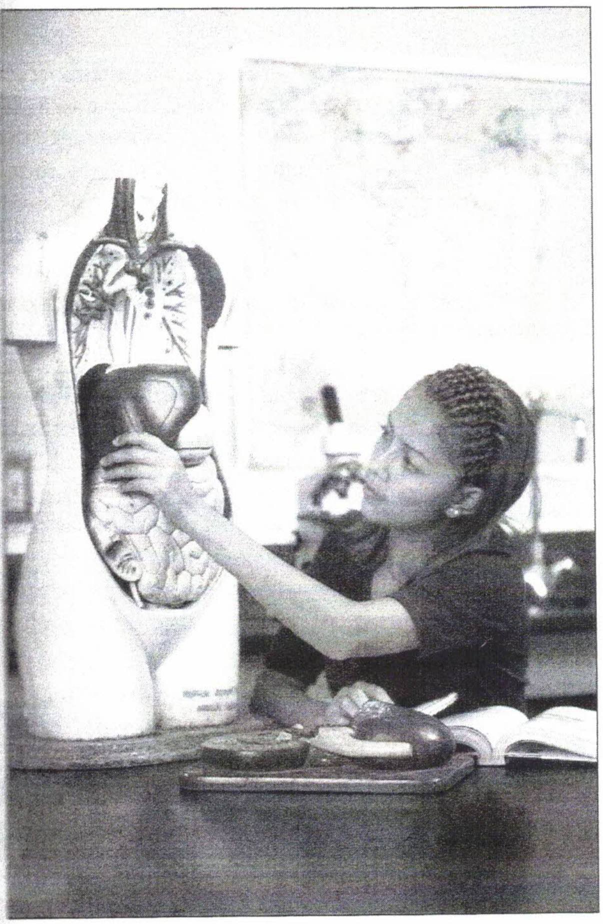
Taylor Readings

Classes 2 & 3

Physio Systems

CHAPTER 2

The Systems of the Body



CHAPTER OUTLINE

An understanding of health requires a working knowledge of human physiology. This knowledge makes it possible to understand such issues as how good health habits make illness less likely, how stress affects bodily functioning, how repeated stress can lead to hypertension or coronary artery disease, and how cell growth is radically altered by cancer.

Physiology is the study of the body's functioning. The body is made up of many millions of cells that grouped together form tissues, which form organs whose functions overlap to produce the body's systems. In this chapter, we provide a brief overview of the major systems of the body, the ways in which each system functions normally, and some of the disorders to which the system may be vulnerable.

THE NERVOUS SYSTEM

Overview

The **nervous system** is a complex network of interconnected nerve fibers. Sensory nerve fibers provide input to the brain and spinal cord by carrying signals from sensory receptors; motor nerve fibers provide output from the brain or spinal cord to muscles and other organs, resulting in voluntary and involuntary movement. The nervous system is made up of the central nervous system, which consists of the brain and the spinal cord, and the peripheral nervous system, which consists of the rest of the nerves in the body, including those that connect to the brain and spinal cord.

The peripheral nervous system is, itself, made up of the somatic nervous system and the autonomic nervous system. The somatic, or voluntary, nervous system connects nerve fibers to voluntary muscles and provides the brain with feedback in the form of sensory information about voluntary movement. The autonomic, or involuntary, nervous system connects the central nervous system to all internal organs over which people do not customarily have control.

Regulation of the autonomic nervous system occurs via the sympathetic nervous system and the parasympathetic nervous system. As will be seen in Chapter 6, the **sympathetic nervous system** prepares the body to respond to emergencies, to strong emotions such as anger or fear, and to strenuous activity. As such, it plays an important role in reactions to stress. Because it is concerned with the mobilization and exertion of energy, it is called a catabolic system.

In contrast, the **parasympathetic nervous system** controls the activities of organs under normal circumstances and acts antagonistically to the sympathetic nervous system. When an emergency has passed, the parasympathetic nervous system helps to restore the body to a normal state. Because it is concerned with the conservation of body energy, it is called an anabolic system. The components of the nervous system are summarized in Figure 2.1. We now consider several of these components in greater detail.

FIGURE 2.1 | The Components of the Nervous System

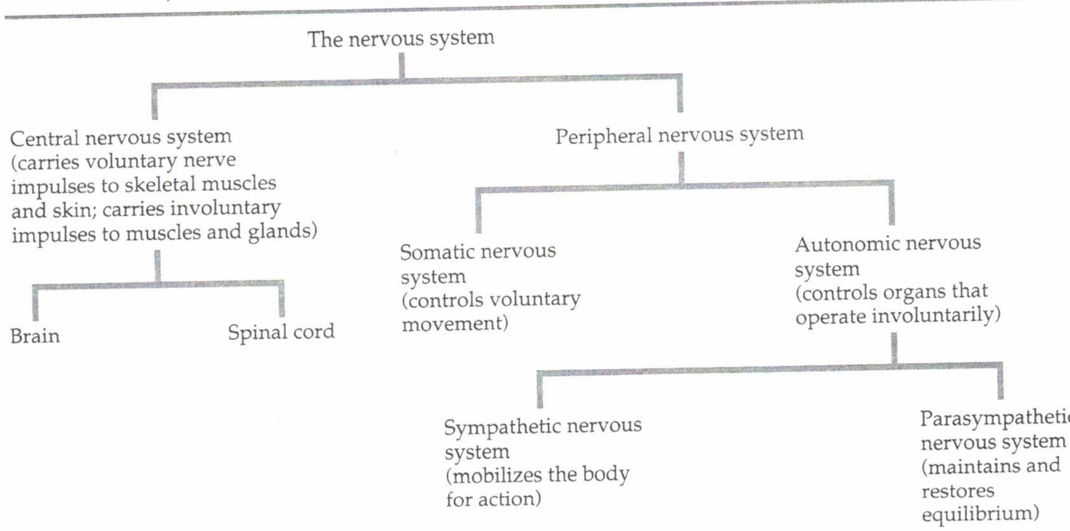
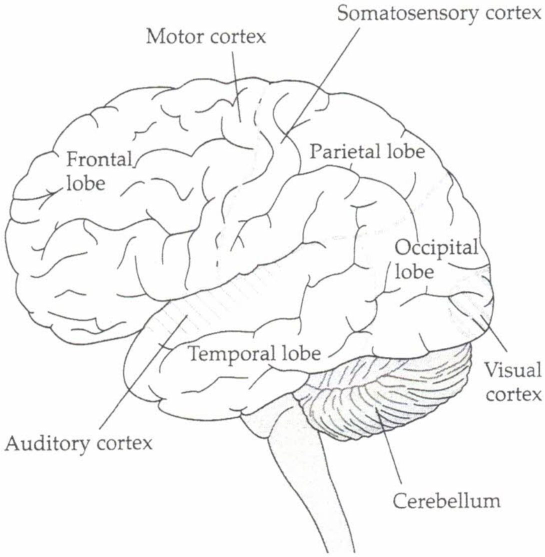
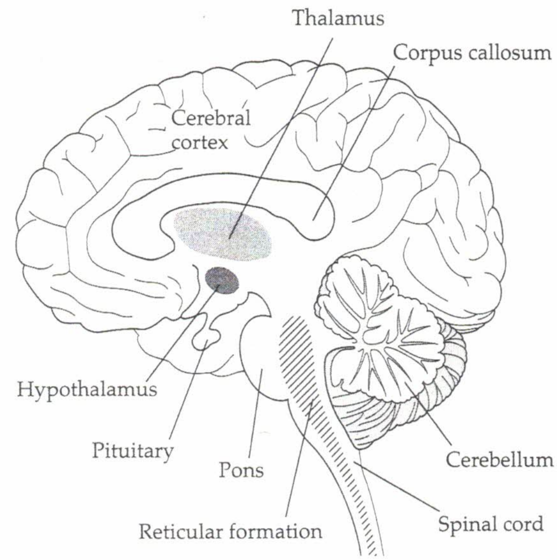


FIGURE 2.2 | The Brain



(a) Surface diagram



(b) Cross-sectional diagram

The Brain

The brain might best be thought of as the command center of the body. It receives afferent (sensory) impulses from the peripheral nerve endings and sends efferent (motor) impulses to the extremities and to internal organs to carry out necessary movement. The parts of the brain are shown in Figure 2.2.

The Hindbrain and the Midbrain

The hindbrain has three main parts: the medulla, the pons, and the cerebellum. The medulla, located just above the point where the spinal cord enters the skull, is heavily responsible for the regulation of heart rate, blood pressure, and respiration. The **medulla** receives information about the rate at which the heart is contracting and speeds up or slows down the heart rate as required. The medulla also receives sensory information about blood pressure and, based on this feedback, regulates constriction or dilation of the blood vessels. Sensory information about the levels of carbon dioxide and oxygen in the body also comes to the medulla, which, if necessary, sends motor impulses to respiratory muscles to alter the rate of breathing. The **pons** serves as a link between the hindbrain and the midbrain and also helps control respiration.

The **cerebellum** coordinates voluntary muscle movement, the maintenance of balance and equilibrium, and the maintenance of muscle tone and posture. Damage to this area makes it hard for a person to coordinate muscles; such damage can produce loss of muscle tone, tremors, and disturbances in posture or gait.

The midbrain is the major pathway for sensory and motor impulses moving between the forebrain and the hindbrain. It is also responsible for the coordination of visual and auditory reflexes.

The Forebrain

The forebrain has two main sections: the diencephalon and the telencephalon. The diencephalon is composed of the thalamus and the hypothalamus. The **thalamus** is involved in the recognition of sensory stimuli and the relay of sensory impulses to the cerebral cortex.

The **hypothalamus** helps regulate the centers in the medulla that control cardiac functioning, blood pressure, and respiration. It is also responsible for regulating water balance in the body and for regulating appetites, including hunger and sexual desire. It is an important transition center between the thoughts generated in the cerebral cortex of the brain and their impact on internal organs. Thus, for example, embarrassment can lead to blushing via the hypothalamus through the vasomotor center in the medulla to the blood vessels. Likewise, anxiety may result from secretion of hydrochloric acid in the stomach via signals from the hypothalamus. Together with the pituitary gland, the hypothalamus helps regulate the endocrine system, which releases hormones that affect functioning in target organs throughout the body.

