The Endocrine Glands

When you hear the word "hormone," what do you think of? Many people think first of sex hormones, such as estrogen and testosterone, but hormones are not limited to sex hormones. Your body contains dozens of different hormones, each tailored to a specific task or sometimes more than one task. Hormones help to make you hungry, and they make you tired when it gets dark.

Hormones, which are produced by the endocrine system, are like a chemical management system for the body. The endocrine system is a system of glands located in various parts of the body. These glands produce hormones and secrete them into the bloodstream, which carries them throughout the body. **Figure 1** shows some of the major endocrine glands in humans. Many other important hormones are secreted by other organs, such as the heart, liver, kidneys, and intestines, and have different primary functions.

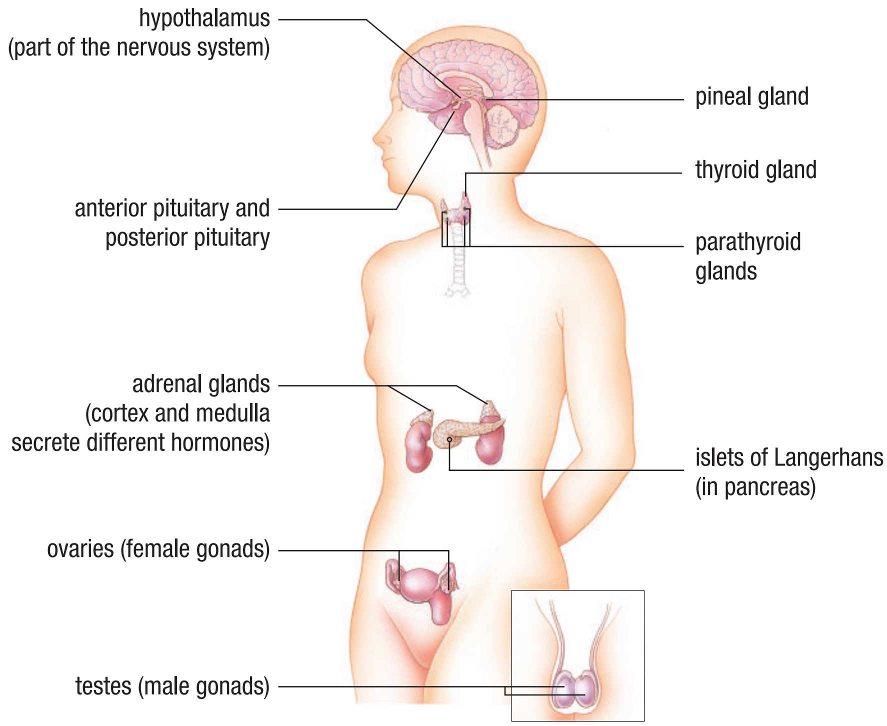

Figure 1 The major endocrine glands and cells in humans

The Vertebrate Endocrine System

In this section, you will consider the hypothalamus and pineal glands, which lie within the brain, and the pituitary gland, which lies just below the brain. You will also consider the thyroid and parathyroid glands in the throat and the adrenal glands on the tops of the kidneys.

Hypothalamus and Pituitary Gland

The **hypothalamus** is unlike other endocrine glands. It is a region of the brain and thus part of the nervous system. The nervous system is a system of specialized cells and fibres that transmit nerve impulses between different parts of the body. Neurons (nerve cells) in the hypothalamus produce a special type of hormone, called **neurohormones**. The neurohormones travel along the length of the nerve cells, diffuse into the bloodstream, and then travel through the blood into the pituitary gland.

hypothalamus the region of the brain that releases hormones to control the pituitary gland, which, in turn, controls other endocrine glands

neurohormone a hormone produced by neurons, such as in the hypothalamus, that controls the production of other hormones in the pituitary gland

The hypothalamus itself is controlled by input from other parts of the nervous system. Some neurons connect directly to the hypothalamus from sensory receptors that monitor the blood for changes in body chemistry or temperature. Input to the hypothalamus also comes from numerous connections from control centres elsewhere in the brain. Negative feedback systems help to control how the hypothalamus releases its hormones.

pituitary gland a two-lobed gland within the cranial cavity that produces hormones that control the other endocrine glands

The **pituitary gland** is located within the cranium, just below the brain. It has two major lobes: the anterior lobe and the posterior lobe. The neurohormones travel through a portal vein that connects capillaries inside the hypothalamus with the capillaries inside the anterior pituitary gland. The portal vein provides a critical link between the nervous system and the endocrine system, because most of the blood that enters the anterior pituitary gland must first pass through the hypothalamus. There are two types of neurohormones produced by the hypothalamus: releasing hormones and inhibiting hormones. These hormones either stimulate or inhibit the release of specific hormones that are created in the anterior pituitary gland. The hormones secreted by the endocrine cells inside the anterior pituitary gland are then released into the bloodstream to reach their target tissues, where they control many other endocrine glands and some bodily processes directly. The hypothalamic and pituitary hormones are summarized in **Table 1**.

