CHAPTER 13: ENDOCRINE SYSTEM

OBJECTIVES:

1. Explain why the endocrine system is so closely related to the nervous system.

2. Distinguish between an endocrine gland and an exocrine gland.

3. Define the term *hormone* and explain its general characteristics.

4. Distinguish between a steroidal and non-steroidal hormone, in terms of composition and action.

5. Locate the following endocrine glands (organs) on a diagram: hypothalamus, pituitary, pineal gland, thyroid, parathyroids, thymus, adrenals, pancreas, ovaries, testes.

6. Name the three endocrine glands (see above) that are actually divided into two endocrine glands with different functions.

7. For each of the glands listed in #5 & #6 above, name the hormone(s) they secrete, identify the target organ of each hormone, and the effect of each hormone.

8. Name the "master" of the anterior pituitary gland.

9. Define the term *gonadotropin*, name the two gonadotropins secreted by the anterior pituitary gland, and distinguish between them according to their actions.

10. Explain how the posterior pituitary gland does not produce hormones, but does secrete them.

11. Name the gland that requires iodine to produce most of its hormones.

12. Describe how calcium levels are maintained in the blood.

13. Name the two hormones that work together to regulate water and electrolyte levels in the blood and therefore regulate blood pressure.

14. Describe how glucose levels are maintained in the blood.

15. Explain why the thymus gland decreases in size as we age.
CHAPTER 13: ENDOCRINE SYSTEM

Objectives (continued)

16. Name the gland (hormone) whose production is stimulated by sunlight.

17. Define the term *gonad*, list the primary gonads in both sexes, and name the hormones that target those gonads.

18. Explain what is meant by "secondary sexual characteristics", name the hormone that causes their development in both sexes, and list target organs.

19. Name the hormones secreted by the ovary, distinguish which particular portion of the ovary secretes each, and name target organs and actions of those hormones.

20. Distinguish between dwarfism, giantism, and acromegaly.

21. Explain why so few cases of cretinism are seen today.

22. Compare and contrast cretinism, myxedema, Grave’s Disease, and goiter.

23. Distinguish between Addison’s Disease and Cushing’s Syndrome.

24. Compare and contrast the two types of the disease Diabetes Mellitus.

CHAPTER 13: ENDOCRINE SYSTEM

I. INTRODUCTION

The general function of the endocrine system is to integrate body systems, in conjunction with the nervous system. Recall that glands are effectors or responsive body parts that are stimulated by motor impulses from the autonomic nervous system. Some of these glands, endocrine glands compose the endocrine system.

II. IMPORTANT DEFINITIONS: See Figure 13.1, page 481.

A. ENDOCRINE GLAND = a gland that secretes hormones directly into the bloodstream; a ductless gland.

B. Exocrine gland = a gland that secretes substances into ducts which then leave the body (i.e. sweat/sebaceous glands) or into a internal space or lumen (i.e. digestive glands). Exocrine glands are not part of the endocrine system!

C. HORMONE = a very powerful substance secreted by an endocrine gland into the bloodstream, that affects the function of another cell or "target cell".

III. HORMONES

A. General Characteristics:
   1. needed in very small amounts (potent);
   2. produce long-lasting effects in the cells they target;
   3. regulate metabolic processes (maintain homeostasis);
   4. are regulated by negative-feedback mechanisms;
   5. may be steroid (produced from cholesterol = fat-soluble) or non-steroid (water-soluble). See Fig 13.3, page 482.
      a. A steroid hormone passes easily through the target cell membrane;
      b. A non-steroid hormone requires a receptor on the target cell membrane to allow the hormone to enter the target cell.

IV. ENDOCRINE GLANDS

A. See Fig 13.2, page 481 to see an overview of the endocrine glands. They include the following glands:
   1. hypothalamus;
   2. pituitary;
   3. pineal gland;
   4. thyroid;
   5. parathyroids;
   6. thymus;
   7. adrenals;
   8. pancreas;
   9. testes;
   10. ovaries.
CHAPTER 13: ENDOCRINE SYSTEM

V. CONTROL OF HORMONAL SECRETIONS

The overall scheme for the release of most hormones is presented in Figure 13.13, page 491 in the text. First of all, the HYPOTHALAMUS secretes "releasing hormones" that target the anterior pituitary gland.