The other portion of the forebrain, the telencephalon, is composed of the two hemispheres (left and right) of the cerebral cortex. The **cerebral cortex** is the largest portion of the brain and is involved in higher-order intelligence, memory, and personality. The sensory impulses that come from the peripheral areas of the body, up the spinal cord, and through the hindbrain and midbrain are received and interpreted in the cerebral cortex. Motor impulses, in turn, pass down from the cortex to the lower portions of the brain and from there to other parts of the body.

The cerebral cortex consists of four lobes: frontal, parietal, temporal, and occipital. Each lobe has its own memory storage area or areas of association. Through these complex networks of associations, the brain is able to relate current sensations to past ones, giving the cerebral cortex its formidable interpretive capabilities.

In addition to its role in associative memory, each lobe is generally associated with particular functions. The frontal lobe contains the motor cortex, which coordinates voluntary movement. The left part of the motor cortex controls activities of the voluntary muscles on the right side of the body, while the right part of the motor cortex controls voluntary activities on the left side of the body. The parietal lobe contains the somatosensory cortex, in which sensations of touch, pain, temperature, and pressure are registered and interpreted. The temporal lobe contains the cortical areas responsible for auditory and olfactory (smell) impulses, and the occipital lobe contains the visual cortex, which receives visual impulses. Finally, the basal ganglia—four round masses embedded deep in the cerebrum (the main portion of the brain)—help make muscle contractions orderly, smooth, and purposeful.

The Limbic System

The structures of the limbic system, which border the midline of the brain, play an important role in stress and emotional responses. The amygdala and the hippocampus are involved in the detection of threat and in emotionally charged memories, respectively. The cingulate gyrus, the septum, and areas in the hypothalamus are related to emotional functioning as well. The anterior portion of the thalamus and some nuclei within the hypothalamus are important for socially relevant behaviors.

The Role of Neurotransmitters

The nervous system functions by means of chemicals, called **neurotransmitters,** that regulate nervous system functioning. Stimulation of the sympathetic nervous system prompts the secretion of large quantities of two neurotransmitters, epinephrine and norepinephrine, together termed the **catecholamines.** These substances enter the bloodstream and are carried throughout the body promoting the activity of sympathetic stimulation.

The release of catecholamines prompts a variety of important bodily changes. Heart rate increases, the heart's capillaries dilate, and blood vessels constrict, increasing blood pressure. Blood is diverted into muscle tissue. Respiration rate goes up, and the amount of air flowing into the lungs is increased. Digestion and urination are generally decreased. The pupils of the eyes dilate, and sweat glands are stimulated to produce more sweat. These changes are familiar to anyone who has experienced a highly stressful event or a strong emotion, such as fear or embarrassment. As we will see in Chapter 6, engagement of the sympathetic nervous system and the production and release of catecholamines are critically important in responses to stressful circumstances. Repeated arousal of the sympathetic nervous system may have implications for the development of several chronic disorders, such as coronary artery disease and hypertension, which will be discussed in greater detail in Chapter 13.

Parasympathetic functioning is a counterregulatory system that helps restore homeostasis following sympathetic arousal. The heart rate decreases, the heart's capillaries constrict, blood vessels dilate, respiration rate decreases, and the metabolic system resumes its activities.

Disorders of the Nervous System

Approximately 25 million Americans have some disorder of the nervous system, which accounts for 20% of hospitalizations each year and 12% of deaths. The most common forms of neurological dysfunction are epilepsy and Parkinson's disease. Cerebral palsy, multiple sclerosis, and Huntington's disease also affect substantial numbers of people.

Epilepsy

A disease of the central nervous system affecting more than 3 million people in the United States (Epilepsy Foundation, 2007), epilepsy is often idiopathic, which means that no specific cause for the symptoms can be identified. Symptomatic epilepsy may be traced to injury during birth, severe injury to the head, infectious disease such as meningitis or encephalitis, or metabolic or nutritional disorders. Risk for epilepsy may also be inherited.

Epilepsy is marked by seizures, which range from barely noticeable staring or purposeless motor movements (such as chewing and lip smacking) to violent convulsions accompanied by irregular breathing, drooling, and loss of consciousness. Epilepsy cannot be cured, but it can often be controlled through medication and behavioral interventions designed to manage stress (see Chapters 7 and 11).

Cerebral Palsy Currently, more than 500,000 people in the United States have cerebral palsy (United Cerebral Palsy of Greater Birmingham, 2007). Cerebral palsy is a chronic, nonprogressive disorder marked by lack of muscle control. It stems from brain damage caused by an interruption in the brain's oxygen supply, usually during childbirth. In older children, a severe accident or physical abuse can produce the condition. Apart from being unable to control motor functions, sufferers may (but need not) also have seizures, spasms, mental retardation, difficulties of sensation and perception, and problems with sight, hearing, and/or speech.

Parkinson's Disease Patients with Parkinson's disease suffer from progressive degeneration of the basal ganglia, the group of nuclei that controls smooth motor coordination. The result of this deterioration is tremors, rigidity, and slowness of movement. As many as one million Americans suffer from Parkinson's disease, which primarily strikes people age 50 and older (Dawson & Dawson, 2003; Parkinson's Disease Foundation, 2007); men are more likely than women to develop the disease. Although the cause of Parkinson's is not fully known, depletion of the neurotransmitter dopamine may be involved.

Parkinson's patients may be treated with medication, but massive doses, which can cause undesirable side effects, are often required for control of the symptoms. More recently, a technique for making cells within the substantia nigra regenerate has been developed that makes use of a pump implanted in a patient's chest. A brain protein that may restore damaged neurons is pumped through the catheter under the skin and into the substantia nigra of the basal ganglia. Recent trials suggest some success with this method (Arnst & Weintraub, 2002).

Multiple Sclerosis Approximately 400,000 Americans have multiple sclerosis, and every week about 200 more people are diagnosed (National Multiple Sclerosis Society, 2005). This degenerative disease of certain brain tissues can cause paralysis and, occasionally, blindness, deafness, and mental deterioration. Early symptoms include numbness, double vision, dragging of the feet, loss of bladder or bowel control, speech difficulties, and extreme fatigue. Symptoms may appear and disappear over a period of years; after that, deterioration is continuous.

The effects of multiple sclerosis result from the disintegration of myelin, a fatty membrane that surrounds the nerve fibers and facilitates the conduction of nerve impulses. Multiple sclerosis is an autoimmune disorder, so-called because the immune system fails to recognize its own tissue and attacks the myelin sheath surrounding the nerves.

Huntington's Disease A hereditary disorder of the central nervous system, Huntington's disease is characterized by chronic physical and mental deterioration. Symptoms include involuntary muscle spasms, loss of motor abilities, personality changes, and other signs of mental disintegration. Because some of the symptoms are similar to those of epilepsy, Huntington's disease is sometimes mistaken for epilepsy.

The disease affects men and women alike, occurring at a rate of about 1 in every 10,000 (Huntington's Disease Society of America, 2007). The gene for Huntington's has been isolated, and a test is now available that indicates not only if one is a carrier of the gene but also at what age (roughly) one will succumb to the disease (Morell, 1993). As will be seen later in this chapter, genetic counseling with this group of at-risk individuals is important.

Polio Poliomyelitis is a viral disease that attacks the spinal nerves and destroys the cell bodies of motor neurons so that motor impulses cannot be carried from the spinal cord outward to the peripheral nerves or muscles. Depending on the degree of damage that is done, the individual may be left with difficulties of walking and moving properly, ranging from shrunken and ineffective limbs to full paralysis. Once a scourge of childhood, polio is now on the verge of being conquered, although sufferers often experience complications late in life from polio contracted years earlier (called postpolio syndrome).

Paraplegia and Quadriplegia Paraplegia is paralysis of the lower extremities of the body; it results from an injury to the lower portion of the spinal cord.

Quadriplegia is paralysis of all four extremities and the trunk of the body; it occurs when the upper portion of the spinal cord is severed. Once the spinal cord has been severed, no motor impulses can descend to tissues below the cut, nor can sensory impulses from the tissues below the cut ascend to the brain. As a consequence, a person usually loses bladder and bowel control. Moreover, the muscles below the cut area may well lose their tone, becoming weak and flaccid.

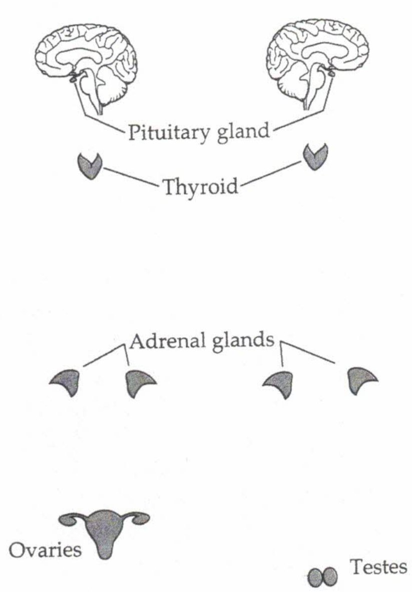
THE ENDOCRINE SYSTEM

Overview

The **endocrine system,** diagrammed in Figure 2.3, complements the nervous system in controlling bodily activities. The endocrine system is made up of a number of ductless glands, which secrete hormones into the blood, stimulating changes in target organs. The endocrine and nervous systems depend on each other, stimulating and inhibiting each other's activities. The nervous system is chiefly responsible for fast-acting, short-duration responses to changes in the body, whereas the endocrine system mainly governs slow-acting responses of long duration.

FIGURE 2.3 | The Endocrine System

(*Source:* Lankford, 1979, p. 232)



The endocrine system is regulated by the hypothalamus and the **pituitary gland.** Located at the base of the brain, the pituitary has two lobes. The posterior pituitary lobe produces oxytocin, which controls contractions during labor and lactation and may be involved in social affiliation, and vasopressin, or antidiuretic hormone (ADH), which controls the water-absorbing ability of the kidneys, among other functions. The anterior pituitary lobe of the pituitary gland secretes hormones responsible for growth: somatotropic hormone (STH), which regulates bone, muscle, and other organ development; gonadotropic hormones, which control the growth, development, and secretion of the gonads (testes and ovaries); thyrotropic hormone (TSH), which controls the growth, development, and secretion of the thyroid gland; and adrenocorticotropic hormone (ACTH), which controls the growth and secretions of the cortex region of the adrenal glands.

