between the follicles

Parathyroid Glands
- Tiny masses on the posterior of the thyroid
- Secrete parathyroid hormone (PTH)
  - Stimulate osteoclasts to remove calcium from bone
  - Stimulate the kidneys and intestine to absorb more calcium
  - Raise calcium levels in the blood

Adrenal Glands
- Sit on top of the kidneys
- Two regions
  - Adrenal cortex—outer glandular region has three layers
    - Mineralocorticoids secreting area
    - Glucocorticoids secreting area
    - Sex hormones secreting area
  - Adrenal medulla—inner neural tissue region

Hormones of the Adrenal Cortex
- Mineralocorticoids (mainly aldosterone)
  - Produced in outer adrenal cortex
  - Regulate mineral content in blood
  - Regulate water and electrolyte balance
  - Target organ is the kidney
  - Production stimulated by renin and aldosterone
  - Production inhibited by atrial natriuretic peptide (ANP)

Hormones of the Adrenal Cortex
- Glucocorticoids (including cortisone and cortisol)
  - Produced in the middle layer of the adrenal cortex
  - Promote normal cell metabolism
  - Help resist long-term stressors
  - Released in response to increased blood levels of ACTH
Hormones of the Adrenal Cortex

- Sex hormones
  - Produced in the inner layer of the adrenal cortex
  - Small amounts are made throughout life
  - Mostly androgens (male sex hormones) are made but some estrogens (female sex hormones) are also formed

Adrenal Glands

- Adrenal cortex disorders
  - Addison’s disease
    - Results from hyposecretion of all adrenal cortex hormones
    - Bronze skin tone, muscles are weak, burnout, susceptibility to infection
  - Hyperaldosteronism (cushings syndrome)
    - May result from an ACTH-releasing tumor
    - Excess water and sodium are retained leading to high blood pressure and edema

Adrenal gland malfunction

- Addison’s disease – hyposecretion of glucocorticoids by the adrenal cortex characterized by bronzing of the skin

Adrenal Glands

- Adrenal cortex disorders
  - Cushing’s syndrome
    - Results from a tumor in the middle cortical area of the adrenal cortex
    - “Moon face,” “buffalo hump” on the upper back, high blood pressure, hyperglycemia, weakening of bones, depression
  - Masculinization
    - Results from hypersecretion of sex hormones
    - Beard and male distribution of hair growth

Cushing syndrome

- Cushing syndrome – hypersecretion of glucocorticoids by the adrenal cortex characterized by weight gain in the trunk of the body but not arms and legs
Hormones of the Adrenal Medulla
- Produces two similar hormones (catecholamines)
  - Epinephrine (adrenaline)
  - Norepinephrine (noradrenaline)
- These hormones prepare the body to deal with short-term stress (“fight or flight”) by
  - Increasing heart rate, blood pressure, blood glucose levels
  - Dilating small passageways of lungs

Pancreatic Islets
- The pancreas is a mixed gland and has both endocrine and exocrine functions
- The pancreatic islets produce hormones
  - Insulin—allows glucose to cross plasma membranes into cells from beta cells
  - Glucagon—allows glucose to enter the blood from alpha cells
- These hormones are antagonists that maintain blood sugar homeostasis

Health focus: What is diabetes?
- Inability to control blood glucose levels
- There are two types: Type 1 and Type 2
  - 18 million people in the US have diabetes
- General symptoms:
  - Frequent urination
  - Unusual hunger and/or thirst
  - Unexplained change in weight
  - Blurred vision
  - Sores that heal slowly or not at all
  - Excessive fatigue
- Long-term effects are blindness, loss of limbs, nerve deterioration, kidney and cardiovascular disease

Diabetes: Understanding the 2 types
- Type 1:
  - Usually early-onset
  - Autoimmune disorder that tends to run in families
  - Pancreatic cells are attacked and cannot produce insulin
  - Need insulin injections
- Type 2:
  - Usually adult-onset and most common type
  - Tends to occur in obese, sedentary people
  - Cells do not respond to insulin
  - Usually diet and exercise are important for controlling this and may even prevent this!

11. Pineal gland
- Located in the brain
- Secretes melatonin that regulates the sleep/wake cycle (circadian rhythm)
- May also regulate sexual development

Pineal Gland
- Found on the third ventricle of the brain
- Secretes melatonin
  - Helps establish the body’s wake and sleep cycles
  - Believed to coordinate the hormones of fertility in humans
  - Secretion controlled by exposure to light.
Thymus gland

- Lies beneath the sternum

- This gland is largest and most active during childhood

- T lymphocytes mature here

- Secretes hormones called thymosins that aid in differentiation of lymphocytes

Gonads

- Ovaries
  - Produce eggs
  - Produce two groups of steroid hormone
    - Estrogens
    - Progesterone

- Testes
  - Produce sperm
  - Produce androgens, such as testosterone

Hormones of the Ovaries

- Estrogens
  - Stimulate the development of secondary female characteristics
  - Mature female reproductive organs
  - With progesterone, estrogens also
  - Promote breast development
  - Regulate menstrual cycle

Hormones of the Ovaries

- Progesterone
  - Acts with estrogen to bring about the menstrual cycle
  - Helps in the implantation of an embryo in the uterus
  - Helps prepare breasts for lactation

Hormones of the Testes

- Produce several androgens
- Testosterone is the most important androgen
  - Responsible for adult male secondary sex characteristics
  - Promotes growth and maturation of male reproductive system
  - Required for sperm cell production

Other Hormone-Producing Tissues and Organs

- Parts of the small intestine
- Parts of the stomach
- Kidneys
- Heart
- Many other areas have scattered endocrine cells
Other Hormone-Producing Tissues and Organs

### Table 9.2 Hormones Produced by Organs Other Than the Major Endocrine Organs

<table>
<thead>
<tr>
<th>Hormone</th>
<th>Chemical composition</th>
<th>Source</th>
<th>Stimulus for secretion</th>
<th>Target organ(s) / Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erythropoietin</td>
<td>Protein</td>
<td>Kidney</td>
<td>Increase red blood cell production</td>
<td></td>
</tr>
<tr>
<td>ANP</td>
<td>Protein</td>
<td>Heart and blood vessels</td>
<td>Increased blood volume</td>
<td></td>
</tr>
<tr>
<td>Prostaglandins</td>
<td>Protein and small peptides</td>
<td>Various cells, including those of the reproductive system</td>
<td>Increased blood flow, smooth muscle contraction</td>
<td></td>
</tr>
<tr>
<td>Endocrine</td>
<td>Peptide</td>
<td>Unknown</td>
<td>Unknown</td>
<td></td>
</tr>
</tbody>
</table>

### Other Hormone-Producing Tissues and Organs

#### Erythropoietin: secreted by the kidney to increase red blood cell production
- **ANP**: Promotes urination when blood pressure rises.
- **Prostaglandins**: A group of potent chemicals that are not carried in the bloodstream but work locally on neighboring cells. Some cause smooth muscle contraction. Major impact on reproductive organs. Many other roles in the body. Aspirin and ibuprofen block the synthesis of these.

#### Endocrine Function of the Placenta
- Produces hormones that maintain the pregnancy
- Some hormones play a part in the delivery of the baby
- Produces human chorionic gonadotropin (hCG) in addition to estrogen, progesterone, and other hormones