A. The ANTERIOR PITUITARY GLAND (which hangs from the base of the brain) may then secrete 6 different hormones:

1. **Human Growth Hormone (HGH)**
   a. controls growth of the body;
   b. targets the bone, muscle and adipose tissue.

2. **Thyroid stimulating hormone (TSH)**
   a. controls the secretion of hormones by the thyroid gland;
   b. targets thyroid gland.

3. **Adrenocorticotropic Hormone (ACTH)**
   a. controls the secretion of hormones by the adrenal cortex;
   b. targets the outer portion of the adrenal gland (cortex).

4. **Prolactin (PRL)**
   a. stimulates the production of milk by the mammary glands;
   b. targets the mammary glands.

5. **Follicle Stimulating Hormone (FSH)**
   a. response depends upon sex:
      m In females, FSH stimulates maturation of an ovarian follicle and ovum;
      m In males, FSH stimulates the maturation of sperm in the testes;
   b. A gonadotropin = targets the primary sex organs (ovary & testis).

6. **Luteinizing Hormone (LH)**
   a. response depends upon sex:
      m In females, LH causes ovulation;
      m In males, LH causes secretion of testosterone.
   b. A gonadotropin; targets ovaries & testes.
CHAPTER 13: ENDOCRINE SYSTEM

V. Control of Hormonal Secretions (continued):

B. The POSTERIOR PITUITARY GLAND (See Fig 13.10, page 490)

1. is located behind the anterior pituitary gland;
2. is continuous with nerve fibers (supraoptichypophyseal tract) of the hypothalamus;
3. does not actually produce hormones (they are produced by the hypothalamus), but stores them until it is stimulated to release them;
4. secretes 2 hormones: See Table 13.5, page 496.

a. Anti-Diuretic Hormone (ADH):

m targets the kidney tubules (DCT);
m causes the kidney tubules to reabsorb water back into the bloodstream, and therefore controls water balance and blood pressure.

b. Oxytocin (OT):

m targets uterine smooth muscle and breasts;
m causes uterine muscle contraction and milk production.

C. The THYROID GLAND: See Fig 13.16 & 13.17, page 506 & 507.

1. is located below larynx and around trachea;
2. is involved in iodine uptake (in order to produce thyroxine (T₄) & triiodothreonine (T₃) below);
3. produces 3 hormones when stimulated by TSH:

a. Thyroxine (T₄) & Triiodothreonine (T₃):

m increase basal metabolic rate by stimulating cellular oxygen use to produce ATP;
m regulate metabolism.

b. Calcitonin:

m release is triggered by an increase in blood calcium levels;
m targets bone cells (inhibits osteoclast activity) & kidney tubules (causes secretion of calcium into urine);
m Therefore, causes a decrease in blood calcium and phosphate levels to normal.
V. Control of endocrine secretions (continued)

D. The PARATHYROID GLANDS: See Fig 13.22, page 499.

1. consist of 4 small glands;
2. are located within the thyroid gland;
3. produce a hormone called **Parathyroid Hormone (PTH)**:
   a. release is stimulated by a decrease in blood calcium levels;
   b. PTH targets bone cells (activates osteoclasts) and kidney cells (causes kidney tubules to reabsorb more calcium);
   c. Therefore, causes an increase in blood calcium and phosphate levels to normal.

4. PTH and calcitonin together maintain the homeostasis of Ca\(^{++}\) in the blood.

See Fig 13.25, page 501.

E. The ADRENAL GLANDS

See Fig 13.26, page 502.

1. are located atop the kidneys;
2. are divided into an outer adrenal cortex and an inner renal medulla.

a. The **ADRENAL MEDULLA**:

   m is located in the central portion of the adrenal glands;
   m produces 2 closely related hormones which function in the sympathetic division of the autonomic nervous system:

   1. epinephrine;
   2. norepinephrine.