The Adrenal Glands

The **adrenal glands** are small glands located on top of each of the kidneys. Each adrenal gland consists of an adrenal medulla and an adrenal cortex. The hormones of the adrenal medulla are epinephrine and norepinephrine, which were described earlier.

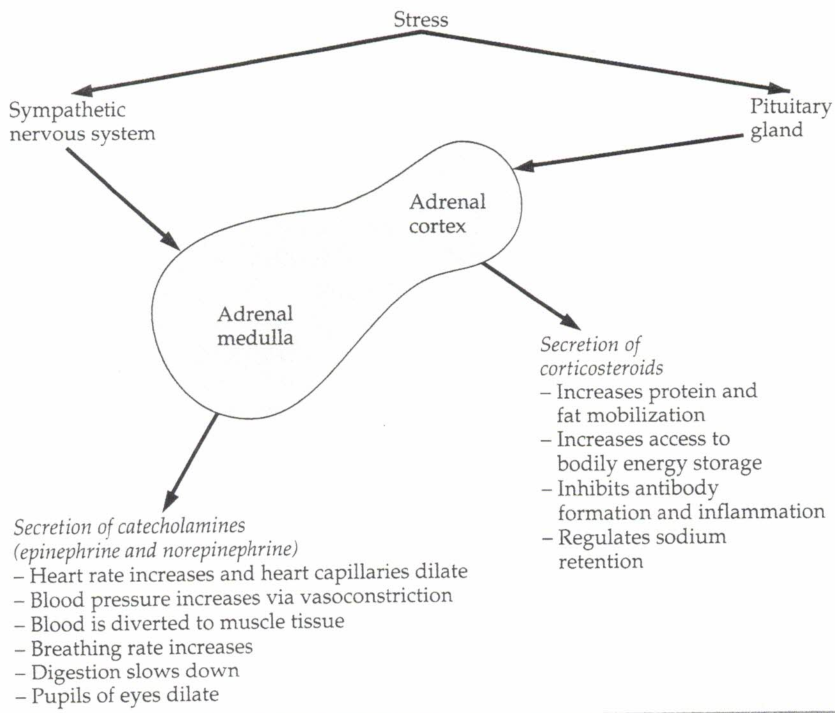
The adrenal cortex is stimulated by adrenocorticotropic hormone (ACTH) from the anterior lobe of the pituitary, and it releases hormones called steroids, which include mineralocorticoids, glucocorticoids, androgens, and estrogens.

As Figure 2.4 implies, the adrenal glands are critically involved in physiological and neuroendocrine reactions to stress. Both catecholamines, secreted in conjunction with sympathetic arousal, and corticosteroids are implicated in biological responses to stress. We will consider these stress responses more fully in Chapter 6.

Disorders Involving the Endocrine System

Diabetes Diabetes is a chronic endocrine disorder in which the body is not able to manufacture or properly use insulin. It is the third most common chronic illness in this country and one of the leading causes of death. Diabetes consists of two primary forms. Type I diabetes (sometimes called insulin-dependent diabetes) is a severe disorder that typically arises in late childhood or early adolescence. At least partly genetic in origin, Type I diabetes is believed to be an autoimmune disorder, possibly precipitated by an earlier viral infection.

FIGURE 2.4 | Adrenal Gland Activity in Response to Stress



The immune system falsely identifies cells in the islets of Langerhans in the pancreas as invaders and destroys those cells, compromising or eliminating their ability to produce insulin.

Type II diabetes, which typically occurs after age 40, is the more common form. In Type II diabetes, insulin may be produced by the body, but there may not be enough of it, or the body may not be sensitive to it. It is heavily a disease of lifestyle, involving a disturbance in glucose metabolism and the delicate balance between insulin production and insulin responsiveness. This balance appears to be dysregulated by such factors as obesity and stress, among others.

Diabetes is associated with a thickening of the arteries due to the buildup of wastes in the blood. As a consequence, diabetic patients show high rates of coronary heart disease. Diabetes is also the leading cause of blindness among adults, and it accounts for 50% of all the patients who require renal dialysis for kidney failure. Diabetes can also produce nervous system damage, leading to pain and loss of sensation. In severe cases, amputation of the extremities, such as toes and feet, is often required. As a consequence of these manifold complications, diabetics have a considerably shortened life expectancy. In Chapter 13, we will consider diabetes and the issues associated with its management more fully.

THE CARDIOVASCULAR SYSTEM

Overview

The **cardiovascular system** comprises the heart, blood vessels, and blood and acts as the transport system of the body. Blood carries oxygen from the lungs to the tissues and carbon dioxide, excreted as expired air, from the tissues to the lungs. Blood also carries nutrients from the digestive tract to the individual cells so that the cells may extract nutrients for growth and energy. The blood carries waste products from the cells to the kidneys, from which the waste is excreted in the urine. It also carries hormones from the endocrine glands to other organs of the body and transports heat to the surface of the skin to control body temperature.

The arteries carry blood from the heart to other organs and tissues, where oxygen and nutrients are transported through the arterioles (tiny branches of the arteries) and the capillaries (smaller vessels that branch off from the arteries) to individual cells. Veins return the deoxygenated blood to the heart. Together, these vessels control peripheral circulation, dilating or constricting in response to a variety of bodily events.

The Heart

The heart functions as a pump, and its pumping action causes the blood to circulate throughout the body. The left side of the heart, consisting of the left atrium and left ventricle, takes in heavily oxygenated blood from the lungs and pumps it out into the aorta (the major artery leaving the heart), from which the blood passes into the smaller vessels (the arteries, arterioles, and capillaries) to reach the cell tissues. The blood exchanges its oxygen and nutrients for the waste materials of the cells and is then returned to the right side of the heart (right atrium and right ventricle), which pumps it back to the lungs via the pulmonary artery. Once oxygenated, the blood returns to the left side of the heart through the pulmonary veins. The anatomy and functioning of the heart are pictured in Figure 2.5.

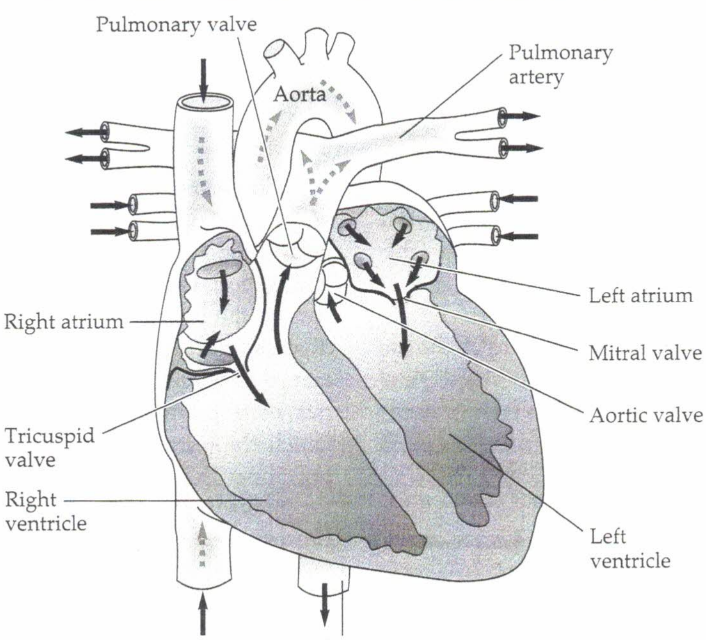
The heart performs these functions through regular rhythmic phases of contraction and relaxation known as the cardiac cycle. There are two phases in the cardiac cycle: systole and diastole. During systole, blood is pumped out of the heart, and blood pressure in the blood vessels increases. As the muscle relaxes during diastole, blood pressure drops and blood is taken into the heart.

The flow of blood into and out of the heart is controlled by valves at the inlet and outlet of each ventricle. These heart valves ensure that blood flows in one direction only. The sounds that one hears when listening to the heart are the sounds of these valves closing. These heart sounds make it possible to time the cardiac cycle to determine how rapidly or slowly blood is being pumped into and out of the heart.

A number of factors influence the rate at which the heart contracts and relaxes. During exercise, emotional excitement, or stress, for example, the heart speeds up, and the cardiac cycle is completed in a shorter time. Most of this speedup comes out of the diastolic period, so that a chronically rapid heart rate reduces overall time for rest. Consequently, a chronically or excessively rapid heart rate can decrease the heart's strength, which may reduce the volume of blood that is pumped.

Heart rate is also regulated by the amount of blood flowing into the veins. The larger the quantity of blood available, the harder the heart will have to pump. On the other hand, a lower supply of blood leads to a weaker and less frequent heartbeat.

FIGURE 2.5 | The Heart



Disorders of the Cardiovascular System

The cardiovascular system is subject to a number of disorders. Some of these are due to congenital defects—that is, defects present at birth—and others, to infection. By far, however, the major threats to the cardiovascular system are due to damage over the course of life that produces cumulative wear and tear. Lifestyle, in the form of diet, exercise, smoking, and stress exposure, among other factors, heavily affects the development of cardiovascular disease.

Atherosclerosis

The major cause of heart disease in this country is atherosclerosis, a problem that becomes worse with age. **Atherosclerosis** is caused by deposits of cholesterol and other substances on the arterial walls, which form plaques that narrow the arteries. The presence of atherosclerotic plaques reduces the flow of blood through the arteries and interferes with the passage of nutrients from the capillaries into the cells—a process that can lead to tissue damage. Damaged arterial walls are also potential sites for the formation of blood clots, which in themselves can completely obstruct a vessel and cut off the flow of blood.

Atherosclerosis is, in part, a disease of lifestyle, as we will see in Chapter 13. It is associated with a number of poor health habits, such as smoking and a high-fat diet. Moreover, it is a very common health problem. These two factors make it of paramount interest to health psychologists and explain the interest in changing these poor health behaviors.

Atherosclerosis is associated with two primary clinical manifestations:

- **Angina pectoris,** or chest pain, which occurs because the muscle tissue of the heart must continue its activity without a sufficient supply of oxygen or adequate removal of carbon dioxide and other waste products.
- **Myocardial infarction (MI),** which is most likely to occur when a clot has developed in a coronary vessel and blocks the flow of blood to the heart. A myocardial infarction, also known as a heart attack, can cause death.