Table 1 Hypothalamic and Pituitary Hormones

Endocrine gland	Hormone produced	Target tissue	Function
hypothalamus	releasing and inhibiting hormones, e.g., growth hormone–releasing hormone (GHRH) or growth hormone–inhibiting hormone (somatostatin)	anterior pituitary	regulates the secretion of anterior pituitary hormones
anterior pituitary	prolactin (PRL)	mammary glands	stimulates breast development and milk production
	growth hormone (GH)	bone, soft tissue	stimulates the growth of bones and soft tissues; helps to control the metabolism of glucose and other fuel molecules
	thyroid-stimulating hormone (TSH)	thyroid gland	stimulates the secretion of thyroid hormones and the growth of the thyroid gland
	adrenocorticotropic hormone (ACTH)	adrenal cortex	stimulates the secretion of glucocorticoids by the adrenal cortex
	follicle-stimulating hormone (FSH)	ovaries in females, testes in males	stimulates egg growth and development and the secretion of sex hormones in females; stimulates sperm production in males
	luteinizing hormone (LH)	ovaries in females, testes in males	regulates ovulation in females and the secretion of sex hormones in males
	melanocyte-stimulating hormone (MSH)	melanocytes in the skin of some vertebrates	promotes darkening of the skin
	endorphins	pain pathways in the nervous system	inhibit the perception of pain
posterior pituitary	antidiuretic hormone (ADH)	kidneys	increases blood volume and pressure by increasing water reabsorption in the kidneys
	oxytocin	uterus, mammary glands	promotes uterine contractions; stimulates milk release from the breasts

The pituitary gland is sometimes referred to as the "master gland" because it produces hormones that control most of the other endocrine glands (**Figure 2**). The anterior pituitary secretes several major hormones into the bloodstream, some of which drive hormone secretion in other glands. The posterior lobe of the pituitary gland stores and releases two important hormones, one of which helps to control blood pressure.

