VI Semester
PHYSIOLOGICAL PSYCHOLOGY
Unit IV

HORMONES AND BEHAVIOR

Hormones (from the Greek word horman, "to excite") are chemicals secreted by one group of cells and carried through the bloodstream to other parts of the body, where they act on specific target tissues to produce specific physiological effects. Many hormones are produced by endocrine glands (from the Greek word endon, "within", and krinein, "to secrete"), so called because they release their hormones within the body. Endocrine glands are sometimes contrasted with exocrine glands (tear glands, salivary glands, and sweat glands) which use ducts to secrete fluid outside the body (the Greek exo means "out").

Hormones function more like a radio station: They convey a message to any receiver tuned in to the right station. Hormones are particularly useful for coordinating long lasting changes in multiple parts of the body. For example, birds that are preparing for migration secrete hormones that change their eating and digestion to store extra energy for a long journey. Among the various types of hormones are protein hormones and peptide hormones, composed of chains of amino acids. (Proteins are longer chains and peptides are shorter.) Protein and peptide hormones attach to membrane receptors, where they activate a second messenger within the cell—exactly like a metabotropic synapse. In fact, many chemicals serve as both neurotransmitters and hormones. A hormone is a chemical that is secreted by cells in one part of the body and conveyed by the blood to influence other cells.

Brown (1994) has provided five ways in which hormone can be defined:

1. First, a hormone is a chemical messenger which is effective in minute quantities.
2. Second, a hormone is synthesized within ductless glands.
3. Third, a hormone is secreted into the circulatory system and transported around the body in the blood.
4. Fourth, a hormone acts upon receptors in target cells located distantly from the organ of synthesis.
5. Finally, a hormone exerts a specific biochemical or physiological regulatory effect on the target cell.

Most hormones fall into one of the three categories: protein hormones, amine hormones, or steroid hormones. A protein hormone is composed of a string of amino acids. Amino hormones are smaller and simpler, consisting of a modified version of a single amino acid.

Steroid hormones are derivatives of cholesterol and thus share its structure of four rings of carbon atoms.

Endocrine glands and hormones

1. The pituitary gland – Resting in a socket in the base of the skull is the pituitary gland (or hypophysis). The hypothalamus sits just above it. The pituitary gland was used to be referred as the master gland, mainly because of its regulatory role with regard to several other endocrine glands. But this gland is enslaved by the hypothalamus. The pituitary gland consists of two main parts; the anterior pituitary (or adenohypophysis) and the posterior pituitary (or neurohypophysis). The anterior pituitary and the posterior pituitary develop from different embryonic tissues and are completely separate in function. The pituitary is connected to the hypothalamus by a thin piece of tissue called the pituitary stalk or infundibulum. The stalk contains many axons and is richly supplied with blood vessels.

(a) The posterior pituitary – secretes two principal hormones: oxytocin and arginine vasopressin (AVP), often called vasopressin. Vasopressin increases blood pressure by causing blood vessels to contract. It also inhibits the formation of urine, so it is sometimes called antidiuretic hormone, or ADH. This action of vasopressin helps conserve water. Oxytocin Is involved in many aspects of reproductive and parental behavior. One of its functions is to stimulate contractions of the uterus in childbirth. Injections of oxytocin (synthetic) are frequently used in medial settings to induce or accelerate labor and delivery. Oxytocin also triggers the milk letdown reflex, the contraction of mammary gland cells that ejects milk into the breast ducts.

(b) The anterior pituitary – Different cells of the anterior lobe of the pituitary synthesize and release different tropic hormones. The anterior pituitary gland secretes six tropic hormones. Two of these regulate the function of the adrenal cortex and the thyroid gland:

(i) Adrenocorticotropic hormone (ACTH) – controls the production and release of hormones of the adrenal cortex. The adrenal cortex, in turn, releases steroid hormones. The levels of ACTH and adrenal steroids show a marked daily rhythm.

(ii) Thyroid-stimulating hormone (TSH) – increases the release of thyroid hormones from the thyroid gland and markedly affects thyroid gland size.

Two other tropic hormones of the anterior pituitary influence the gonads, and consequently are termed gonadotropins:

(iii) Follicle – stimulating hormone (FSH) – gets its name from the actions in the ovary, where it stimulates the growth and maturation of egg-containing follicles and the secretion of estrogens from the follicles. In males, FSH governs sperm production.

(iv) Luteinizing hormone (LH) – stimulate the follicles of the ovary to rupture, release their eggs, and form into structures called corpora lutea (corpus luteum) that secrete the sex steroid hormone progesterone. In males, LH stimulates the testes to produce testosterone.

