Chapter 16
Endocrine System II
Lecture 15

Lecture Overview

• The Hypothalamus / Pituitary Gland

• The Thyroid Gland

• The Parathyroid Glands

Major Endocrine Glands

[Diagram showing major endocrine glands: Hypothalamus, Pituitary gland, Parathyroid gland, Thyroid gland, Thymus, Kidney, Adrenal gland, Pancreas, Testis (in male), Ovary (in female).]
Pituitary Gland (Hypophysis)

Two distinct portions
- anterior pituitary (adenohypophysis)
- posterior pituitary (neurohypophysis)

Overview of the Pituitary Hormones

All anterior and posterior pituitary hormones bind to membrane receptors and use 2nd messengers (cAMP)

Pituitary Gland Control

- Hypothalamic releasing hormones stimulate cells of anterior pituitary to release their hormones
- Nerve impulses from hypothalamus stimulate nerve endings in the posterior pituitary gland to release its hormones

Note the hypophyseal portal system (two capillaries in series)
Tropic hormones in black control the activity of other endocrine glands.

All anterior pituitary hormones use second messengers.

Anterior Pituitary Hormones - GH

Growth Hormone (GH)
- main target is skeletal muscle, bone, and cartilage
- stimulates increase in size and metabolic rate of body cells
- anabolic (tissue building) and diabetogenic (↑ glucose)
- Circadian (24-hour) pattern of secretion - highest during sleep
- action via insulin-like growth factors (somatomedins)
- enhances movement of amino acids through membranes
- promotes lipolysis and glycogenolysis (diabetogenic effect)
- promotes growth of long bones
- secretion inhibited by somatostatin (GHIH)
- somatotrope secretion stimulated by growth hormone-releasing hormone (GHRH)

Anterior Pituitary Hormones - PRL

Prolactin (PRL)
- stimulates milk production by the breasts (rises at end of pregnancy; infant suckling after birth)
- amplifies effect of LH in males (↑ sens. of interstitial cells)
- secretion inhibited by hypothalamic PIH (dopamine)
- secretion stimulated by PRF (serotonin?)
- produced by lactotropes (mammotropes)
- brief rise in PRL levels just before menstrual period partially accounts for breast swelling and tenderness
Anterior Pituitary Hormones – TSH/ACTH

Thyroid Stimulating Hormone (TSH)
• controls secretions of hormones from the thyroid gland
• release controlled by thyrotropin-releasing hormone (TRH) from the hypothalamus
• produced by thyrotropes

Adrenocorticotropin Hormone (ACTH)
• controls secretions of some hormones of adrenal cortex
• release controlled by corticotropin-releasing hormone (CRH) from the hypothalamus
• produced by corticotropes

What term would describe these two hormones that cause the secretion of other hormones in distant endocrine tissues?
- Tropic hormones -

Anterior Pituitary Hormones – FSH/LH

- Tropic hormones -

Follicle-Stimulating Hormone (FSH)
• stimulates gamete production in males and females
• controlled by gonadotropin-releasing hormone (GnRH)
• stimulates follicular cells to secrete estrogen

Luteinizing Hormone (LH)
• promotes secretions of sex hormones in both sexes
• controlled by gonadotropin-releasing hormone (GnRH)
• stimulates release of egg from ovaries in females
• promotes growth of long bones
• known as Interstitial Cell Stimulating Hormone in males

FSH and LH are gonadotropins produced by gonadotropes

Posterior Pituitary Hormones – ADH/OT

Antidiuretic Hormone (ADH; vasopressin or AVP)
• causes kidneys to reduce water excretion
• in high concentration, raises blood pressure
• controlled by hypothalamus in response to changes in blood water concentration (osmoreceptors) and blood volume
• inhibited by alcohol, diuretics

Oxytocin (OT)
• stimulates uterine contractions
• stimulates lactating mammary glands to eject milk
• controlled by hypothalamus in response to stretch in uterine and vaginal walls and stimulation of breasts
• thought also to play a role in sexual arousal, orgasm, sexual satisfaction, and promotion of “cuddling behavior”