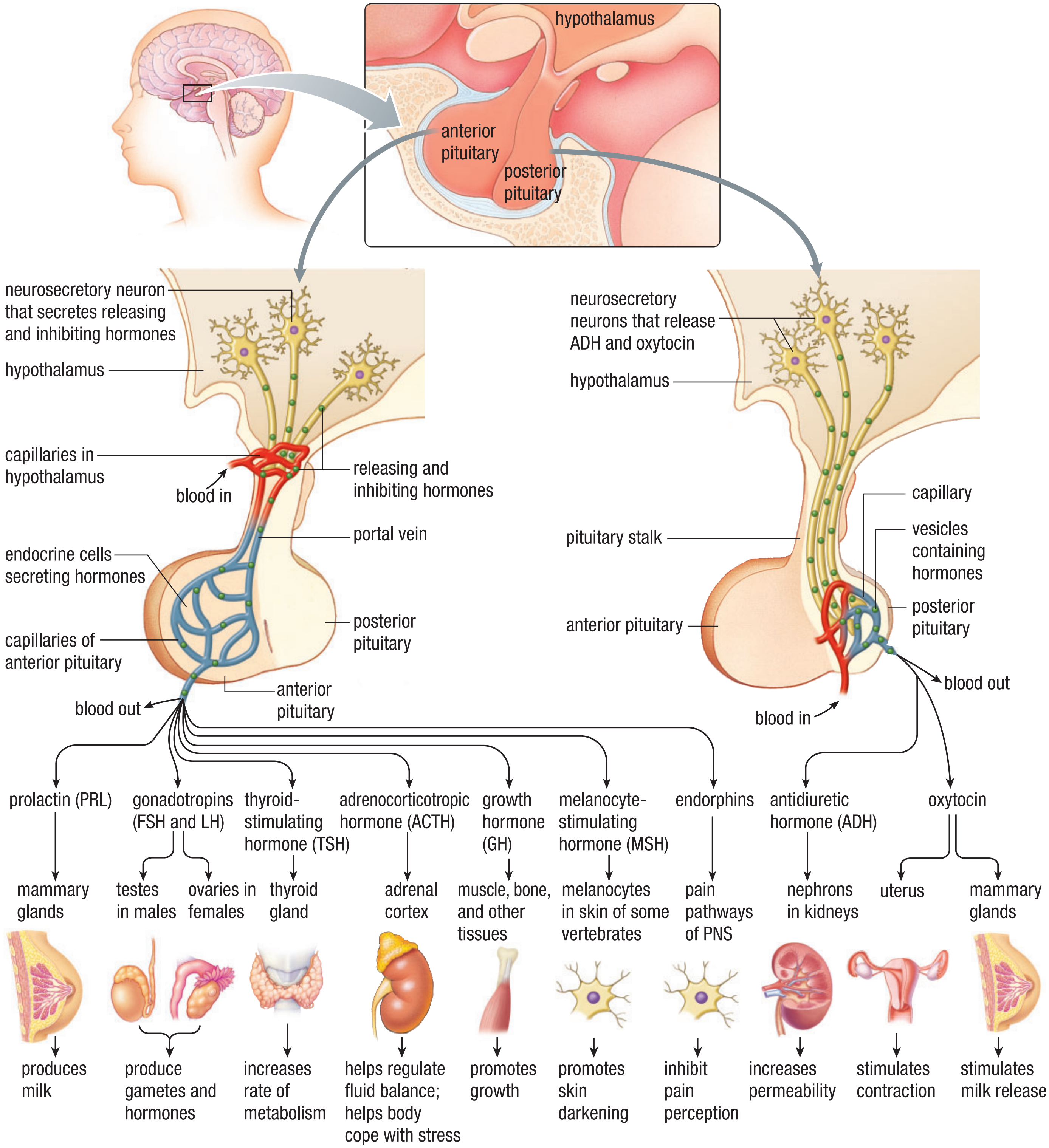

Figure 2 The hypothalamus and the pituitary gland link the endocrine system and the nervous system. Neurohormones produced by the hypothalamus control the anterior and posterior pituitary hormones, which control other endocrine glands.

ANTERIOR PITUITARY GLAND

The endocrine system is largely controlled by the anterior pituitary hormones, which, in turn, are controlled by the releasing or inhibiting hormones that come from the hypothalamus. The anterior pituitary secretes six major hormones into the bloodstream: prolactin, growth hormone, thyroid-stimulating hormone, adrenocorticotropic hormone, follicle-stimulating hormone, and luteinizing hormone (Figure 2).

Prolactin (PRL) influences reproductive activities and parental care in vertebrates. In mammals, PRL stimulates the development of the secretory cells of the mammary glands during late pregnancy, and milk synthesis after birth. Stimulation of the mammary glands and the nipples, which occurs during suckling, leads to the release of PRL. In all vertebrates, PRL has a role in promoting both maternal and paternal behaviour. PRL also occurs in non-mammalian vertebrates, where it has a variety of functions. In fish, for example, it is one of the hormones that controls water balance.

Growth hormone (GH) stimulates cell division, protein synthesis, and bone growth in children and adolescents, thereby causing body growth. GH also stimulates protein synthesis and cell division in adults. To carry out these functions, GH binds to muscle and other target tissues, causing them to release insulin-like growth factor (IGF), a protein hormone that directly stimulates the growth processes. GH also directly controls a number of major metabolic processes in mammals of all ages, including the conversion of glycogen to glucose and fats to fatty acids as a means of regulating their levels in the blood. As well, GH stimulates body cells to take up fatty acids and amino acids and limits the rate at which muscle cells can take up glucose. These actions help to maintain the availability of glucose and fatty acids to tissues and organs between meals, which is particularly important for the brain. In humans, deficiencies in GH secretion during childhood produce pituitary dwarfs, who remain small in stature (**Figure 3(a)**). Overproduction of GH during childhood or adolescence, often due to a tumour of the anterior pituitary, produces pituitary giants, who may grow up to 2.7 m in height (**Figure 3(b)**).

Figure 3 (a) A pituitary dwarf and (b) a pituitary giant

Many of the other hormones secreted by the anterior pituitary gland control endocrine glands elsewhere in the body. These hormones are referred to as tropic hormones. Thyroid-stimulating hormone (TSH) stimulates the thyroid gland to grow in size and secrete thyroid hormones. Adrenocorticotropic hormone (ACTH) triggers hormone secretion by cells in the adrenal cortex. Follicle-stimulating hormone (FSH) affects egg development in females and sperm production in males. As well, it stimulates the secretion of sex hormones in female mammals. Luteinizing hormone (LH) regulates part of the menstrual cycle in human females and the secretion of sex hormones in males. FSH and LH are grouped together as gonadotropins because they regulate the activities of the gonads (ovaries and testes). The roles of the gonadotropins and sex hormones in the reproductive cycle are described in Section 10.7.

Melanocyte-stimulating hormone (MSH) and endorphins are also secreted by the anterior pituitary gland. MSH is named because of its effect on melanocytes, skin cells that contain the black pigment melanin. An increase in MSH secretion produces a darkening of the skin of fish, amphibians, and reptiles. The darkening is caused by a dispersal of melanin in melanocytes so that it covers a greater area. In humans, an increase in MSH secretion also causes skin darkening, although the effect is not as obvious. MSH secretion increases in pregnant women. Combined with the effects of increased estrogens, MSH results in increased skin pigmentation. The effects are reversed after the birth of the baby.