Other related vessel disorders include arteriosclerosis (or hardening of the arteries), aneurysms, phlebitis, and varicose veins. Arteriosclerosis results when calcium, salts, and scar tissue react with the elastic tissue of the arteries. The consequence is a decrease in the elasticity of the arteries, making them rigid and hard. Blood pressure then increases because the arteries cannot dilate and constrict to help blood move, and hypertension (high blood pressure) may result. An aneurysm is a bulge in a section of the wall of an artery or vein; it is the reaction of a weak region to pressure. When an aneurysm ruptures, it can produce instantaneous death from internal hemorrhaging and loss of blood pressure.

Phlebitis is an inflammation of a vein wall, often accompanied by water retention and pain. The condition typically results from an infection surrounding the vein, from varicose veins, from pregnancy-related bodily changes, or from the pressure of a tumor on the vein. The chief threat posed by phlebitis is that it can encourage the production of blood clots, which then block circulation.

Varicose veins are superficial veins that have become dilated or swollen. Typically, veins in the lower extremities of the body are most susceptible because they are subjected to great pressure from the force of gravity.

Rheumatic Fever

Rheumatic fever is a bacterial infection that originates in the connective tissue and can spread to the heart, potentially affecting the functioning of the heart valves. The flaps of the valves may be changed into rigid, thickened structures that interfere with the flow of blood between the atrium and the ventricle. People with rheumatic fever, or with congenital heart disease, are particularly vulnerable to endocarditis, the inflammation of the membrane that lines the cavities of the heart, which is caused by staphylococcus or streptococcus organisms.

Blood Pressure

Blood pressure is the force that blood exerts against the blood vessel walls. During systole, the force on the blood vessel walls is greatest; during diastole, it falls to its lowest point. The measurement of blood pressure is a ratio of these two pressures.

Blood pressure is influenced by several factors. The first is cardiac output—pressure against the arterial walls is greater as the volume of blood flow increases. A second factor influencing blood pressure is peripheral resistance, or the resistance to blood flow in the small arteries of the body (arterioles). Peripheral resistance is influenced by the viscosity (thickness) of the blood—specifically, the number of red blood cells and the amount of plasma the blood contains. Highly viscous blood produces higher blood pressure. In addition, blood pressure is influenced by the structure of the arterial walls: If the walls have been damaged, if they are clogged by deposits of waste, or if they have lost their elasticity, blood pressure will be higher. Chronically high blood pressure, called hypertension, is the consequence of too high a cardiac output or too high a peripheral resistance. We will consider the psychosocial issues involved in the management and treatment of hypertension in Chapter 13.

The Blood

An adult's body contains approximately 5 liters of blood, which consists of plasma and cells. Plasma, the fluid portion of blood, accounts for approximately 55% of the blood volume. The blood cells are suspended in the plasma, which contains plasma proteins and plasma electrolytes (salts) plus the substances that are being transported by the blood (oxygen and nutrients or carbon dioxide and waste materials). The remaining 45% of blood volume is made up of cells.

Blood cells are manufactured in the bone marrow, the substance in the hollow cavities of bones. Bone marrow contains five types of blood-forming cells: myeloblasts and monoblasts, both of which produce particular white blood cells; lymphoblasts, which produce lymphocytes; erythroblasts, which produce red blood cells; and megakaryocytes, which produce platelets. Each of these types of blood cells has an important function.

White blood cells play an important role in healing by absorbing and removing foreign substances from the body. They contain granules that secrete digestive enzymes, which engulf and act on bacteria and other foreign particles, turning them into a form conducive to excretion.

Lymphocytes also play an important role in combating foreign substances. They produce antibodies—agents that destroy foreign substances through the antigen-antibody reaction. Together, these groups of cells play an important role in fighting infection and disease. We will consider them more fully in our discussion of the immune system.

Red blood cells are important mainly because they contain hemoglobin, which is needed to carry oxygen and carbon dioxide throughout the body.

Platelets serve several important functions. They clump together to block small holes that develop in blood vessels, and they also play an important role in blood clotting. When an injury occurs and tissues are damaged, platelets help form thromboplastin, which, in turn, acts on a substance in the plasma known as fibrinogen, changing it to fibrin. The formation of fibrin produces clotting.

Blood flow is responsible for the regulation of body temperature. When the body temperature is too high, skin blood vessels dilate and blood is sent to the skin, so that heat will be lost. When the body temperature is too low, skin blood vessels constrict and blood is kept away from the skin so that heat will be conserved and body temperature maintained. Alterations in skin blood flow are caused partly by the direct action of heat on skin blood vessels and partly by the temperature-regulating mechanism located in the hypothalamus, which alters the sympathetic impact on the surface blood vessels. Blood flow to the skin is also regulated by the catecholamines—epinephrine and norepinephrine. Norepinephrine generally constricts blood vessels (vasoconstriction), whereas epinephrine constricts skin blood vessels while dilating muscle blood vessels. These changes, in turn, increase the force of the heart's contractions.

Disorders Related to White Cell Production

Some blood disorders affect the production of white blood cells; they include leukemia, leukopenia, and leukocytosis. Leukemia is a disease of the bone marrow, and it is a common form of cancer. It causes the production of an excessive number of white blood cells, thus overloading the blood plasma and reducing the number of red blood cells that can circulate in the plasma. In the short term, anemia (a shortage of red blood cells) will result. In the long term, if left untreated, leukemia will cause death.

Leukopenia is a deficiency of white blood cells; it may accompany such diseases as tuberculosis, measles, and viral pneumonia. Leukopenia leaves an individual susceptible to disease because it reduces the number of white blood cells available to combat infection.

Leukocytosis is an excessive number of white blood cells. It is a response to many infections, such as leukemia, appendicitis, and infectious mononucleosis. Infection stimulates the body to overproduce these infection-combating cells.

Disorders Related to Red Cell Production

Anemia is a condition in which the number of red blood cells or amount of hemoglobin is below normal. A temporary anemic condition experienced by many women is a consequence of menstruation; through loss of blood, much vital iron (essential for the production of hemoglobin) is lost. Iron supplements must sometimes be taken to offset this problem. Other forms of anemia, including aplastic anemia, may occur because the bone marrow is unable to produce a sufficient number of red blood cells. The result is a decrease in the blood's transport capabilities, causing tissues to receive too little oxygen and to be left with too much carbon dioxide. When it is not checked, anemia can cause permanent damage to the nervous system and produce chronic weakness.

Erythrocytosis is characterized by an excess of red blood cells. It may result from a lack of oxygen in the tissues or be a secondary manifestation of other diseases. Erythrocytosis increases the viscosity of the blood and reduces the rate of blood flow.

Sickle-cell anemia is another disease related to red blood cell production. Most common among Blacks, it is a genetically transmitted inability to produce normal red blood cells. These cells are sickle-shaped instead of flattened spheres, and they contain abnormal hemoglobin protein molecules. They are vulnerable to rupture, leaving the individual susceptible to anemia. The sickle cell appears to be a genetic adaptation promoting resistance to malaria among African Blacks. Unfortunately, although these cells are effective in the short term against malaria, the long-term implications are life threatening.

Clotting Disorders

A third group of blood disorders involves clotting dysfunctions. Hemophilia affects individuals who are unable to produce thromboplastin and fibrin. Therefore, their blood cannot clot naturally in response to injury, and they may bleed to death unless they receive medication.

As noted earlier, clots (or thromboses) may sometimes develop in the blood vessels. This is most likely to occur if arterial or venous walls have been damaged or roughened because of the buildup of cholesterol. Platelets then adhere to the roughened area, leading to the formation of a clot. A clot formed in this manner may have serious consequences if it occurs in the blood vessels leading to the heart (coronary thrombosis) or brain (cerebral thrombosis), because it will block the vital flow of blood to these organs. When a clot occurs in a vein, it may become detached and form an embolus, which may finally become lodged in the blood vessels to the lungs, causing pulmonary obstruction. Death is a likely consequence of these conditions.

THE RESPIRATORY SYSTEM

Overview

Respiration, or breathing, has three main functions: to take in oxygen, to excrete carbon dioxide, and to regulate the composition of the blood.

The body needs oxygen to metabolize food. During the process of metabolism, oxygen combines with carbon atoms in food, producing carbon dioxide (CO_2). The respiratory system brings in air, most notably oxygen, through inspiration; it eliminates carbon dioxide through expiration.

The Structure and Functions of the Respiratory System

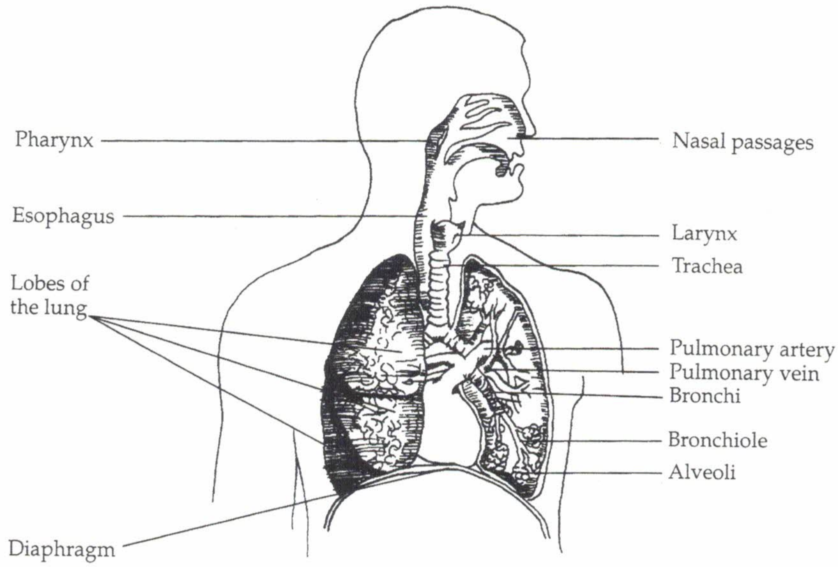
The **respiratory system** involves a number of organs, including the nose, mouth, pharynx, trachea, diaphragm, abdominal muscles, and lungs. Air is inhaled through the nose and mouth and then passes through the pharynx and larynx to the trachea. The trachea, a muscular tube extending downward from the larynx, divides at its lower end into two branches called the primary bronchi. Each bronchus enters a lung, where it then subdivides into secondary bronchi, still-smaller bronchioles, and, finally, microscopic alveolar ducts, which contain many tiny, clustered sacs called alveoli. The alveoli and the capillaries are responsible for the exchange of oxygen and carbon dioxide. A diagram of the respiratory system appears in Figure 2.6.