These hormones target:

1. the heart (increased heart rate and blood pressure);
2. smooth muscle contraction (blood vessels,);
3. the lungs (increased breathing: rate, rhythm, depth).
CHAPTER 13: ENDOCRINE SYSTEM

E. Adrenal Glands (continued)

b. The ADRENAL CORTEX:

- is located in the outer portion of the adrenal glands;
- produces many steroid hormones when stimulated by ACTH:

1. **aldosterone** regulates water and electrolyte levels in the blood (regulates blood pressure);

   See Fig 13.29, page 504.

2. **cortisol** regulates glucose metabolism;

3. sex hormones that supplement those of the ovary and testis.

F. The PANCREAS: See Fig 13.32, page 507.

a. is located behind the stomach on the left side of abdomen;

b. functions as both an exocrine gland (digestion) and endocrine gland (see below);

c. contains endocrine organs called **Islets of Langerhans** which produce 2 hormones: See Fig 13.33, page 507.

1. **Insulin:**

   - is produced by **Beta cells** \( \beta \) Langerhans;
   - decreases blood glucose levels (i.e. moves glucose from bloodstream into cells and promotes glycogen formation [liver/muscle]).

2. **glucagon:**

   - is produced by **Alpha cells** \( \alpha \) Langerhans;
   - increases blood glucose levels (i.e. causes breakdown of glycogen and release of glucose into bloodstream).

d. See Fig 13.34, page 508 to review how these two hormones regulate glucose homeostasis in the blood.
CHAPTER 13: ENDOCRINE SYSTEM

V. Control of hormonal secretions (continued)

G. The **THYMUS GLAND**:(See Fig 13.2, page 481.)
   1. is located in the mediastinum region behind sternum;
   2. produces a hormone called **thymosin** that affects the maturation of lymphocytes (T-cells);
   3. plays an important role in lymphatic system and immunity;
   4. decreases in size as we age.

H. The **PINEAL GLAND**:(See Fig 13.2, page 481)
   1. is attached to the thalamus of the brain stem;
   2. secretes a hormone called **melatonin**:
      a. production is stimulated by daylight (circadian rhythm);
      b. affects moods, emotions, etc.

I. The **OVARIES**:
   1. An ovarian follicle (and ovum) start to mature each month following puberty under the influence of FSH.
      a. The developing follicle secretes **estrogen**:
         m develops and maintains female secondary sexual characteristics; targets:
         1. hair follicles;
         2. mammary glands/ breasts;
         3. adipose tissue.
   2. LH causes the follicle to rupture and release the ovum (ovulation); the follicle becomes the corpus luteum.
      a. The corpus luteum secretes **progesterone**:
         m prepares the uterus for implantation of the zygote.

J. The **TESTES**:
   1. FSH causes the production of sperm.
   2. LH causes the production of **testosterone**:
      a. develops and maintains male secondary sexual characteristics; targets:
         m hair follicles;
         m muscle, bone;
         m larynx.
### HORMONE SUMMARY TABLE
(Keyed on page 277 of this outline)

<table>
<thead>
<tr>
<th>HORMONE</th>
<th>SECRETED BY WHAT GLAND?</th>
<th>TARGETS WHAT GLAND OR ORGAN OR TISSUE?</th>
<th>AFFECT(S) AT TARGET SITE</th>
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<tbody>
<tr>
<td>GH</td>
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<td>PROGESTERONE</td>
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<td>TESTOSTERONE</td>
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<td>ADH</td>
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<td>THYMOSIN</td>
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</tbody>
</table>
CHAPTER 13: ENDOCRINE SYSTEM

VII. ABNORMAL HORMONAL LEVELS:

A. Growth Hormone

1. Pituitary Dwarfism = hyposecretion of GH during growth years.
   a. slow bone growth & closing of epiphyseal plates before normal height is reached;
   b. Treatment = oral GH therapy.

2. Pituitary giantism = hypersecretion of GH during growth years.
   a. abnormal increase in the length of long bones.

3. Acromegaly = hypersecretion of GH during adulthood.
   a. Bones of hands, feet, cheeks, and jaw thicken;
   b. Soft tissues also grow.