Endorphins—protein hormones produced by the hypothalamus and the pituitary gland—are released by the intermediate lobe of the pituitary gland. In humans, the intermediate lobe is not well developed, comprising only a thin layer of cells between the anterior and posterior lobes. In the human nervous system, endorphins act as neurotransmitters in pathways that control pain, thereby inhibiting the perception of pain. Hence, endorphins are often called "natural painkillers."

POSTERIOR PITUITARY GLAND

The posterior lobe of the pituitary gland stores and releases two important hormones, antidiuretic hormone and oxytocin, into the bloodstream (Figure 2). These hormones are produced in the cells of the hypothalamus. They are transferred to the posterior pituitary gland along nerve cells that reach from the hypothalamus into the posterior pituitary. The posterior pituitary gland stores the hormones and releases them into the bloodstream when the appropriate nerves from the hypothalamus are stimulated.

Antidiuretic hormone (ADH) stimulates the kidney cells to absorb more water from the urine, which increases the volume of the blood. ADH is released when sensory receptor cells of the hypothalamus detect an increase in the blood's Na^+ concentration after a salty meal or when the body is dehydrated. Ethanol and caffeine inhibit ADH secretion, explaining, in part, why alcoholic drinks and coffee increase the volume of urine excreted. Nicotine and emotional stress, in contrast, stimulate ADH secretion and water retention. After severe stress is relieved, the return to normal ADH secretion often makes a trip to the bathroom among our most pressing needs. The hypothalamus also releases a flood of ADH when an injury results in heavy blood loss or another event triggers a severe drop in blood pressure. ADH helps maintain blood pressure by reducing water loss and causing blood vessels in some tissues to constrict.

ADH enables the kidneys to maintain a homeostatic balance of extracellular fluid in the body. Most (approximately 85 %) of the water filtered into the nephron is reabsorbed in the proximal convoluted tubule. The remainder is absorbed in the distal convoluted tubule, but only if ADH is present. ADH causes the upper part of the distal convoluted tubule to become permeable to water. The high concentration of NaCl in the interstitial fluid causes water to move, by osmosis, out of the upper part of the distal tubule and the collecting duct into the interstitial fluid. It is the control of this volume of water (15 %) in the kidneys that balances the concentrations of the body fluids.

Hormones similar to those of ADH are also secreted in fish, amphibians, reptiles, and birds. In amphibians, these ADH-like hormones increase the amount of water that enters the body through the skin and from the urinary bladder.

Oxytocin is the second important hormone stored and released by the posterior lobe of the pituitary gland. Oxytocin stimulates the release of milk from the mammary glands of a nursing mother. The stimulation of the nipples in suckling sends neuronal signals to the hypothalamus and leads to the release of oxytocin. The released oxytocin stimulates more oxytocin secretion by a positive feedback mechanism. Oxytocin causes the smooth muscle cells surrounding the mammary glands to contract, forcibly expelling the milk through the nipples. The entire cycle, from the onset of suckling to milk ejection, takes less than a minute in mammals. Oxytocin also plays a key role in childbirth by stimulating the contraction of the muscles of the uterus.

In males, oxytocin is also secreted into the seminal fluid by the testes. When the seminal fluid is ejaculated into the vagina during sexual intercourse, oxytocin stimulates contractions of the uterus, which aid the movement of sperm through the female reproductive tract.

Thyroid and Parathyroid Hormones

thyroid gland an endocrine gland located in the throat that is regulated by the hypothalamus-pituitary system

The **thyroid gland** is located in the front of the throat in humans and is shaped like a bow tie. It secretes the same hormones in all vertebrates. The thyroid hormones have an extraordinarily wide range of effects. The primary thyroid hormone, thyroxine, is known as T_4 because it contains four iodine atoms. A supply of iodine in the diet is necessary to produce all of these hormones. Normally, the concentrations of thyroid hormones are kept at finely balanced levels in the blood by negative feedback loops. **Table 2** lists the thyroid and parathyroid hormones and their functions in the body.

Table 2 Thyroid and Parathyroid Hormones

Endocrine gland	Hormone produced	Target tissue	Function
thyroid	calcitonin	bones	lowers the calcium concentration in the blood
	thyroxine and triiodothyronine	most cells	increases the metabolic rate; essential for normal body growth
parathyroid	parathyroid hormone (PTH)	bones, kidneys, and intestines	raises the calcium concentration in the blood; stimulates vitamin D activation

Figure 4 The very swollen area on the neck is a goiter, an enormously enlarged thyroid gland. Goiters are more common in parts of the world without modern medical care and without a natural supply of iodine in the diet.