The inspiration of air is an active process, brought about by the contraction of muscles. Inspiration causes the lungs to expand inside the thorax (the chest wall). Expiration, in contrast, is a passive function, brought about by the relaxation of the lungs, which reduces the volume of the lungs within the thorax. The lungs fill most of the space within the thorax, called the thoracic cavity, and are very elastic, depending on the thoracic walls for support. Therefore, if air gets into the space between the thoracic wall and the lungs, one or both lungs will collapse.

Respiratory movements are controlled by a respiratory center in the medulla of the brain. The functions of this center depend partly on the chemical composition of the blood. For example, if the blood's carbon dioxide level rises too high, the respiratory center will be stimulated and respiration will be increased. If the carbon dioxide level falls too low, the respiratory center will slow down until the carbon dioxide level is back to normal.

The respiratory system is also responsible for coughing. Dust and other foreign material is inhaled with every breath. Some of these substances are trapped in the mucus of the nose and the air passages and are then conducted back toward the throat, where they are swallowed. When a large amount of mucus collects in the large airways, it is removed by coughing (a forced expiratory effort).

FIGURE 2.6 | The Respiratory System (*Source:* Lankford, 1979, p. 467)



Disorders of the Respiratory System

Asphyxia, Anoxia, and Hyperventilation

Several disorders of the respiratory system—including asphyxia, anoxia, and hyperventilation—have little significance because they are typically short-lived. When they occur on a long-term basis, however, these disorders can have severe effects.

Asphyxia, a condition of oxygen lack and carbon dioxide excess, may occur when there is a respiratory obstruction, when breathing occurs in a confined space so that expired air is reinhaled, or when respiration is insufficient for the body's needs. Asphyxia increases respiratory activity.

Anoxia, a shortage of oxygen alone, is more serious. People suffering from anoxia may rapidly become disoriented, lose all sense of danger, and pass into a coma without increasing their breathing. This is a danger to which test pilots are exposed when they take their planes to very high altitudes, so pilots are trained to be alert to the signs of anoxia so that they can take immediate corrective steps.

Another disruption of the carbon dioxide–oxygen balance results from hyperventilation. During periods of intense emotional excitement, people often breathe deeply, reducing the carbon dioxide content of the blood. Because carbon dioxide is a vasodilator (that is, it dilates the blood vessels), a consequence of hyperventilation is constriction of blood vessels and reduced blood flow to the brain. As a result, the individual may experience impaired vision, difficulty in thinking clearly, and dizziness.

Severe problems occur when a person stops breathing and becomes unconscious. If artificial respiration is not initiated within 2 minutes, brain damage and death may result.

Hay Fever

Hay fever is a seasonal allergic reaction to foreign bodies—including pollens, dust, and other airborne allergens—that enter the lungs. These irritants prompt the body to produce substances called histamines, which cause the capillaries of the lungs to become inflamed and to release large amounts of fluid. The result is violent sneezing among other symptoms.

Asthma

Asthma is a more severe allergic reaction that can be caused by a variety of foreign substances, including dust, dog or cat dander, pollens, and fungi. An asthma attack can also be touched off by emotional stress or exercise. These attacks may be so serious that they produce bronchial spasms and hyperventilation.

During an asthma attack, the muscles surrounding air tubes constrict, inflammation and swelling of the lining of the air tubes may occur, and increased mucus is produced, clogging the air tubes. The mucus secretion, in turn, may then obstruct the bronchioles, reducing the supply of oxygen and increasing the amount of carbon dioxide.

Statistics show a dramatic increase in the prevalence of allergic disorders including asthma in the past 20–30 years (Facts of Life, 2007). Currently, more than 130 million people worldwide have asthma, and the numbers are increasing, especially in industrialized countries and in urban as opposed to rural areas. The reasons for these dramatic changes are not yet fully known. One intriguing fact that may provide a clue to the increase in allergic sensitization is that children who have a lot of childhood infectious diseases are less likely to develop allergies, suggesting that exposure to infectious agents may actually play a protective role against developing allergies. Thus, paradoxically, the improved hygiene of industrialized countries may actually be contributing to the high rates of allergic disorders currently seen (Yazdanbakhsh, Kremsner, & van Ree, 2002).

Viral Infections The respiratory system is vulnerable to a number of infections and chronic disorders. Perhaps the most familiar of these is the common cold, a viral infection of the upper and sometimes the lower respiratory tract. The infection that results causes discomfort, congestion, and excessive secretion of mucus. The incubation period for a cold—that is, the time between exposure to the virus and onset of symptoms—is 12–72 hours, and the typical duration of a cold is a few days. Secondary bacterial infections may complicate the illness. These occur because the primary viral infection causes inflammation of the mucous membranes, reducing their ability to prevent secondary infection.

A more serious viral infection of the respiratory system is influenza, which can occur in epidemic form. Flu viruses attack the lining of the respiratory tract, killing healthy cells. Fever and inflammation of the respiratory tract may result. A common complication is a secondary bacterial infection, such as pneumonia.

A third infection, bronchitis, is an inflammation of the mucosal membrane inside the bronchi of the lungs. Large amounts of mucus are produced in bronchitis, leading to persistent coughing.

Bacterial Infections The respiratory system is also vulnerable to bacterial attack by, for example, strep throat, whooping cough, and diphtheria. Strep throat, an infection of the throat and soft palate, is characterized by edema (swelling) and reddening.

Whooping cough invades the upper respiratory tract and moves down to the trachea and bronchi. The associated bacterial growth leads to the production of a viscous fluid, which the body attempts to expel through violent coughing. Although diphtheria is an infection of the upper respiratory tract, its bacterial organisms secrete a toxic substance that is absorbed by the blood and is thus circulated throughout the body. Therefore, this disease can damage nerves, cardiac muscle, kidneys, and the adrenal cortex.

For the most part, strep throat, whooping cough, and diphtheria do not cause permanent damage to the upper respiratory tract. Their main danger is the possibility of secondary infection, which results from lowered resistance. However, these bacterial infections can cause permanent damage to other tissues, including heart tissue.

Chronic Obstructive Pulmonary Disease

Chronic obstructive pulmonary disease (COPD) is the fourth-leading killer of people in the United States. Some 13 million Americans have COPD, and although lung cancer is deadlier than COPD, COPD is much more common and nearly as deadly (Lemonick, 2004). Chronic bronchitis and emphysema are two of the familiar disorders comprised in COPD.

Pulmonary emphysema involves a persistent obstruction of the flow of air. It occurs when the alveoli become dilated, atrophied, and thin, so that they lose their elasticity and cannot constrict during exhalation. As a result, exhalation becomes difficult and forced, so that carbon dioxide is not readily eliminated. Emphysema is caused by a variety of factors, including long-term smoking.

Although COPD is not curable, it is highly preventable. Its chief cause is smoking, which accounts for approximately 85% of all cases of COPD. Specifically, exposure to toxic substances over a long period leads to inflammation and swelling of the cells lining the lungs. In COPD, this swelling is to a point that it restricts the flow of air, thus sapping energy and producing substantial resulting disability, high medical costs, and costs to the economy (Lemonick, 2004).

Pneumonia There are two main types of pneumonia. Lobar pneumonia is a primary infection of the entire lobe of a lung. The alveoli become inflamed, and the normal oxygen–carbon dioxide exchange between the blood and alveoli can be disrupted. Spread of infection to other organs is also likely.

Bronchial pneumonia, which is confined to the bronchi, is typically a secondary infection that may occur as a complication of other disorders, such as a severe cold or flu. It is not as serious as lobar pneumonia.

Tuberculosis and Pleurisy Tuberculosis is an infectious disease caused by bacteria that invade lung tissue. When the invading bacilli are surrounded by macrophages (white blood cells of a particular type), they form a clump called a tubercle, which is the typical manifestation of this disease. Eventually, through a process called caseation, the center of the tubercle turns into a cheesy mass, which can produce cavities in the lung. Such cavities, in turn, can give rise to permanent scar tissue, causing chronic difficulties in oxygen and carbon dioxide exchange between the blood and the alveoli.

Pleurisy is an inflammation of the pleura, the membrane that surrounds the organs in the thoracic cavity. The inflammation, which produces a sticky fluid, is usually a consequence of pneumonia or tuberculosis and can be extremely painful.

Lung Cancer Lung cancer, or carcinoma of the lung, is caused by smoking, environmental carcinogens (air pollution), or cancer-causing substances encountered in the workplace (such as asbestos). Recognition of the underlying causes has led to changes (such as reduced rates of smoking and emissions legislation), and as a result, lung cancer is on the decline.

The affected cells in the lungs begin to divide in a rapid and unrestricted manner, producing a tumor. Malignant cells grow faster than healthy cells; they crowd out the healthy cells and rob them of nutrients, causing them to die, and then spread into surrounding tissue.

Dealing with Respiratory Disorders

A number of respiratory disorders are tied directly to health problems that can be addressed by health psychologists. For example, smoking is a major health problem that is implicated in both pulmonary emphysema and lung cancer. The spread of tuberculosis can be reduced by encouraging people at risk to have regular chest X rays. Faulty methods of infection control, dangerous substances in the workplace, and air pollution are also factors that contribute to the incidence of respiratory problems.

As we will see in Chapters 3–5, health psychologists have addressed many of these problems. In addition, some of the respiratory disorders we have considered are chronic conditions with which an individual may live for some time. Consequently, issues of long-term physical, vocational, social, and psychological rehabilitation become crucial, and we will cover these issues in Chapters 11, 13, and 14.

THE DIGESTIVE SYSTEM AND THE METABOLISM OF FOOD

Overview

Food, essential for survival, is converted through the process of metabolism into heat and energy, and it supplies nutrients for growth and the repair of tissues. But before food can be used by cells, it must be changed into a form suitable for absorption into the blood. This conversion process is called digestion.

The Functioning of the Digestive System

Food is first lubricated by saliva in the mouth, where it forms a soft, rounded lump called a bolus. It passes through the esophagus by means of peristalsis, a unidirectional muscular movement toward the stomach. The stomach produces various gastric secretions, including pepsin and hydrochloric acid, to further the digestive process. The sight or even the thought of food starts the flow of gastric juices.

