C. Organization of the Brain

Divisions of the Nervous System

How many nervous systems?

Because you have one brain, you may think that means you have one nervous system. In fact, your brain is much more complex: It has two major nervous systems, one of which has four subdivisions. We'll explain the overall organization of the brain's several nervous systems, beginning with its two major divisions, the central and peripheral nervous systems.

A. Major Divisions of the Nervous System

Central Nervous System—CNS

You are capable of many complex cognitive functions—such as thinking, speaking, and reading, as well as moving, feeling, seeing, and hearing—because of your central nervous system.

The *central nervous system* is made up of the brain and spinal cord. From the bottom of the brain emerges the spinal cord, which is made up of neurons and bundles of axons and dendrites that carry information back and forth between the brain and the body.

We'll discuss the major parts of the brain throughout this module.

Peripheral Nervous System—PNS

You are able to move your muscles, receive sensations from your body, and perform many other bodily responses because of the peripheral nervous system.

The *peripheral nervous system* includes all the nerves that extend from the spinal cord and carry messages to and from various muscles, glands, and sense organs located throughout the body.

The peripheral nervous system has two subdivisions, the somatic and autonomic nervous systems.

B. Subdivisions of the PNS

Somatic Nervous System

The *somatic nervous system* consists of a network of nerves that connect either to sensory receptors or to muscles that you can move voluntarily, such as muscles in your limbs, back, neck, and chest. Nerves in the somatic nervous system usually contain two kinds of fibers. Afferent, or sensory, fibers carry information from sensory receptors in the skin, muscles, and other organs to the spinal cord and brain. Efferent, or motor, fibers carry information from the brain and spinal cord to the muscles.

For example, this gymnast controls her muscles, knows where her arms and legs are located in space, and maintains her coordination and balance because the somatic nervous system sends electrical signals back and forth to her brain.

ANS—Autonomic Nervous System

The *autonomic nervous system* regulates heart rate, breathing, blood pressure, digestion, hormone secretion, and other functions. The autonomic nervous system usually functions without conscious effort, which means that only a few of its responses, such as breathing, can also be controlled voluntarily.

The autonomic nervous system also has two subdivisions, the sympathetic and parasympathetic divisions.

C. Subdivisions of the ANS

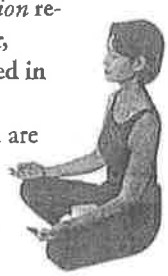
Sympathetic Division

The *sympathetic division*, which is triggered by threatening or challenging physical or psychological stimuli, increases physiological arousal and prepares the body for action.

For example, the sight of a frightening snake would trigger the sympathetic division, which, in turn, would arouse the body for action, such as fighting or fleeing.

Parasympathetic Division

The *parasympathetic division* returns the body to a calmer, relaxed state and is involved in digestion.



For example, when you are feeling calm and relaxed or digesting food, your parasympathetic system is activated.

Now that you know the overall organization of the nervous system, we'll focus on major parts of the brain.

Autonomic Nervous System

Why don't you worry about breathing?

You are unaware of what regulates your breathing, heart rate, hormone secretions, or body temperature. You're not concerned about these vital functions because they are usually controlled by a separate nervous system, called the autonomic nervous system, which, in turn, is regulated by a master control center, the hypothalamus (discussed on the preceding page).

The autonomic nervous system, which regulates numerous physiological responses, has two divisions, the sympathetic and parasympathetic nervous systems. The sympathetic division is activated when you suddenly see a snake; then the parasympathetic division helps you relax (Faller et al., 2004). We'll explain some of the specific and automatic functions of the sympathetic and parasympathetic divisions.

Sympathetic Nervous System

If you were on a nature hike and suddenly saw a snake, your cortex would activate the hypothalamus, which in turn triggers the sympathetic division of the autonomic nervous system (S. Johnson, 2003).

The *sympathetic division*, which is one part of the autonomic nervous system, is triggered by threatening or challenging physical stimuli, such as a snake, or by psychological stimuli, such as the thought of having to give a public speech. Once triggered, the sympathetic division increases the body's physiological arousal.

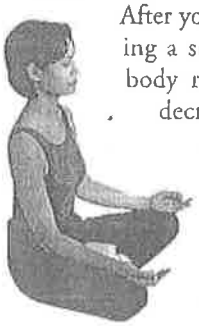
All of the physiological responses listed in the left-hand column under *Sympathetic*, such as increased heart rate, inhibited digestion, and dilated pupils, put your body into a state of heightened physiological arousal, which is called the fight-flight response.

