CHAPTER 18
ENDOCRINE GLANDS

CHAPTER OVERVIEW: This chapter reviews in detail the major secretions of all of the endocrine glands. The target tissues, effects and regulation of each hormone is discussed. The importance of the hypothalamohypophyseal axis is explained.

OUTLINE (two or three fifty-min. lectures):
Seeley A&P, 5/e

hapt. bject.	**Topic Outline, Chapter 18**	**Figures & Tables**	**Transparency Acetates**
1	I. Introduction, p. 547		
	A. Anatomy of the Gland		
	B. Hormones Secreted by the Gland		
	C. Target Tissues and Their Responses		
	D. Regulation of Secretion		
	E. Consequences of Hypersecretion and Hyposecretion		
2	II. Pituitary Gland and Hypothalamus, p. 547		
	A. Structure of the Pituitary Gland	Fig. 18.1, p.547	TA-347
	1. Infundibulum = Physical Connection to Hypothalamus		
	B. Posterior Pituitary, or Neurohypophysis	Fig. 18.2, p.548	TA-347
	C. Anterior Pituitary, or Adenohypophysis		
	D. Relationship of the Pituitary to the Brain		
4	1. Hypothalamohypophyseal Portal System	Fig. 18.3a, p.549	TA-348
	a. System of Blood Vessels		
	b. Carries Blood from Capillaries in Hypothalamus to Capillaries in Adenohypophysis		
	c. Neurohormones from Hypothalamus	Fig. 18.4, p.550	TA-349
	Delivered to Target Cells in Adenohypophysis	Table 18.1, p.551	
	1). Releasing Hormones		
	2). Inhibiting Hormones		
3	2. Hypothalamohypophyseal Tract	Fig. 18.3b, p.549	TA-348
	a. Bodies of Neurosecretory Cells in Hypothalamus		
	b. Release of Neurohormones from Terminals in Neurohypophysis	Fig. 18.4, p.550 Predict Quest. 1	TA-349
	III. Hormones of the Pituitary Gland	Table 18.2, p.551	
3, 5	A. Posterior Pituitary Hormones		
	1. Antidiuretic Hormone (ADH or Vasopressin)	Fig. 18.5, p.552	TA-350
	a. Secreted in Response to		
	1). Activity of Hypthalamic Osmoreceptors		
	2). Direct Osmotic Stim. of Neurosecretory Cells in Supraoptic Nuclei		

3). Drop in systemic Blood Pressure
b. ADH Action = Increased Kidney Reabsorption of Water — Clinical Note, p.550
2. Oxytocin (discussed in Greater Detail in Chapter 29)
a. Synthesized by Neurosecretory Cells of Paraventricular Nuclei
b. Actions
1). Increases Smooth Muscle Contraction of Uterus
2). Causes Milk Ejection in Lactating Females
c. Stimuli
1). Stretch of Uterus or Uterine Cervix
2). Stimulation of Nipples during Infant Suckling

4, 5 B. Anterior Pituitary Hormones — Table 18.1, p.551
1. Growth Hormone (GH or Somatotropin) — Clinical Focus, p.554
a. Promotes Amino Acid Uptake and Protein Synthesis
b. Increases Availability of Fatty Acids as Energy Source = Glucose Sparing
c. Indirect Effects Through Somatomedins from Liver and Other Cells
1). Stimulate Cartilage and Bone Growth
2). Increase Protein synthesis in Skeletal Muscle
3). Insulin-Like Growth Factors I and II
d. Increased Secretion by — Fig. 18.6, p.553 — TA-351
1). Growth Hormone-Releasing Hormone (GH-RH)
2). Low Blood Glucose
c). Stress
e. Decreased Secretion by Growth Hormone-Inhibiting Hormone (GH-IH)
f. Cyclic Secretion; Highest Levels During Deep Sleep — Predict Quest. 2
2. Thyroid-Stimulating Hormone (TSH) or Thyrotropin
3. Adrenocorticotropic Hormone and Related Substances
a. All Derived from Proopiomelanocortin
b. Adrenocorticotropic Hormone (ACTH)
1). Increases Cortisol Secretion
2). Acts on Adrenal cortex
c. Lipotropins
1). Acts on Adipose Cells
2). Causes Fat Breakdown and Release of Fatty Acids
d. Beta-Endorphins
1). Same Effects as Opiate Drugs, esp. Analgesia
2). Increase in Response to Stress and