As food progresses from the stomach to the duodenum (the intersection of the stomach and lower intestine), the pancreas becomes involved in the digestive process. Pancreatic juices, which are secreted into the duodenum, contain several enzymes that break down proteins, carbohydrates, and fats. A critical function of the pancreas is the production of the hormone insulin, which facilitates the entry of glucose into the bodily tissues. The liver also plays an important role in metabolism by producing bile, which enters the duodenum and helps break down fats. Bile is stored in the gallbladder and is secreted into the duodenum as needed.

Most metabolic products are water soluble and can be easily transported in the blood. However, other substances are not soluble in water and so must be transported in the blood plasma as complex substances combined with plasma protein. Known as lipids, these substances include fats, cholesterol, and lecithin. An excess of lipids in the blood is called hyperlipidemia, a condition common in diabetes, some kidney diseases, hyperthyroidism, and alcoholism. It is also a causal factor in the development of heart disease (see Chapters 4 and 13).

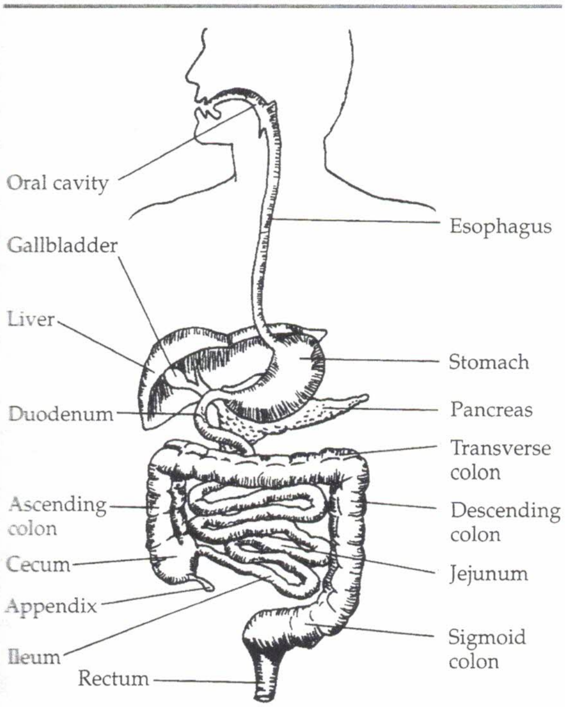
The absorption of food takes place primarily in the small intestine, which produces enzymes that complete the breakdown of proteins to amino acids. The motility of the small intestine is under the control of the sympathetic and parasympathetic nervous systems, such that parasympathetic activity speeds up metabolism, whereas sympathetic nervous system activity reduces it.

Food then passes into the large intestine (whose successive segments are known as the cecum and the ascending, transverse, descending, and sigmoid colon), which acts largely as a storage organ for the accumulation of food residue and helps in the reabsorption of water. The entry of feces into the rectum then brings about the urge to defecate, or expel the solid waste from the body via the anus. The organs involved in the metabolism of food are pictured in Figure 2.7.

Disorders of the Digestive System

The digestive system is susceptible to a number of disorders, some of which are only mildly uncomfortable and temporary, and others of which are more serious and chronic.

FIGURE 2.7 | The Digestive System
(*Source:* Lankford, 1979, p. 523)



Gastroenteritis, Diarrhea, and Dysentery

Gastroenteritis is an inflammation of the lining of the stomach and small intestine. It may be caused by such factors as excessive amounts of food or drink, contaminated food or water, or food poisoning. Symptoms appear approximately 2–4 hours after the ingestion of food; they include vomiting, diarrhea, abdominal cramps, and nausea.

Diarrhea, characterized by watery and frequent bowel movements, occurs when the lining of the small and large intestines cannot properly absorb water or digested food. Chronic diarrhea may result in serious disturbances of fluid and electrolyte (sodium, potassium, magnesium, calcium) balance.

Dysentery is similar to diarrhea except that mucus, pus, and blood are also excreted. It may be caused by a protozoan that attacks the large intestine (amoebic dysentery) or by a bacterial organism. Although these conditions are only rarely life threatening in industrialized countries, in developing countries, they are among the most common causes of death.

Peptic Ulcer A peptic ulcer is an open sore in the lining of the stomach or the duodenum. It results from the hypersecretion of hydrochloric acid and occurs when pepsin, a protein-digesting enzyme secreted in the stomach, digests a portion of the stomach wall or duodenum. A bacterium called H. pylori is believed to contribute to the development of many ulcers. Once thought to be primarily psychological in origin, ulcers are now believed to be aggravated by stress, but not necessarily caused by it (Goodwin & Stein, 2002).

Gallstones Gallstones are made up of a combination of cholesterol, calcium, bilirubin, and inorganic salts. When gallstones move into the duct of the gallbladder, they may cause painful spasms; such stones often must be removed surgically. Infection and inflammation of the gallbladder is called cholecystitis and may be a precondition for gallstones.

Appendicitis Appendicitis is a common condition that occurs when wastes and bacteria accumulate in the appendix. If the small opening of the appendix becomes obstructed, bacteria can easily proliferate. Soon this condition gives rise to pain, increased peristalsis, and nausea. If the appendix ruptures and the bacteria are released into the abdominal cavity or peritoneum, they can cause further infection (peritonitis) or even death.

Hepatitis

A common, serious, contagious disease that attacks the liver is hepatitis. *Hepatitis* means "inflammation of the liver," and the disease produces swelling, tenderness, and sometimes permanent damage. When the liver is inflamed, bilirubin, a product of the breakdown of hemoglobin, cannot easily pass into the bile ducts. Consequently, it remains in the blood, causing a yellowing of the skin known as jaundice. Other common symptoms are fatigue, fever, muscle or joint aches, nausea, vomiting, loss of appetite, abdominal pain, and sometimes diarrhea.

There are several types of hepatitis, which differ in severity and mode of transmission. Hepatitis A, caused by viruses, is typically transmitted through food and water. It is often spread by poorly cooked seafood or through unsanitary preparation or storage of food. Hepatitis B is a more serious form, with more than 350 million carriers in the world (Zuckerman, 1999) and an estimated 1.25 million infected people in the United States (Centers for Disease Control and Prevention, 2006f). Also known as serum hepatitis, it is caused by a virus and is transmitted by the transfusion of infected blood, by improperly sterilized needles, through sexual contact, and through mother-to-infant contact. It is a special risk among intravenous drug users. Its symptoms are similar to those of hepatitis A but are far more serious. At present, hepatitis B is a particular risk for people of Asian descent. They are 20–30 times more likely to be infected than any other group in the United States, in large part because hepatitis B is so common throughout Asia (Gottlieb & Yi, 2003).

Hepatitis C, also spread via blood and needles, is most commonly caused by blood transfusions; more than 1.6% of Americans are infected (Centers for Disease Control and Prevention, 2006g). Hepatitis D is found mainly in intravenous drug users who are also carriers of hepatitis B, necessary for the hepatitis D virus to spread. Finally, hepatitis E resembles hepatitis A but is caused by a different virus (Centers for Disease Control and Prevention, 2006e).

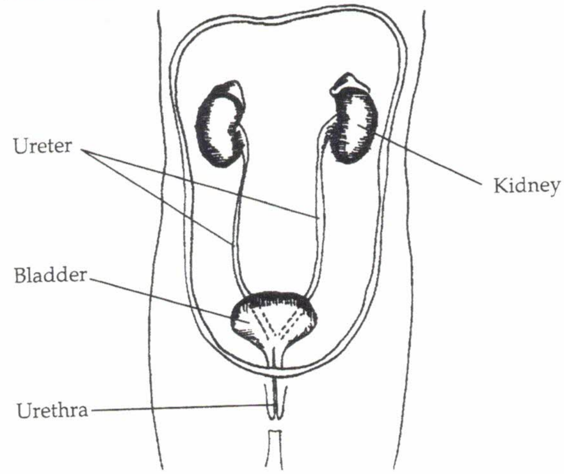
THE RENAL SYSTEM

Overview

The **renal system**—consisting of the kidneys, ureters, urinary bladder, and urethra—is also critically important in metabolism. The kidneys are chiefly responsible for the regulation of bodily fluids; their principal function is to produce urine. The ureters contain smooth muscle tissue, which contracts, causing peristaltic waves to move urine to the bladder, a muscular bag that acts as a reservoir for urine. The urethra then conducts urine from the bladder out of the body. The anatomy of the renal system is pictured in Figure 2.8.

FIGURE 2.8 | The Renal System

(*Source:* Lankford, 1979, p. 585)



Urine contains surplus water, surplus electrolytes, waste products from the metabolism of food, and surplus acids or alkalis. By carrying these products out of the body, urine maintains water balance, electrolyte balance, and blood pH. Of the electrolytes, sodium and potassium are especially important because they are involved in the normal chemical reactions of the body, muscular contractions, and the conduction of nerve impulses. Thus, an important function of the kidneys is to maintain an adequate balance of sodium and potassium ions.

In the case of certain diseases, the urine also contains abnormal amounts of some constituents; therefore, urinalysis offers important diagnostic clues to many disorders. For example, an excess of glucose may indicate diabetes, and an excess of red blood cells may indicate a kidney disorder. This is one of the reasons that a medical checkup usually includes a urinalysis.

One of the chief functions of the kidneys is to control the water balance in the body. For example, on a hot day, when a person has been active and has perspired profusely, relatively little urine will be produced, so that the body may retain more water. This is because much water has already been lost through the skin. On the other hand, on a cold day, when a person is relatively inactive or has consumed a good deal of liquid, urine output will be higher so as to prevent overhydration.

To summarize, the urinary system regulates bodily fluids by removing surplus water, surplus electrolytes, and the waste products generated by the metabolism of food.

Disorders of the Renal System

The renal system is vulnerable to a number of disorders. Among the most common are urinary tract infections, to which women are especially vulnerable and which can result in considerable pain, especially on urination. If untreated, they can lead to more serious infection.

Nephrons are the basic structural and functional units of the kidneys. In many types of kidney disease, such as that associated with hypertension, large numbers of nephrons are destroyed or damaged so severely that the remaining nephrons cannot perform their normal functions.

Acute glomerular nephritis is a disease that results from an antigen-antibody reaction in which the glomeruli of the kidneys become markedly inflamed. These inflammatory reactions can cause total or partial blockage of a large number of glomeruli, which may lead to increased permeability of the glomerular membrane, allowing large amounts of protein to leak in. When there is rupture of the membrane, large numbers of red blood cells may also pass into the glomerular filtrate. In severe cases, total renal shutdown occurs. Acute glomerular nephritis is usually a secondary response to a streptococcus infection. The infection itself does not damage the kidneys, but when antibodies develop, the antibodies and the antigen react with each other to form a precipitate, which becomes entrapped in the middle of the glomerular membrane. This infection usually subsides within 2 weeks.