The *fight-flight response*, which is a state of increased physiological arousal caused by activation of the sympathetic division, helps the body cope with and survive threatening situations.

You have no doubt experienced the fight-flight response many times, such as when you felt your heart pound and your mouth go dry. Later, we'll discuss the role of the fight-flight response in stressful situations and its role in psychosomatic diseases (pp. 484–489).

Sympathetic		Parasympathetic
Pupils dilated, dry; far vision	*Eyes*	Pupils constricted, moist; near vision
Dry	*Mouth*	Salivation
Goose bumps	*Skin*	No goose bumps
Sweaty	*Palms*	Dry
Passages dilated	*Lungs*	Passages constricted
Increased rate	*Heart*	Decreased rate
Supply maximum to muscles	*Blood*	Supply maximum to internal organs
Increased activity	*Adrenal glands*	Decreased activity
Inhibited	*Digestion*	Stimulated
Climax	*Sexual functions*	Arousal

Parasympathetic Nervous System



After you have been physiologically aroused by seeing a snake, it is usually some time before your body returns to a calmer state. The process of decreasing physiological arousal and calming down your body is triggered by the hypothalamus, which activates the parasympathetic division.

The *parasympathetic division*, which is the other part of the autonomic nervous system, decreases physiological arousal and helps return the body to a calmer, more relaxed state. It also stimulates digestion during eating.

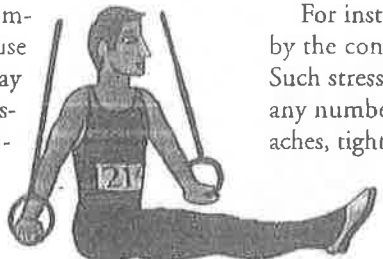
As shown in the right column under the heading *Parasympathetic*, the parasympathetic division, once activated, decreases physiological arousal by decreasing heart rate, stimulating digestion, and constricting pupils. These responses result in the body returning to a more relaxed state.

In dealing with stress, we'll discuss many relaxation techniques (pp. 502–503), such as the relaxation response, various forms of meditation, and biofeedback, which help increase parasympathetic activity, decrease body arousal, and thus help you calm down after stressful experiences.

Homeostasis

One problem that some students face is becoming too stressed or upset by life's events. Because it is potentially harmful to your body to stay stressed or aroused, the autonomic nervous system tries to keep the body's arousal at an optimum level, a state called homeostasis.

Homeostasis (ho-me-oh-STAY-sis) **means that the sympathetic and parasympathetic systems work together to keep the body's level of arousal in balance for optimum functioning.**



Homeostasis—physiological arousal kept in balance

For instance, your body's balance, or homeostasis, may be upset by the continuous stress of final exams or a difficult relationship. Such stress usually results in continuous physiological arousal and any number of physical problems, including headaches, stomachaches, tight muscles, or fatigue. These physical symptoms, which are called psychosomatic problems, may result in real pain. We'll discuss these problems in Module 21: Health, Stress & Coping (pp. 480–507).

Besides triggering your autonomic nervous system, the hypothalamus is also involved in regulating a complex hormonal system, which we'll examine next.

F. Endocrine System

Definition

What is your chemical system?

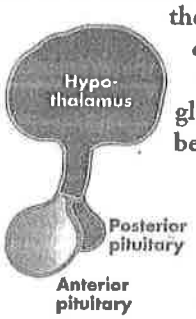
You have two major systems for sending signals to the body's muscles, glands, and organs. We have already discussed the nervous system, which uses neurons, nerves, and neurotransmitters to send information throughout the body. The second major system for sending information is called the endocrine system.

The *endocrine system* is made up of numerous glands that are located throughout the body. These glands secrete various chemicals, called *hormones*, which affect organs, muscles, and other glands in the body.

The location and function of some of the endocrine system's glands are shown in the figure below.

Control Center

In many ways, the *hypothalamus*, which is located in the lower middle part of the brain, controls much of the endocrine system by regulating the pituitary gland, which is located directly below and outside the brain. The hypothalamus is often called the control center of the endocrine system.



The drawing on the left shows that the hypothalamus is connected to the pituitary gland.

Other Glands

We'll describe some of the endocrine system's major glands as well as their dysfunctions.