Exercise
e. Melanocyte-Stimulating Hormone (MSH) - Stimulates Melanin Deposition in Skin
4. Gonadotropins and Prolactin
a. Involved in Regulating Reproduction - Explained More Fully in Chapter 28
b. Luteinizing Hormone (LH) - Involved in Gamete Production
c. Follicle Stimulating Hormone (FSH) - Also Involved in Gamete Production
d. Both LH and FSH Secretion Regulated by Gonadotropin-Releasing Hormone (Gn-RH) [a.k.a. Luteinizing Hormone-Releasing Hormone (LH-RH)]
e. Prolactin
1). Involved in Milk Production
2). Permissive Effect for FSH and LH on Ovary
3). Enhances Progesterone Secretion by Ovary After Ovulation
4). Prolactin-Releasing Hormone (PRH)
5). Prolactin-Inhibiting Hormone (PIH)

6 IV. Thyroid Gland, p. 555
A. Histology — Fig. 18.7, p.555 — TA-352
1. Follicles
a. Follicular Cells
b. Lumen Filled with Thyrogobulin - Precursor to Thyroid Hormones
2. Parafollicular Cells
a. Between Follicles
b. Secrete Calcitonin

7 B. Thyroid Hormones — Table 18.3, p.556
1. Secretory Products = Triiodothyronine (T_3) 10% and Tetraiodothyronine (T_4) 90%
2. Thyroid Hormone Synthesis (and Secretion -TSH Must be Present, Activates cAMP Second Messenger System) — Fig. 18.8, p.557 — TA-353
a. Active Absorption of I^- Ions
b. Synthesis of Thyroglobulins by Follicle Cells
c. Tyrosine Residues Iodinated
d. Iodinated Thryroglobulin Moved by Exocytosis to Lumen of Follicle
e. Iodinated Tyrosines Combined to Form Iodinated Thyronine
1). Two Diiodotyrosines form Tetraiodothyronine
2). One Diiodotyrosine and one Mono-iodotyrosine Form Triiodothyronine
3). Both Stored as Part of Thyroglobulin in Lumen

4). Two-week Supply Kept
f. Thryoglobulin Taken into Follicle Cell by Endocytosis
1). Lysosomes Fuse Wtih Endocytotic Vesicles
2). T_3 , T_4, and Free Amino Acids Released
g. T_3 and T_4 diffuse out of Follicle Cell into Interstitial Spaces then Blood, Amino Acids Reused within Follicle Cells
3. Transport in the Blood
a. Combined with Plasma Proteins - 10-75% Bound to Thyroxine-Binding Globulin (TBG)
b. 33-40% of T_4 Converted to T_3 (the More Active Form) in Body Tissues
4. Mechanism of Action of Thyroid Hormones
a. Readily Diffuse through Membranes
b. Nuclear Receptor Molecules
c. Initiate New Protein Synthesis
d. Increase ATP and Heat Production by Mitochondria
5. Effects of Thyroid Hormones — Table 18.4, p.559
a. Increased Metabolism of Glucose, Fat and Protein
b. Increased Body Temperature
c. Normal Growth Patterns Require Presence of Thyroid Hormones - Permissive Effect on Growth Hormone
d. Hypothyroidism During Development and Cretinism
6. Regulation of Thyroid Hormone Secretion — Fig. 18.9, p.559; Table 18.5, p.559; Predict Quest. 3 — TA-354
a. TSH
b. TRH
c. Negative Feedback Inhibition of TSH & TRH by T_3 and T_4

8 C. Calcitonin
1. Secretion by Parafollicular Cells
2. Target Cells in Bone
3. Secretion Associated with High Blood Calcium
4. Lowers Blood Calcium and Phosphate
a. Inhibits Osteoclasts
b. Stimulates bone Deposition
5. Calcitonin secretion Decreases with Age - Osteoporosis Increases with Age

V. Parathyroid Glands, p. 560
A. Location and Structure — Fig. 18.10, p.560 — TA-355
9 B. Parathyroid Hormone (PTH) — Table 18.3, p.556
1. Secretion Stimulated by Low Blood Calcium, — Fig. 18.11, p.561 — TA-356