Another common cause of acute renal shutdown is tubular necrosis, which involves destruction of the epithelial cells in the tubules of the kidneys. Poisons that destroy the tubular epithelial cells and severe circulatory shock are the most common causes of tubular necrosis.

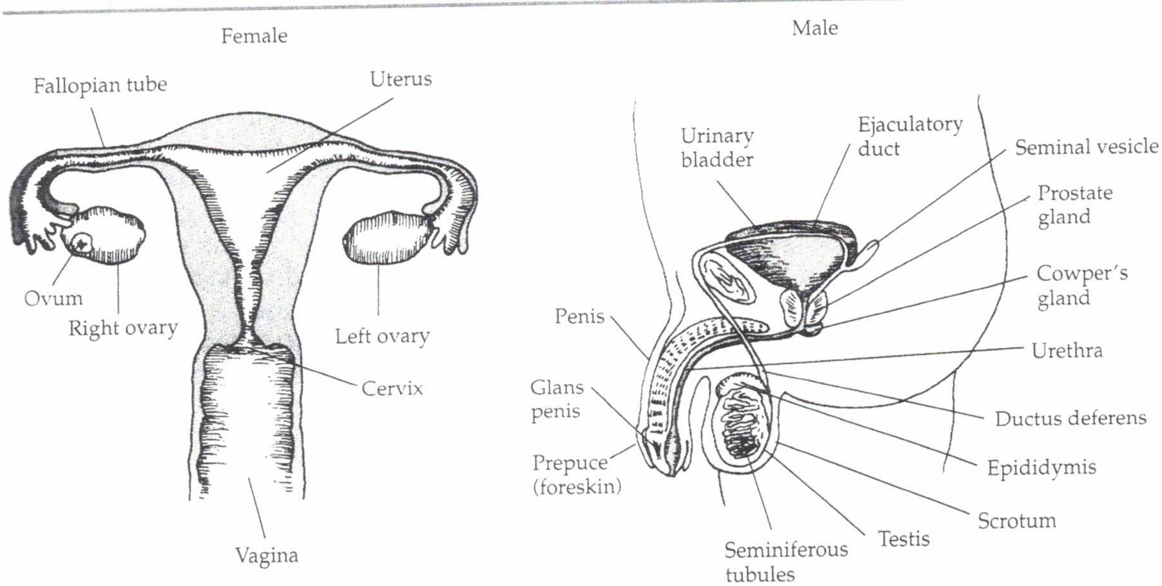
Kidney failure is a severe disorder because the inability to produce an adequate amount of urine will cause the waste products of metabolism, as well as surplus inorganic salts and water, to be retained in the body. An artificial kidney, a kidney transplant, or **kidney dialysis** may be required in order to rid the body of its wastes. Although these technologies can cleanse the blood to remove the excess salts, water, and metabolites, they are highly stressful medical procedures. Kidney transplants carry many health risks, and kidney dialysis can be extremely uncomfortable for patients. Consequently, health psychologists have been involved in addressing the problems experienced by kidney patients.

THE REPRODUCTIVE SYSTEM AND AN INTRODUCTION TO GENETICS

Overview

The development of the reproductive system is controlled by the pituitary gland. The anterior pituitary lobe produces the gonadotropic hormones, which control development of the ovaries in females and the testes in males. A diagrammatic representation of the human reproductive system appears in Figure 2.9.

FIGURE 2.9 | The Reproductive System (*Source:* Green, 1978, p. 122; Lankford, 1979, p. 688)



The Ovaries and Testes

The female has two ovaries located in the pelvis. Each month, one of the ovaries produces an ovum (egg), which is discharged at ovulation into the fallopian tubes. If the ovum is not fertilized (by sperm), it remains in the uterine cavity for about 14 days and is then flushed out of the system with the uterine endometrium and its blood vessels (during menstruation).

The ovaries also produce the hormones estrogen and progesterone. Estrogen leads to the development of secondary sex characteristics in the female, including breasts and the distribution of both body fat and body hair. Progesterone, which is produced during the second half of the menstrual cycle to prepare the body for pregnancy, declines if pregnancy fails to occur.

In males, testosterone is produced by the interstitial cells of the testes under the control of the anterior pituitary lobe. It brings about the production of sperm and the development of secondary sex characteristics, including growth of the beard, deepening of the voice, distribution of body hair, and both skeletal and muscular growth.

Fertilization and Gestation

When sexual intercourse takes place and ejaculation occurs, sperm are released into the vagina. These sperm, which have a high degree of motility, proceed upward through the uterus into the fallopian tubes, where one sperm may fertilize an ovum. The fertilized ovum then travels down the fallopian tube into the uterine cavity, where it embeds itself in the uterine wall and develops over the next 9 months into a human being.

Disorders of the Reproductive System

The reproductive system is vulnerable to a number of diseases and disorders. Among the most common and problematic are sexually transmitted diseases (STDs), which occur through sexual intercourse or other forms of sexually intimate activity. These include herpes, gonorrhea, syphilis, genital warts, chlamydia, and, most seriously, AIDS.

For women, a risk of several STDs is that chronic pelvic inflammatory disease (PID) may result, which may produce a variety of unpleasant symptoms, including severe abdominal pain, and may lead to infections that may compromise fertility. Other gynecologic disorders to which women are vulnerable include vaginitis, endometriosis (in which pieces of the endometrial lining of the uterus move into the fallopian tubes or abdominal cavity, grow, and spread to other sites), cysts, and fibroids (nonmalignant growths in the uterus).

The reproductive system is also vulnerable to cancer, including testicular cancer in men (see Chapter 4) and gynecologic cancers in women. Every 6.4 minutes, or more than 80,000 times per year, a woman in the United States is diagnosed with a gynecologic cancer, including cancer of the cervix, uterus, and ovaries (Gynecological Cancer Foundation, 2003). Endometrial cancer is the most common female pelvic malignancy, while ovarian cancer is the most lethal.

Women are vulnerable to disorders of the menstrual cycle, including amenorrhea, which is absence of menses, and oligomenorrhea, which is infrequent menstruation. These problems may originate in the hypothalamus, in the anterior pituitary, or in the ovaries or reproductive tract. Location of the cause is essential for correcting the problem, which may include hormone therapy or surgery.

Approximately 7% of U.S. couples experience fertility problems, defined as the inability to conceive a pregnancy after one year of regular sexual intercourse without contraception (National Center for Health Statistics, 2006b). Although physicians once believed that infertility has emotional origins, researchers have now concluded that there is little evidence for this idea (Pasch & Dunkel-Schetter, 1997). Infertility, nonetheless, can create substantial psychological distress. Fortunately, over the past few decades, the technology for treating infertility has improved. A variety of drug treatments have been developed, as have more invasive technologies. In vitro fertilization (IVF) is the most widely used method of assistive reproductive technology, and the success rate for IVF is nearly 30% (American Society for Reproductive Medicine, 2004).

Menopause is not a disorder of the reproductive system; rather, it occurs when a woman's reproductive life ends. Because of a variety of unpleasant symptoms that can occur during the transition into menopause, including sleep disorders, hot flashes, joint pain, forgetfulness, and dizziness, many women choose to take hormone therapy (HT), which typically includes estrogen or a combination of estrogen and progesterone. HT was once thought not only to reduce the symptoms of menopause but also to protect against the development of coronary artery disease, osteoporosis, and even Alzheimer's disease. It is now believed that, rather than protecting against these disorders, HT may actually increase some of these risks (Hays et al., 2003; Hodis et al., 2003; Manson et al., 2003). HT also somewhat increases the risks of breast cancer. As a result of this new evidence, many women and their doctors are rethinking the use of HT, especially over the long term.

Genetics and Health

The fetus starts life as a single cell, which contains all the inherited information from both parents that will determine its characteristics. The genetic code regulates such factors as eye and hair color, as well as behavioral factors. Genetic material for inheritance lies in the nucleus of the cell in the form of 46 chromosomes, 23 from the mother and 23 from the father. Two of these 46 are sex chromosomes, which are an X from the mother and either an X or a Y from the father. If the father provides an X chromosome, a female child will result; if he provides a Y chromosome, a male child will result.

Genetic Studies Genetic studies have provided valuable information about the inheritance of susceptibility to disease (Harmon, 2004). Among several methods, scientists have bred strains of rats, mice, and other laboratory animals that are sensitive or insensitive to the development of particular diseases and then used these strains to study other contributors to illness onset, the course of illness, and so on. For example, a strain of rats that are susceptible to cancer may be used to study the development of this disease and the cofactors that determine its appearance. The initial susceptibility of the rats ensures that many of them will develop malignancies when implanted with carcinogenic (cancer-causing) materials.

In humans, several types of research help demonstrate whether a characteristic is genetically acquired. Studies of families, for example, can reveal whether members of the same family are statistically more likely to develop a disorder, such as heart disease, than are unrelated individuals within a similar environment. If a factor is genetically determined, family members would be expected to show it more frequently than would unrelated individuals.

Twin research is another method for examining the genetic basis of a characteristic. If a characteristic is genetically transmitted, identical twins share it more commonly than do fraternal twins or other brothers and sisters. This is because identical twins share the same genetic makeup, whereas other brothers and sisters have only partially overlapping genetic makeup.

Examining the characteristics of twins reared together as opposed to twins reared apart is also informative regarding genetics. Attributes that emerge for twins reared apart are suspected to be genetically determined, especially if the rate of occurrence between twins reared together and those reared apart is the same.

Finally, studies of adopted children also help identify which characteristics are genetic and which are environmentally produced. Adopted children will not manifest genetically transmitted characteristics from their adoptive parents, but they will very likely manifest environmentally transmitted characteristics.

Consider, for example, obesity, which is a risk factor for a number of disorders, including coronary artery disease and diabetes. If twins reared apart show highly similar body weights, then we would suspect that body weight has a genetic component. If, on the other hand, weight within a family is highly related, and adopted children show the same weight as parents and their natural offspring, then we would look to the family diet as a potential cause of obesity. For many attributes, including obesity, both environmental and genetic factors are involved.