When there is not enough iodine in the body to produce thyroxine, the negative feedback loop fails and the thyroid is continually stimulated by TSH from the pituitary gland. The overstimulated thyroid swells and results in a condition called a goiter, which can result in a noticeable swelling on the neck (**Figure 4**). To ensure that people get enough iodine in their diet to produce thyroxine and prevent goiter, iodine is added to table salt in many places in the world, including Canada.

The thyroid hormone T_4 is not a steroid hormone, but it is lipid soluble and can pass through the cell membrane. Once inside the cell, T_4 loses an iodine atom and is converted into T_3. T_3 enters the nucleus and combines with nuclear receptors. There, it alters gene expression, bringing about many of its effects.

Thyroid hormones are vital to growth, development, maturation, and metabolism in all vertebrates. They interact with growth hormone for their effects on growth and development. Thyroid hormones also increase the sensitivity of many body cells to the effects of epinephrine and norepinephrine—hormones released by the adrenal medulla as part of the fight-or-flight response. In amphibians, rising concentrations of thyroid hormones trigger metamorphosis or a change in body form from tadpole to adult (**Figure 5**). Thyroid hormones also contribute to seasonal moulting, leading to changes in the plumage of birds and the coat colour of mammals.

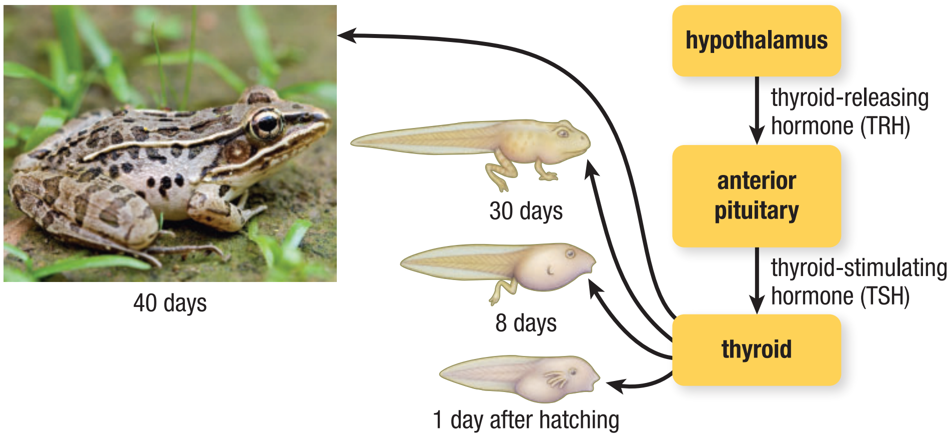

Figure 5 Metamorphosis of a tadpole into an adult frog is controlled by the thyroid hormones.

In mammals, the thyroid also has specialized cells that secrete calcitonin, a protein hormone. Calcitonin was originally discovered in fish by Dr. Harold Copp, a professor at the University of British Columbia. This hormone lowers the level of Ca^{2+} in the blood by inhibiting the ongoing release of calcium from bones. Calcitonin secretion is stimulated when the Ca^{2+} level in the blood rises above the normal range. It is inhibited when the Ca^{2+} level falls below the normal range. Although the specialized cells of the thyroid are the principal source, calcitonin is also synthesized in the lungs and intestines.

The parathyroid glands are found only in amphibians, reptiles, birds, and mammals. Mammals have four parathyroid glands, two on each side of the posterior surface of the thyroid gland. Each parathyroid is a spherical structure about the size of a pea. The single hormone they produce, called **parathyroid hormone** (PTH), is secreted in response to a fall in the Ca^{2+} level in the blood (**Figure 6**). The PTH pathway is a negative feedback loop. PTH stimulates bone cells to dissolve the mineral matter of bone tissues, releasing both calcium and phosphate ions into the blood. The released Ca^{2+} is available for enzyme activation, conduction of nerve signals across synapses, muscle contraction, blood clotting, and other uses.

parathyroid hormone a hormone secreted by the parathyroid glands that controls calcium and phosphate levels in the blood