(v) Prolactin – so named because it promotes lactation in female mammals. But prolactin has a number of roles in addition to its actions on breast tissue. For example, it is closely involved in the parental behavior of a wide variety of vertebrate species.

(vi) Growth hormone (GH) – also known as somatotropin or somatotropic hormone. It acts throughout the body to influence the growth of cells and tissues by affecting protein metabolism. GH is released almost exclusively during sleep.

2. Adrenal gland – Resting on top of each kidney is an adrenal gland, which secretes a large variety of hormones. In mammals, the adrenal structure is divided into two major portions. The outer 80% of the gland, the adrenal cortex is composed of distinct layers of cells, each producing different steroid hormones. The core 20% of the gland is the adrenal medulla which is richly supplied with autonomic nerves.

(a) Adrenal medulla – As part of the "fight or flight" reaction to threat, the adrenal medulla secretes hormones – the catecholamines epinephrine (adrenaline) and norepinephrine (noradrenaline) – that prepare the body for action, raising heart rate and respiration, among other things. Because emergencies demand quick action, secretions of these hormones is under direct control of the brain, via sympathetic nerve terminals that release acetylcholine in the adrenal medulla.

(b) Adrenal cortex – the adrenal cortex produces and secretes a variety of steroid hormones, collectively known as adrenocorticoids (or adrenal steroids). One subgroup consists of the glucocorticoids, so called because of their effects on the metabolism of carbohydrates, including glucose. Hormones of this type, such as, cortisol, increase the level of blood glucose and accelerate the breakdown of proteins. In high concentrations, glucocorticoids have a marked anti-inflammatory effect; that is, they inhibit the swelling around injuries and infections. This action normally results in the temporary decrease of bodily responses to tissue injury, which is why synthetic glucocorticoids (such as prednisone) are important and useful drugs. However, sustained high levels of glucocorticoids are harmful to the brain. A long term excess of glucocorticoids results in Cushing's syndrome, a constellation of symptoms that includes fatigue, depression, hirsutism (unusual hair growth, such as beard in women), and various autonomic changes. Excessive glucocorticoid exposure is also associated with steroid dementia syndrome, a long-lasting impairment of cognition, including memory and attention.

A second subgroup of adrenal steroids consists of the mineralocorticoids, so named because of their effects on minerals such as sodium and potassium. The primary mineralocorticoid hormone is aldosterone, which acts on the kidneys to retain sodium and thus reduces the amount of urine produced, conserving water. This action helps maintain a homeostatic equilibrium of ions in blood and extracellular fluids.

The adrenal cortex also produces sex steroids notably androstenedione which contributes to the adult pattern of body hair in men and women.

3. Thyroid gland – situated in the throat, just below the larynx is the thyroid gland. Normal secretions of the thyroid gland are associated with good health (growth and metabolism) and that hypo and hyper secretion leads to poor physical and mental health. This gland produces and secretes several hormones. Two of these – thyroxine (or tetraiodothyronine) and triiodothyronine – are usually referred to as thyroid hormones; a third – calcitonin – promotes calcium deposition in bones. Small glands embedded within the thyroid glands – parathyroid glands – secrete parathyroid hormone (PTH) which is also important in calcium regulation.

The thyroid is unique among the endocrine glands because it stores a large amount of hormone – at least a 100-day supply – which it slowly releases. Although thyroid hormones are amines, they behave like steroids. They bind to specialized receptors found inside cells. They thyroid hormone-receptor complex then binds to DNA and regulates gene expression. Thyroid hormones are the only substances produced by the body that contain iodine, and their manufacture is critically dependent on the supply of iodine. When people suffer from hypothyroidism, a condition called goiter is formed. Thyroid hormones have a general effect on the nervous system, maintaining alertness and reflexes. Hypothyroidism can also cause depression and cognitive impairment. Thyroid hormones also influence growth. When thyroid deficiency starts early in life, body growth is stunted and the face malformed. Thyroid deficiency also produces a marked reduction in brain size and in the branching of axons and dendrites. This state, called cretinism, or congenital hypothyroidism, is accompanied by intellectual disability. Parathyroid deficiency results in calcium deposition in the basal ganglia and leads to symptoms that resemble schizophrenia. Patients with excessive thyroid release frequently appear intensely anxious.

4. Gonads – the gonads produce sex cells (gametes). They also produce hormones required for gamete development, the development of secondary sexual characteristics and the mediation of sexual behaviours. The gonads are regulated by tropic hormones from the anterior pituitary. The sexes have different forms of gonads, but all prodeuce three types of sex steroid hormones – androgens, estrogens and progestins.