B. ADH

1. Diabetes insipidus = hyposecretion of ADH.
   a. diuresis, dehydration, thirst;
   b. ADH in nasal spray.

C. Thyroid Hormones

1. Cretinism = hyposecretion of T3/T4 during fetal life and infancy. See Fig 13.9, page 498.
   a. dwarfism & mental retardation;
   b. prevention = newborn testing;
   c. treatment = oral thyroid therapy.

   a. edema, slow heart rate, low body temp, dry hair & skin, muscular weakness, lethargy, weight gain;
   b. Oral thyroid hormones reduce symptoms.

3. Grave’s Disease = an autoimmune disorder that causes growth of thyroid and hypersecretion of thyroid hormones, with no negative feedback.
   a. enlarged thyroid (2-3x larger);
   b. peculiar edema of the eyes (bulging);
   c. increased metabolic rate, heat intolerance, increased sweating, weight loss, insomnia, tremor, nervousness.
   d. treatment = surgical removal, use of radioisotopes to destroy some of the thyroid, and anti-thyroid drugs to block synthesis of the hormones.
   e. See Fig 13.20, pg 498.
CHAPTER 13: ENDOCRINE SYSTEM

VI. Abnormal hormone levels (continued)

D. Adrenal Cortical Hormones (See CA 13.3, page 506)

1. **Addison’s Disease** = hyposecretion of AC hormones due to autoimmunity or disease (TB).
   
   Symptoms: mental lethargy, anorexia, nausea, vomiting, weight loss, hypoglycemia, muscle weakness, ↑K+, ↓Na+, ↓bp, dehydration, arrhythmias, cardiac arrest, ↑skin pigmentation.

2. **Cushing’s Syndrome** = hypersecretion of AC hormones due to pituitary tumor or steroid administration.
   
   Symptoms: redistribution of fat, thin limbs due to wasting of muscles (i.e. protein catabolism), "moon face", "buffalo hump", "beer belly", stretch marks, bruises, poor wound healing, hyperglycemia, osteoporosis, weakness, hypertension, ↑susceptibility to infection, ↓resistance to stress, mood swings.

   Usual cause: administration of steroids (i.e. prednisone) for transplant patients, asthma, and chronic inflammatory disorders.

E. Pancreatic (Islet) Hormones (See CA 13.4, pg 509)

1. **Diabetes Mellitus** = hyperglycemia.
   
   Symptoms (3 poly’s): polyuria, polydypsia, polyphagia. Two types:
   
   a. **Type I/IDDM** (10%):
      
      m absolute insulin deficiency.
      
      m Patients < 20 years;
      
      m ? DQARP PXQHVRGCHUZKHHJ FHQUDHGWHR HG
      
      m insulin administration.
      
      m Cells can’t use glucose so fat is broken down, releasing ketone bodies, causing ketoacidosis, lowering blood pH, causing death.
      
      m Atherosclerosis, CV disease, IHD, PVD, gangrene.
      
      m Complications = blindness due to cataracts (lens) and retinal vascular disease; renal failure.
      
      m Treatments:
      
      1. ? artificial pancreas that detects fall in glucose levels and automatically releases insulin;
      
     2. ? transplants ?
CHAPTER 13: ENDOCRINE SYSTEM

VI. ABNORMAL HORMONAL LEVELS:

E. Pancreatic (Islet) Hormones (See CA 13.4, pg 509)

1. Diabetes Mellitus

   b. Type II/NIDDM (90%)

   m patients > 40 years,
   m overweight,
   m hypertensive,
   m (smokers);
   m Problem is usually with receptors on target cells;
   m Controlled by diet, exercise, and weight loss;
   m Drug Diabeta(glyburide) may help stimulate insulin secretion