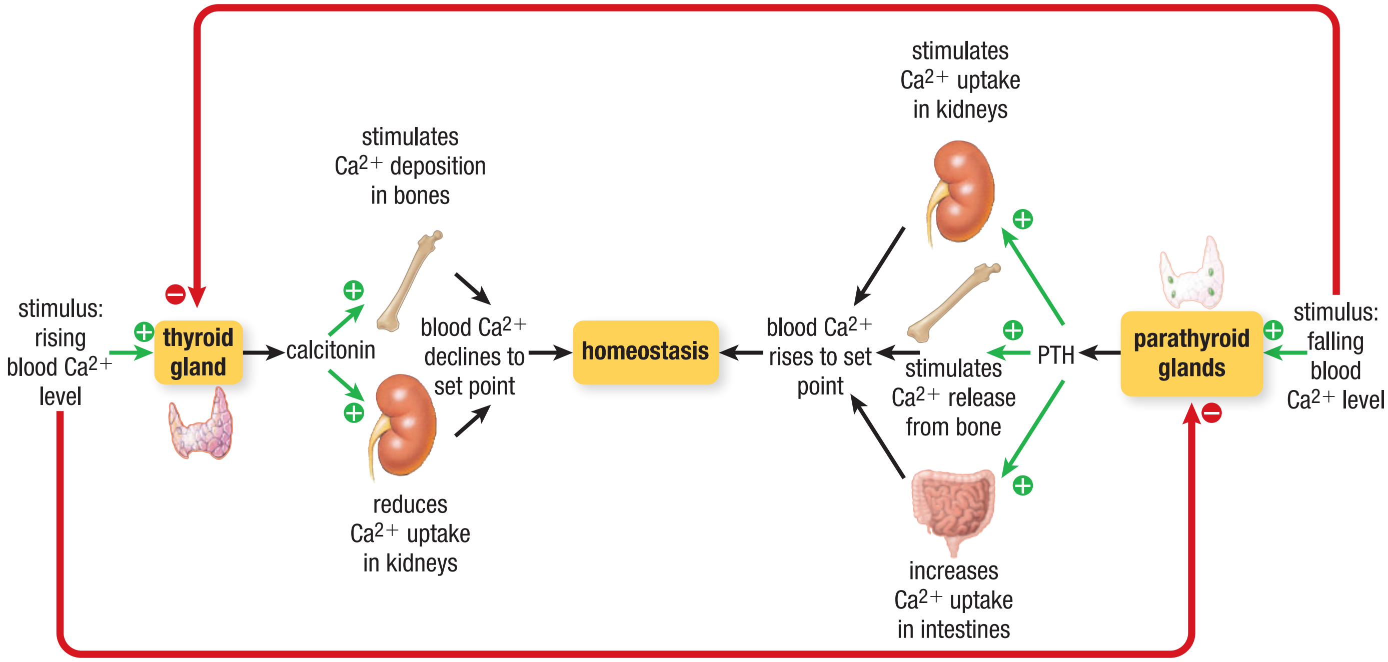

Figure 6 The negative feedback control of parathyroid hormone (PTH) and calcitonin by the Ca^{2+} level in the blood

PTH also stimulates enzymes in the kidneys to convert vitamin D, a steroid-like molecule, into calcitriol, its fully active form in the body. The activated vitamin D increases the absorption of Ca^{2+} and phosphates from ingested food by promoting the synthesis of a calcium-binding protein in the intestines. It also increases the release of Ca^{2+} from bones in response to PTH.

PTH underproduction causes the Ca^{2+} concentration in the blood to fall steadily, disturbing nerve and muscle function. As a result, the muscles twitch and contract uncontrollably, and convulsions and cramps occur. Without treatment, the condition is usually fatal because the severe muscular contractions interfere with breathing. Overproduction of PTH results in the loss of so much calcium from the bones that they become thin and fragile. This condition is known as osteoporosis. At the same time, the elevated Ca^{2+} concentration in the blood causes calcium deposits to form in soft tissues, especially in the lungs, arteries, and kidneys (where the deposits form kidney stones).

Although fish do not have a parathyroid gland, they produce PTH and have PTH receptors. However, the origin of the hormone and its precise function remain uncertain.

Adrenal Hormones

The adrenal glands of mammals (from *ad* meaning "next to" or "near" and *renes* meaning "kidneys") have two distinct regions. The central region, the adrenal medulla, contains highly modified neurosecretory neurons. The tissue surrounding the adrenal medulla, the adrenal cortex, contains non-neural endocrine cells. The two regions secrete hormones with entirely different functions.

The adrenal medulla secretes two adrenal hormones, epinephrine and norepinephrine, which are chemicals that can act as hormones or neurotransmitters (chemicals that transmit nerve signals). They bind to receptors in the plasma membrane of their target cells. Norepinephrine is also released as a neurotransmitter by some neurons of the nervous system. The adrenal cortex secretes several hormones, including aldosterone and cortisol. Aldosterone, the main hormone of the group of mineralocorticoids, is involved in osmoregulation and control of blood pressure. Cortisol is the main hormone of a group of glucocorticoid hormones that help to regulate blood glucose levels and promote the breakdown of fats and proteins as alternative fuels when the glucose supply is low.