The *pituitary gland*, a key component of the endocrine system, hangs directly below the hypothalamus, to which it is connected by a narrow stalk. The pituitary gland is divided into anterior (front) and posterior (back) sections.

Posterior pituitary. **The rear portion of the pituitary regulates water and salt balance.**

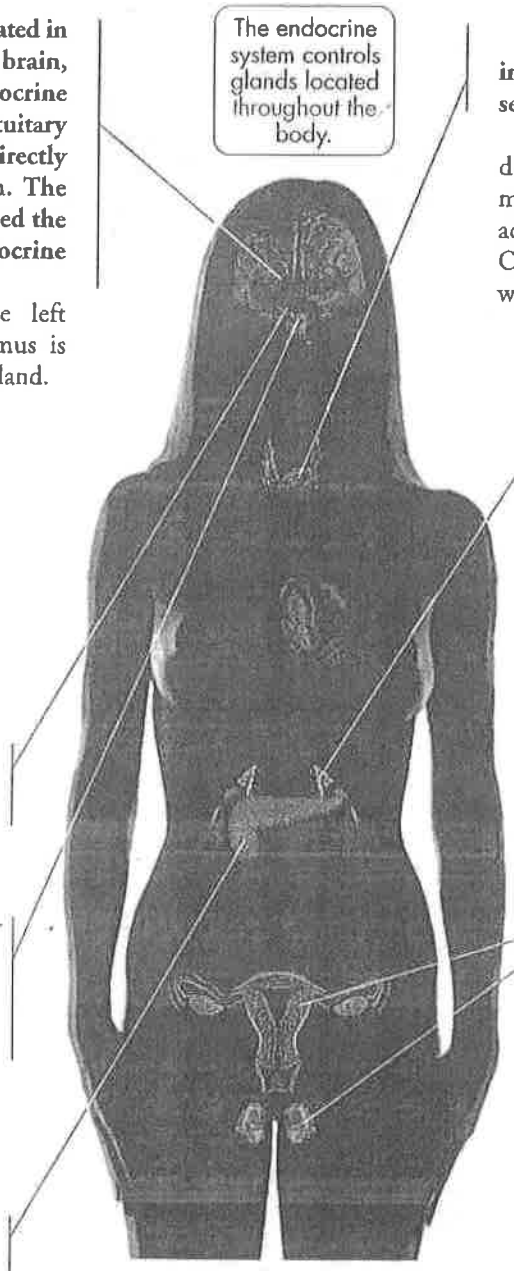
Dysfunction: Lack of hormones causes a less common form of diabetes.

Anterior pituitary. **The front part of the pituitary regulates growth through secretion of growth hormone and produces hormones that control the adrenal cortex, pancreas, thyroid, and gonads.**

Dysfunction: Too little growth hormone produces dwarfism; too much causes gigantism. Other problems in the pituitary cause problems in the glands it regulates.

Pancreas. **This organ regulates the level of sugar in the bloodstream by secreting insulin.**

Dysfunction: Lack of insulin results in the more common form of diabetes, while too much causes hypoglycemia (low blood sugar).



Thyroid. **This gland, which is located in the neck, regulates metabolism through secretion of hormones.**

Dysfunction: Hormone deficiency during development leads to stunted growth and mental retardation. Undersecretion during adulthood leads to reduction in motivation. Oversecretion results in high metabolism, weight loss, and nervousness.

Adrenal glands. **The adrenal cortex (outside part) secretes hormones that regulate sugar and salt balances and help the body resist stress; they are also responsible for growth of pubic hair, a secondary sexual characteristic. The adrenal medulla (inside part) secretes two hormones that arouse the body to deal with stress and emergencies: epinephrine (adrenaline) and norepinephrine (noradrenaline).**

Dysfunction: With a lack of cortical hormones, the body's responses are unable to cope with stress.

Gonads. **In females, the ovaries produce hormones that regulate sexual development, ovulation, and growth of sex organs. In males, the testes produce hormones that regulate sexual development, production of sperm, and growth of sex organs.**

Dysfunction: Lack of sex hormones during puberty results in lack of secondary sexual characteristics (facial and body hair, muscles in males, breasts in females).

Up to this point, we have examined many of the structures and functions that make up the incredible nervous and endocrine systems. After the Concept Review, we'll discuss a question that students often ask: Do the brains of males differ from those of females?