	Inhibited by High Plasma Calcium		
	2. PTH Raises Blood Calcium		
	a. Stimulates Osteoclasts Possibly Acting through Local Factor Produced By Osteoblasts in Response to PTH		
	b. Promotes Calcium Reabsorption at Kidney		
	c. Promotes Activation of Vitamin D at Kidney		
10	1). Vit. D Increases Calcium Absorption at Intestine		
	2). Vit. D Increases Phosphate Absorption at Intestine		
	3. PTH Produces Net Lowering of Phosphate Levels by Increasing Kidney Excretion of Phosphate		
	4. Hypo- and Hyperparathyroidism	Table 18.6, p.562 Predict Quest. 4, 5	
	VI. Adrenal (Suprarenal) Glands, p. 561	Fig. 18.12a, p.562	TA-357
11	A. Histology	Fig. 18.12b, p.562	TA-357
	1. Medulla		
	a. Embryologically from Neural Crest Cells		
	b. Functions as Part of Sympathetic Nervous System		
	2. Cortex Has Layers	Fig. 18.12b, p.562	TA-357
	a. Zona Glomerulosa (Outermost)		
	b. Zona Fasciculata		
	c. Zona Reticularis		
	B. Hormones of the Adrenal Medulla	Table 18.7, p.563	
	1. Hormones		
	a. Epinephrine 80%		
	b. Norepinephrine 20%		
	2. Hormone Action		
	a. Increase Blood Glucose via cAMP Second Messenger Systems		
	b. Increase Heart Rate and Force of Contraction		
	c. Constrict Blood Vessels to Skin and Viscera		
	d. Dilate Blood Vessels to Skeletal and Cardiac Muscle		
12	C. Regulation (Release is Primarily a Response to Sympathetic Stimulation)	Fig. 18.13, p.564 Clinical Note, p.558	TA-358
	D. Hormones of the Adrenal Cortex	Table 18.7, p.563 Clinical Focus p.560 Clinical Focus (Stress), p.573	
	1. Mineralocorticoids - Aldosterone		
	a. From Zona Glomerulosa		
	b. Help Regulate Blood Levels of Na^+, K^+, and H^+	Predict Quest. 6	
	c. Effects and Controls Discussed in Detail with the Kidney (Chpts. 26 &27) and Circulatory System (Chpt. 21)		
	2. Glucocorticoids - Cortisol	Table 18.8, p.565	
	a. From Zona Fasciculata		

	b. Numerous Targets and Responses 1). Increases Fat and Protein Metabolism 2). Increases Blood Glucose Levels 3). Increases Glycogen Stores in Cells		
12	c. Regulation	Fig. 18.14, p.566 Predict Quest. 7	TA-359
	1). ACTH (From Anterior Pituitary) Stimulates Cortisol Secretion 2). Central Stress and Hypoglycemia Cause Increased CRH Secretion by Hypothalamus		
	3. Adrenal Androgens - Androstenedione a. Stimulate Axillary and Pubic Hair Growth in Females b. Negligible Effects in Males Compared to Testosterone		
13	VII. Pancreas, p. 566		
	A. Histology	Fig. 18.15, p.567	TA-360
	1. Exocrine Portion, Ducts and Acini and Pancreatic Juice (Chapter 24)		
	2. Endocrine Portion = Pancreatic Islets	Table 18.10, p.568	
	a. Alpha Cells and Glucagon b. Beta Cells and Insulin c. Delta Cells and Somatostatin		
14	B. Effects Insulin and Glucagon on Their Target Tissues	Table 18.10 & Table 18.11, p.568	
	1. Insulin a. Targets; Liver, Adipose, Muscle and Satiety Center b. Effects; Increase Glucose and Amino Acid Uptake		
	2. Glucagon a. Target; Liver b. Effects; Increase Breakdown of Glycogen and Fats		
	C. Regulation of Pancreatic Hormone Secretion	Fig. 18.16, p.570 Predict Quest. 8, 9 Clinical Focus (Diabetes Mellitus), p.573	TA-361
	1. Insulin a. Secretion 1). Increased Blood Glucose 2). Parasympathetic Stimulation 3). Gastrointestinal Hormones (Chapter 24) b. Inhibition; Somatostatin		
	2. Glucagon a. Secretion 1). Low Blood Glucose 2). Sympathetic Stimulation b. Inhibition; Somatostatin		
14	VIII. Hormonal Regulation of Nutrients, p. 569		

A. Following a Meal — Fig. 18.17a, p.571 — TA-362
1. Increased Blood Levels of Nutrients
2. Increased Parasympathetic Stimulation
3. Increased Insulin Secretion
4. Most Cells Take Up Glucose, Amino Acids and Fatty Acids - Excesses Put into Storage Forms (Glycogen and Fat)
5. Inhibition of Glucagon, Cortisol, GH and Epinephrine Secretion