Epinephrine and norepinephrine are secreted when the body encounters stresses such as emotional excitement, danger (fight-or-flight situations), anger, fear, infection, injury, and even anxiety about midterm and final exams. Epinephrine, in particular, prepares the body for handling stress or physical activity. It causes the heart rate to increase and glycogen and fats to break down, releasing glucose and fatty acids into the blood as fuel molecules. In the heart, skeletal muscles, and lungs, the blood vessels dilate to increase blood flow. Elsewhere in the body, the blood vessels constrict. This raises blood pressure, reduces blood flow to the intestines and kidneys, and inhibits smooth muscle contractions, thus reducing water loss and slowing down the digestive system. At the same time, airways in the lungs dilate, helping to increase the flow of air. The effects of norepinephrine on heart rate, blood pressure, and blood flow to the heart muscle are similar to those of epinephrine.

The effects of epinephrine are what make it a life-saving drug for someone who is experiencing a severe allergic reaction called anaphylaxis. A person who has an extreme allergy—to nuts, insect venom, or any of a large group of allergens—can go into shock and die from an anaphylactic reaction. Epinephrine is the drug of choice to counter anaphylaxis. Its effects are immediate, opening airways and raising blood pressure. People with severe allergies often carry a pen-shaped epinephrine auto-injector that they can use in an emergency.

Pineal Gland

pineal gland an endocrine gland located in or on the brain of vertebrates that secretes the hormone melatonin to regulate biological rhythms

The **pineal gland** regulates several biological rhythms. It is found at different locations in the brain of vertebrates. In mammals, it is near the centre of the brain. In birds and reptiles, it is on the surface of the brain, just under the skull, and is directly sensitive to light. Some of the earliest vertebrates had a light-sensitive organ at the top of the head (called a third eye), and some lizards retain an eyelike structure in this location. In most vertebrates, the third eye became modified into a pineal gland, which may retain some degree of photosensitivity. In mammals, it is too deeply buried in the brain to be affected directly by light. Nonetheless, specialized photoreceptors in the eyes make connections to the pineal gland.

The pineal gland secretes the neurohormone melatonin, which helps to maintain daily biorhythms. The secretion of melatonin is regulated by an inhibitory pathway. When light hits the eyes, it generates signals that inhibit melatonin secretion. As a result, melatonin is secreted most actively during periods of darkness. Melatonin targets a part of the hypothalamus that coordinates body activity to a daily cycle. The nightly release of melatonin may help to synchronize the biological clock with daily cycles of light and darkness. The physical and mental discomfort associated with jet lag may reflect the time that is required for melatonin secretion to reset a traveller's daily biological clock to match the period of daylight in a new time zone. Melatonin is found in organisms throughout the animal kingdom, as well as in many plants and fungi. In invertebrates, it helps control diurnal (daily) rhythms.

Table 3 lists the hormones of the adrenal and pineal glands.

Table 3 Adrenal and Other Hormones

Endocrine gland	Hormone produced	Target tissue	Function
adrenal medulla	epinephrine and norepinephrine throughout the body	receptor sites throughout the body	contribute to the body's responses to stress
adrenal cortex	aldosterone (mineralocorticoid)	kidney tubules	helps to control the salt–water balance in the body by increasing Na^+ reabsorption and K^+ excretion in the kidneys
	cortisol (glucocorticoid)	most body cells, particularly muscle, liver, and adipose cells	increases the blood glucose level by promoting breakdown of proteins and fats
pineal gland	melatonin	brain, anterior pituitary gland, reproductive organs, immune system, and possibly others	helps to synchronize the body's biological clock with day length; may inhibit gonadotropins and the initiation of puberty

Overview of the Invertebrate Endocrine System

Among the best-known invertebrate hormonal systems is the system that governs the growth and development of insects (**Figure 7**). As insects grow, they undergo a series of moults. A new exoskeleton—the hard body covering—is laid down beneath the old exoskeleton, which is then shed. The signal to begin the process is provided by a steroid hormone called ecdysone. The glands that secrete ecdysone respond to a neurohormone produced in the brain.

Juvenile hormone controls the metamorphosis of an insect. When it is present, the insect remains larval. If juvenile hormone is absent, the next moult is metamorphic, producing a pupa and then an adult in some insects, or proceeding directly to the adult in insects lacking a pupal stage. The adult of most insects secretes juvenile hormone and stimulates a number of reproductive processes, especially egg development. The secretion of juvenile hormone is controlled by both inhibitory and stimulatory protein hormones from the brain.

Hormones that control moulting have also been detected in crustaceans, such as lobsters, crabs, and crayfish. During the period between moults, a moult-inhibiting hormone inhibits ecdysone secretion. Therefore, the first step in the moulting process involves inhibiting the secretion of this moult-inhibiting hormone. Ecdysone secretion increases, and the processes leading to the replacement of the exoskeleton are initiated. As in insects, metamorphosis and reproduction are governed by a hormone that is different from, but structurally related to, juvenile hormone.