2. Hyperinsulemia

F. Melatonin

1. Seasonal Affective Disorder & Jet Lag
<table>
<thead>
<tr>
<th>HORMONE</th>
<th>SECRETED BY WHAT GLAND?</th>
<th>TARGET(S)?</th>
<th>EFFECT(S) AT TARGET SITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Hormone (GH)</td>
<td>anterior pituitary</td>
<td>bone, muscle, fat</td>
<td>growth of tissues</td>
</tr>
<tr>
<td>Thyroid Stimulating Hormone (TSH)</td>
<td>anterior pituitary</td>
<td>thyroid</td>
<td>secrete hormones</td>
</tr>
<tr>
<td>Prolactin (PRL)</td>
<td>anterior pituitary</td>
<td>mammary glands</td>
<td>produce milk</td>
</tr>
<tr>
<td>Adrenocorticotropic hormone (ACTH)</td>
<td>anterior pituitary</td>
<td>adrenal cortex</td>
<td>secrete hormones</td>
</tr>
<tr>
<td>Latinizing Hormone (LH)</td>
<td>anterior pituitary</td>
<td>In males: interstitial cells in testes; in females: mature ovarian follicle</td>
<td>males: testosterone secretion; females: ovulation</td>
</tr>
<tr>
<td>Follicle stimulating hormone (FSH)</td>
<td>anterior pituitary</td>
<td>males: semiferous tubules of testes; females: ovarian follicle</td>
<td>males: sperm production; females: follicle/ovum maturation</td>
</tr>
<tr>
<td>Triiodothyronine (T₃) &amp; Thyroxine (T₄)</td>
<td>thyroid</td>
<td>all cells</td>
<td>regulates metabolism</td>
</tr>
<tr>
<td>ALDOSTERONE</td>
<td>adrenal cortex</td>
<td>kidney tubules</td>
<td>reabsorption of water and Na (blood pressure)</td>
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<tr>
<td>CORTISOL</td>
<td>adrenal cortex</td>
<td>all cells</td>
<td>glucose metabolism</td>
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<tr>
<td>ESTROGEN</td>
<td>ovarian follicle</td>
<td>secondary sex organs</td>
<td>development and maintenance</td>
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<td>PROGESTERONE</td>
<td>corpus luteum</td>
<td>uterine endometrium</td>
<td>preparation for implantation (thickens, glandular, vascular)</td>
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<tr>
<td>HORMONE</td>
<td>SECRETED BY WHAT GLAND?</td>
<td>TARGET(S)?</td>
<td>EFFECT(S) AT TARGET SITE</td>
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<tr>
<td>TESTOSTERONE</td>
<td>seminiferous. tubules</td>
<td>secondary sex organs</td>
<td>development and maintenance</td>
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<tr>
<td>Anti-Diuretic Hormone (ADH)</td>
<td>posterior pituitary</td>
<td>distal convoluted tubule (DCT)</td>
<td>reabsorption of water (Blood pressure)</td>
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<td>Oxytocin (OT)</td>
<td>posterior pituitary</td>
<td>uterine smooth muscle</td>
<td>contraction during labor</td>
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<td>Parathyroid Hormone (PTH)</td>
<td>parathyroids</td>
<td>kidney tubules and osteoclasts</td>
<td>reabsorption of Ca++ into blood, bone resorption (increases blood Ca++)</td>
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<tr>
<td>CALCITONIN</td>
<td>thyroid</td>
<td>kidney tubules and osteoblasts</td>
<td>secretion of Ca++ into urine, bone formation (decreases blood Ca++)</td>
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<td>INSULIN</td>
<td>Islets</td>
<td>all cells, liver and skeletal muscle</td>
<td>pushes glucose into cells from blood, glycogen formation (decreases blood glucose)</td>
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<tr>
<td>GLUCAGON</td>
<td>Islets</td>
<td>liver and skeletal muscle</td>
<td>breakdown of glycogen (increase in blood glucose)</td>
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<td>EPINEPHRINE</td>
<td>adrenal medulla</td>
<td>cardiac muscle, arteriole and bronchiole smooth muscle</td>
<td>increases heart rate and blood pressure...</td>
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<td>NOREpinephrine</td>
<td>adrenal medulla</td>
<td>cardiac muscle, arteriole and bronchiole smooth muscle</td>
<td>increases heart rate and blood pressure...</td>
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<td>limbic system</td>
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