B. Several Hours After Last Meal — Fig. 18.17b, p.571 — TA-362
1. Decreased Blood Levels of Nutrients
2. Increased Sympathetic Stimulation
3. Decreased Insulin and Increased Glucagon Secretion
4. Most Cells Decrease Glucose Uptake and Switch to Other Fuels
    a. Increased Gluconeogenesis, Glygogenolysis
    b. Increased Lipolysis
    c. Increased Proteolysis
5. Increased Levels of Epinephrine, GH, and Cortisol

C. Regulation of Blood Nutrient Levels During Exercise — Fig. 18.18, p.572 — TA-363
1. Skeletal Muscle Cells Switch to Fat Metabolism (Increased Protein Catabolism with Prolonged Exercise)
    a. Increased Sympathetic Stimulation
    b. Increased Circulating Levels of
        1). Epinephrine
        2). Glucagon
        3). GH (Prolonged Exercise)
        4). Cortisol (Prolonged Exercise)
    c. Decreaed Insulin
2. Increased Glycogenolysis (Liver and Skeletal Muscle) and Gluconeogenesis (Liver) to Keep Blood Glucose Available to Nerual Tissue — Predict Quest. 10

IX. Reproductive Hormones - Discussed in Chapter 28 — Table 18.12, p. 574

X. Hormones of the Pineal Body, Thymus Gland, and Others, p. 572 — Table 18.13, p.574

15 A. Pineal Body
1. Names - Melatonin, Arginine Vasotocin
2. Associated with Photoperiod and Seasonal Behavior in Animals — Fig. 18.19, p.575 — TA-364

B. Thymus Gland - Thymosin and Immune System Funcitons (Chapter 22)

C. Gastrointestinal Tract - Several Hormones of Local Action (Chapter 24)

XI. Hormonelike Substances, p. 575
A. Paracrine Regulatory Substances
1. Release Near Target Cells
2. Diffuse Without Entering Blood
3. Produce Local Effects

4. Short Half-Lives

B. Prostaglandins
1. Role in Inflammation (Chapter 22)
2. Many Other Local Effects
a. Stimulate Pain Receptors
b. Vasodilation Associated With Headaches
3. Synthesis Inhibited by Aspirin and Other Antiinflammatory Drugs

C. Endorphins, Enkephalins and Dynorphins
1. Endogenous Analgesics (Morphine Binds to Endorphin Receptors)
2. Moderate Sensitivity to Pain
3. Stress and Exercise Seem to Increase Secretion of Endorphins

XII. Systems Pathology

Systems Interactions, p.577
Predict Quest. 11

IMPORTANT CONSIDERATIONS: The natural logical splits in this material occur after the hypothalamohypophyseal axis, and then between the cataloging of individual hormones and the overall body coordination of blood levels of important nutrients under varying conditions.

Much of the material in this chapter just has to be committed to memory. Class time may be best spent in providing students with the framework which allows them to see how having knowledge about the names and sources of hormones committed to memory might be useful. Getting students to predict the consequences of and analyze the symptoms of hyper- and hyposecretion may help them get a firm grasp on the ways (both general and specific) in which hormones regulate most body functions. As always, it is up to the instructor to determine the level of detail for which students will be held accountable. Relating the hormone products with the precise location of secretion and the body parameter or function being regulated should help students see the context in which hormonal regulation fits. Having students develop a thorough understanding of the types of functions regulated by hormones is of greater lasting value than being able to recite the list of hormones and targets from memory. Students should be encouraged to relate the specifics of particular hormone systems to the general control mechanisms discussed in the previous chapter and to role(s) of these hormones in the maintenance of homeostasis.

The hypothalamohypophyseal axis can be confusing to students, perhaps in part because there is a sequence of steps which must be remembered in order. When this is combined with a view that each body function is discrete, it is no wonder that many students get lost at the pituitary and the controls of its secretions. These hormones will all be referred to again when the control of each organ system is discussed with that organ system, but an understanding of these hormones now will mean that the subject will be review (rather than complete relearning) when the other organ systems are discussed (often in a later quarter or semester).

SEE INSTRUCTOR'S MANUAL AND COURSE SOLUTIONS MANUAL FOR ADDITIONAL RESOURCES.