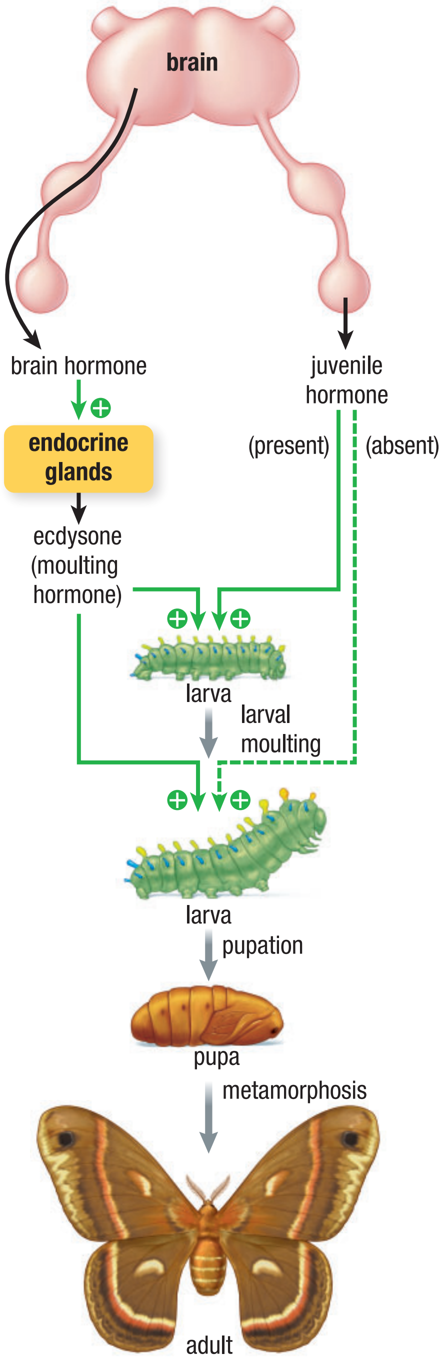

Figure 7 The life cycle of a silkworm moth is controlled by a brain hormone called ecdysone, as well as juvenile hormone.

10.2 Review

Summary

- The endocrine system of glands and the hormones that they produce regulate bodily processes, maintain homeostasis, and control growth, development, and reproduction.
- The hypothalamus and pituitary gland control other endocrine cells and glands throughout the body. The hypothalamus responds to messages from the brain or nerve receptors by releasing hormones. These hormones control the pituitary gland's secretion of other hormones, which regulate the rest of the endocrine system.
- The thyroid gland secretes hormones that control the metabolism of the body and regulate growth and development. The parathyroid glands regulate the concentration of calcium ions in the blood.
- The adrenal glands release epinephrine and norepinephrine, which control the body's response to stress. The adrenal cortex produces glucocorticoid hormones, which help to regulate the blood glucose level.
- The pineal gland helps to regulate biological rhythms by producing the hormone melatonin.
- Many of the hormones found in vertebrates are also found in invertebrates, although their functions may differ. Hormones in invertebrates control metamorphosis, moulting, and reproduction.

Questions

1. Which hormones are primarily responsible for regulating the metabolism of the body? K/U
2. Which hormones help the body respond to stress? K/U
3. How does the function of the posterior pituitary gland differ from the function of the anterior pituitary gland? K/U
4. In both Grade 10 Science and Grade 11 Biology, you learned about the interdependence of body systems. Prepare a brief presentation for Grade 10 or Grade 11 students to help them understand how the endocrine system is linked to and controlled by the nervous system. K/U T/I C
5. Suppose that the thyroid gland had to be removed due to cancer. How would the body be affected, and what treatments do you think would be necessary? T/I
6. What hormones from the anterior pituitary gland are important for reproduction, and what are their functions? K/U
7. Why do alcoholic drinks and coffee increase urination? K/U
8. Why is epinephrine therapeutic for anaphylaxis? Under what conditions might taking epinephrine be dangerous? K/U
9. Which endocrine gland may have been sensitive to light in early vertebrates? How does it respond to light in modern animals? K/U
10. What harmful effect would a complete lack of ecdysone have on a growing invertebrate, such as an insect? T/I
11. How do the releasing hormones of the hypothalamus connect the nervous and endocrine systems? K/U
12. The thyroid gland's production of thyroid hormones (T_3 and T_4) is triggered by thyroid-stimulating hormone (TSH), which is made by the pituitary gland. K/U T/I
    (a) Predict how your body might be affected if the pituitary gland produced too much TSH.
    (b) Predict how it might be affected if the pituitary gland produced too little TSH.
13. In mammals, the pineal gland is located deep in the brain. How can this gland be light-sensitive? K/U