Both hormones use IP3-calcium second messenger
Thyroid Gland

Follicular cells produce thyroglobulin (TG)

After being attached to iodine, TG is stored in colloid in the follicles

I-bound TG is the source of thyroid hormones, \( T_3 (3I^-) \) and \( T_4 (4I^-) \)

Parafollicular cells, or ‘C’, cells, of the thyroid gland produce calcitonin

Thyroid Hormones

Thyroxine (T\(_4\)) and Triiodothyronine (T\(_3\))

- increases BMR and rate of energy release from CHO (calorigenic effect)
- ↑ rate of protein synthesis
- accelerates growth; critical for skeletal/nervous system
- important for reproductive function
- release controlled by TSH (from anterior pituitary); highest before sleep and at night
Thyroid Gland Disorders

General Hyperthyroidism
- high metabolic rate
- hyperactivity
- weight loss
- protruding eyes

Congenital hypothyroidism (Cretinism)
- hypothyroidism in infants
- leads to small stature and mental retardation

Thyroid Gland Disorders

Myxedema
- adult hypothyroidism
- low metabolic rate
- sluggishness

Simple (Endemic) Goiter
- deficiency of iodine
- leads to deficiency of thyroid hormones
- thyroid gland enlarges

Grave's disease
- overstimulation of gland by antibodies that mimic TSH
- hyperthyroidism

Calcitonin
- lowers blood calcium and phosphate ion concentrations by inhibiting release of calcium and phosphate from bones
- increases rate at which calcium and phosphate are deposited in bones
- most important in children; weak hypocalcemic agent in adults

Figure from: Martini, Anatomy & Physiology, Prentice Hall, 2001
**Parathyroid Glands**

- PTH (parathormone, parathyroid hormone)
- Increases blood calcium levels
- Stimulates bone resorption by osteoclasts
- Stimulates kidneys to retain calcium and excrete phosphate
- Promotes calcium absorption into intestine

**Parathyroid Hormone**

Calcium ion homeostasis is maintained by a negative feedback system involving a pair of hormones with opposite effects, PTH and calcitonin.

**Parathyroid Glands**

PTH promotes Ca\(^{2+}\) absorption in the intestine (via vitamin D) and Ca\(^{2+}\) reabsorption by the kidney.
The pituitary gland is a major site of hormone production

- Anterior (adenohypophysis)
  - Hormone secreting cells
  - Release controlled by hypothalamic releasing hormones
    - ACTH, GH, LH/FSH, Prolactin, TSH
- Posterior (neurohypophysis)
  - Storage area for hormones produced in the hypothalamus
  - Release controlled by neural activity
    - ADH and OT

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<th>TARGET(S)</th>
<th>EFFECT(S) AT TARGET SITE</th>
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| Growth Hormone (GH) | anterior pituitary | bone, muscle, fat | growth of bones
| Thyroid Stimulating Hormone (TSH) | anterior pituitary | thyroid | secrete hormones
| Prolactin (PRL) | anterior pituitary | mammary glands | produce milk
| Adrenocorticotropic hormone (ACTH) | anterior pituitary | adrenal cortex | secrete adrenal hormones
| Estrogen stimulating hormone (LH) | anterior pituitary | ovary | production of estrogen
| Follicle stimulating hormone (FSH) | anterior pituitary | ovary | production of estrogen
| Anti-Diuretic Hormone (ADH) (Vasopressin) | posterior pituitary | distal convoluted tubules | reabsorption of water, increases blood pressure
| Oxytocin (OT) | posterior pituitary | uterus | uterine smooth muscle contraction, milk release

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| Triiodothyronine (T3) & Thyroxine (T4) | thyroid follicular cells | all cells | increase rate of metabolism
| Calcitonin | thyroid (C cells) | distal convoluted tubules and osteoblasts | release of Ca++ into urine, bone formation (decreases blood Ca++)
| Parathyroid hormone (PTH) | parathyroid glands | proximal renal tubules, osteocytes, intestine | absorption of Ca++ into blood, bone resorption, dietary Ca++ absorption (increases blood Ca++)

Remember that PTH and calcitonin have opposing effects in regulating blood calcium levels (they are antagonists).