The hypothalamus controls gonadal hormone production by releasing gonadotropin-releasing hormone (GnRH), which drives the anterior pituitary to release

the gonadotropins FSH and LH. FSH and LH drive development and steroid production in both testes and ovaries. The GnRH neurons om turn are stimulated by a hypothalamic peptide called kisspeptin, which appears to play an important role in governing the onset of puberty.

(a) The testes – within the testes are Sertoli cells, which produce sperm, and Leydig cells, which produce and secrete the sex steroid testosterone. Testosterone and other male hormones are called androgens. Testosterone controls a wide range of bodily changes tha become visible at puberty, including changes in voice, hair growth, and genital size. As men age, testosterone level tend to decline.

(b) The ovaries – the paired female gonads, the ovaries, also produce both the mature gametes – called ova (ovum singular) or eggs – and sex steroid hormones. Ovarian hormones are produced in cycles, the duration of which varies with the species. Human ovarian cycles last about 4 weeks. The ovary produces two major classes of steroid hormones: progestins, which helps to maintain pregnancy and estrogens. The primary progestin is progesterone. Estrogens make the brain sensitive to progesterone by promoting the production of progestin receptors there.

Oral contraceptives contain small doses of synthetic estrogen and/or progestin, which exert a negative feedback on the hypothalamus, inhibiting the release of GnRH. The lack of GnRH prevents the release of FSH and LH from the pituitary, and therefore the ovary fails to release an egg for fertilization. Estrogens may improve aspects of cognitive functioning. It may also protect the brain from some of the effects of stress and stroke. For these reasons, estrogen replacement therapy has been a popular postmenopausal treatment.

5. Pineal gland – the pineal gland sits atop the brainstem and in mammals is overlaid by the cerebral hemispheres. The pineal gland plays a crucial role in biological rhythms. Governed by the superior cervical ganglion – part of the sympathetic nervous system – the pineal releases an amine hormone called melatonin. The melatonin is released almost exclusively at night, it provides a signal that tracks day length and by extension, the seasons. Melatonin secretions control breeding condition in many seasonally breeding mammals. In humans, melatonin plays a role in our biological rhythms, especially the timing of sleep onset.

ORGANS	HORMONE	HORMONE FUNCTIONS
Hypothalamus	Various releasing hormones	Promote or inhibit release of various hormones by pituitary
Anterior Pituitary	Thyroid-stimulating hormone (TSH)	Stimulates thyroid gland

	Luteinizing hormone (LH)	Increases production of progesterone (female), testosterone (male); stimulates ovulation
	Follicle-stimulating hormone (FSH)	Increases production of estrogen and maturation of ovum (female) and sperm production (male)
	Adrenocorticotropic hormone (ACTH)	Increases secretion of steroid hormones by adrenal gland
	Prolactin	Increases milk production
	Growth hormone (GH)	Increases body growth, including the growth spurt during puberty
Posterior Pituitary	Oxytocin	Controls uterine contractions, milk release, certain aspects of parental behavior, and sexual pleasure
	Vasopressin (also known as antidiuretic hormone)	Constricts blood vessels and raises blood pressure, decreases urine volume
Pineal gland	Melatonin	Increases sleepiness, influences sleep-wake cycle, also has a role in onset of puberty
Thyroid gland	Thyroxine Triiodothyronine	Increases metabolic rate, growth and maturation
Parathyroid	Parathyroid hormone	Increases blood calcium and decreases potassium
Adrenal cortex	Aldosterone	Reduces secretion of salt by the kidneys
	Cortisol, corticosterone	Stimulates liver to elevate blood sugar, increase metabolism of proteins and fats
Adrenal medulla	Epinephrine, norepinephrine	Similar to effects of sympathetic nervous system
Pancreas	Insulin	Increase entry of glucose to cells and increases storage as fats
	Glucagon	Increases conversion of stored fats to blood glucose
Ovary	Estrogens	Promote female sexual characteristics
	Progesterone	Maintains pregnancy
Testes	Androgens	Promote sperm production, growth of pubic hair, and male sexual characteristics

Liver	Somadomedins	Stimulate growth
Kidney	Renin	Converts blood protein into angiotensin, which regulates blood pressure and contributes to hypovolemic thirst
Thymus	Thymosin (and others)	Support immune response
Fat cells	Leptin	Decreases appetite, increases activity, necessary for onset of puberty

Reference:

Carlson, N. R. (2004). Foundations of Physiological Psychology. 6th Edition. Allyn & Bacon
Kalat, J. W. (2007). Biological Psychology. 9th Edition. Brooks/Cole Publishers.
Leukel, F. (2005). Introduction to Physiological Psychology. 3rd Edition. CBS Publisher.
Rosenzweig, M. R., Leiman, A. L. & Breedlove, S. R. (2001). Biological Psychology. 3rd Edition. Sinauer Associates Inc.