Research like this has increasingly uncovered the genetic contribution to many health disorders and behavioral factors that may pose risks to health. Such diseases as asthma, Alzheimer's disease, cystic fibrosis, muscular dystrophy, Tay-Sachs disease, and Huntington's disease, as well as a number of chromosomal abnormalities, clearly have a genetic basis. There is also a genetic basis for coronary heart disease and for some forms of cancer, including some breast and colon cancers.

Genetic contributions to obesity and alcoholism have emerged in recent years, and even some personality characteristics, such as optimism, which is believed to have protective health effects, appear to have genetic underpinnings (Plomin et al., 1992). Continuing advances in the field of genetics will undoubtedly yield much more information about the genetic contributions to behavioral factors that, in turn, contribute to health and illness (Facts of Life, June 2006).

Genetics and Psychology Health psychologists have important roles to play with respect to the genetic contribution to disorders (Shiloh, Gerad, & Goldman, 2006). The first role involves genetic counseling. Prenatal diagnostic tests are currently available that permit the detection of a variety of genetically based disorders, including Tay-Sachs disease, cystic fibrosis, muscular dystrophy, Huntington's disease, and breast cancer (Harmon, 2004). Helping people cope with genetic vulnerabilities of this kind represents an important role for health psychologists.

In addition, people who have a family history of genetic disorders, those who have already given birth to a child with a genetic disorder, or those who have repeated reproductive problems, such as multiple miscarriages, often seek such counseling. In some cases, technological advances have made it possible to treat some of these problems before birth. For example, drug therapy can treat some genetically transmitted metabolic defects, and surgery in utero has been performed to correct certain neural problems. However, when a prenatal diagnosis reveals that the fetus has an abnormal condition that cannot be corrected, the parents often must make the difficult decision of whether to abort the pregnancy.

In other cases, people may learn of a genetic risk to their health as children, adolescents, or young adults. Breast cancer, for example, runs in families, and among young women whose mothers, aunts, or sisters have developed breast cancer, vulnerability is higher. Some of the genes that contribute to the development of breast cancer have been identified, and tests are now available to determine whether a genetic susceptibility is present, although this type of cancer accounts for only 5% of breast cancer. Women who carry these genetic susceptibilities are more likely to develop the disease at an earlier age; thus, these women are at high risk and need careful monitoring and potentially counseling as well (Grady, 2003).

Many scientific investigations attest to both the immediate and the long-term distress that carriers of genetic disorders may experience (Cella et al., 2002; Lobel, Dias, & Meyer, 2005; Timman, Roos, Maat-Kievit, & Tibben, 2004). In fact, reactions to this kind of bad news can be so problematic that some people concerned with ethical issues in medicine question the value of telling people about their genetic risks if nothing can be done to treat them. Growing evidence suggests, however, that people at risk for treatable disorders may benefit from genetic testing and not suffer substantial psychological distress. People who are chronically anxious, though, may require special attention and counseling (Rimes, Salkovskis, Jones, & Lucassen, 2006; Shiloh & Ilan, 2005).

Moreover, in some cases, genetic risks can be offset by behavioral interventions to address the risk factor. For example, some smokers have a genetic susceptibility to lung cancer. Consequently, if they are identified early, encouraging them not to begin smoking or to stop smoking if they are already smokers may reduce the likelihood of their going on to develop cancer (Lipkus, McBride, Pollack, Lyna, & Bepler, 2004; Rimes et al., 2006).

Health psychologists have an important role to play in genetic counseling to help people modify their risk status. Knowledge of distress patterns (that is, who is mostly likely to be stressed when) can be helpful in counseling those who learn of their genetic risks (Shiloh et al., 2006). There are not only genetic bases of diseases but also genetic bases for fighting diseases. That is, certain genes may act as protective factors against development of a disease. For example, one specific gene appears to regulate whether the immune system can identify cancer (Carey, 2002). Just as attention to the genetic bases of disease will occupy research attention for decades to come, so the protective genetic factors that keep so many of us so healthy for so long may become better understood as well.

The coming decades will reveal other genetic bases of major diseases, and tests will become available for identifying one's genetic risk. What are the psychosocial ramifications of such technological developments? These issues are addressed in Chapter 3, and they take on a special urgency by virtue of the ethical issues they raise. For example, if prospective medical insurers or employers are allowed to conduct genetic screening, could an individual's at-risk status be used to deny her or him health insurance or employment (Faden & Kass, 1993)? How might one avoid such abuses of the technology?

As yet, our ability to deal intelligently with such important psychological, social, and ethical issues has not kept pace with our scientific capacity to elucidate the role of genetics in illness and risk factors. An open discussion is essential if we are to make proper use of these valuable technologies. Suffice it to say here that the role of health psychologists in this debate is expanding and will evolve further in the coming decades.

THE IMMUNE SYSTEM

Overview

Disease can be caused by a variety of factors, including genetic defects, hormone imbalances, nutritional deficiencies, and infection. In this section, we are primarily concerned with the transmission of disease by infection—that is, the invasion of microbes and their growth in the body. The microbes that cause infection are transmitted to people in several ways:

- Direct transmission involves bodily contact, such as handshaking, kissing, and sexual intercourse. For example, genital herpes is generally contracted by direct transmission.

BOX 2.1

Portraits of Two Carriers

Carriers are people who transmit a disease to others without actually contracting that disease themselves. They are especially dangerous because they are not ill and so are not removed from society. Thus, it is possible for a carrier to infect dozens, hundreds, or even thousands of individuals while going about the business of everyday life.

"TYPHOID MARY"

Perhaps the most famous carrier in history was "Typhoid Mary," a young Swiss immigrant to the United States who apparently infected thousands of people during her lifetime. During her ocean crossing, Mary was taught how to cook, and eventually, some 100 individuals aboard the ship died of typhoid, including the cook who trained her. Once Mary arrived in New York, she obtained a series of jobs as a cook, continually passing on the disease to those for whom she worked without contracting it herself.

Typhoid is precipitated by a Salmonella bacterium, which can be transmitted through water, food, and physical contact. Mary carried a virulent form of the infection in her body but was herself immune to the disease. It is believed that she was unaware that she was a carrier for many years. Toward the end of her life, however, she began to realize that she was responsible for the many deaths around her.

Mary's status as a carrier also became known to medical authorities, and she spent the latter part of her life in and out of institutions in a vain attempt to isolate her from others. In 1930, Mary died not of typhoid but of a brain hemorrhage (Federspiel, 1983).

"HELEN"

The CBS News program *60 Minutes* profiled an equally terrifying carrier: a prostitute, "Helen," who is a carrier of AIDS (acquired immune deficiency syndrome). Helen has never had AIDS, but her baby was born with the disease. As a prostitute and heroin addict, she is not only at risk for developing the illness herself but also poses a substantial threat to her clients and anyone with whom she shares a needle.

Helen represents a dilemma for medical and criminal authorities. She is a known carrier of AIDS, yet there is no legal basis for preventing her from coming into contact with others. Although she can be arrested for prostitution or drug dealing, such incarcerations are usually short-term and would have a negligible impact on her ability to spread the disease to others. For as yet incurable diseases such as AIDS, the carrier represents a nightmare. Although the carrier can augment the incidence of the disease, medical and legal authorities have been almost powerless to intervene (Moses, 1984).

- Indirect transmission (or environmental transmission) occurs when microbes are passed to an individual via airborne particles, dust, water, soil, or food. Influenza is an example of an environmentally transmitted disease.
- Biological transmission occurs when a transmitting agent, such as a mosquito, picks up microbes, changes them into a form conducive to growth in the human body, and passes them on to the human. Yellow fever, for example, is transmitted by this method.
- Mechanical transmission is the passage of a microbe to an individual by means of a carrier that is not directly involved in the disease process. Dirty hands, bad water, rats, mice, and flies are methods of mechanical transmission. For example, hepatitis can be acquired through mechanical transmission. Box 2.1 tells about two people who were carriers of deadly diseases.

Once a microbe has reached the body, it penetrates into bodily tissue via any of several routes, including the skin, the throat and respiratory tract, the digestive tract, or the genitourinary system. Whether the invading microbes gain a foothold in the body and produce infection depends on three factors: the number of organisms, the virulence of the organisms, and the body's defensive capacities. The virulence of an organism is determined by its aggressiveness (that is, its ability to resist the body's defenses) and by its toxigenicity (that is, its ability to produce poisons, which invade other parts of the body).

The Course of Infection

Assuming that the invading organism does gain a foothold, the natural history of infection follows a specific course. First, there is an incubation period between the time the infection is contracted and the time the symptoms appear.

Next, there is a period of nonspecific symptoms, such as headaches and general discomfort, which precedes the onset of the disease. During this time, the microbes are actively colonizing and producing toxins. The next stage is the acute phase, when the disease and its symptoms are at their height. Unless the infection proves fatal, a period of decline follows the acute phase. During this period, the organisms are expelled from the mouth and nose in saliva and respiratory secretions, as well as through the digestive tract and the genitourinary system in feces and urine.

Infections may be localized, focal, or systemic. Localized infections remain at their original site and do not spread throughout the body. Although a focal infection is confined to a particular area, it sends toxins to other parts of the body, causing other disruptions. Systemic infections, by contrast, affect a number of areas or body systems.

The primary infection initiated by the microbe may also lead to secondary infections. These occur because the body's resistance is lowered from fighting the primary infection, leaving it susceptible to other invaders. In many cases, secondary infections, such as pneumonia, pose a greater risk than the primary one.

Immunity

Immunity is the body's resistance to harm from invading organisms. It may develop either naturally or artificially. Some natural immunity is passed from the mother to the child at birth and through breast-feeding, although this type of immunity is only temporary. Natural immunity is also acquired through disease. For example, if you have measles once, you are unlikely to develop it a second time; you will have built up an immunity to it.

Artificial immunity is acquired through vaccinations and inoculations. For example, most children and adolescents receive shots for a variety of diseases—among them, diphtheria, whooping cough, smallpox, poliomyelitis, and hepatitis—so that they will not contract them should they ever be exposed.

Nonspecific and Specific Immunity

How does immunity work? The body has a number of responses to invading organisms, some nonspecific and others specific. **Nonspecific immune mechanisms** are a general set of responses to any kind of infection or disorder; **specific immune mechanisms,** which are always acquired after birth, fight particular microorganisms and their toxins.

Nonspecific immunity is mediated in four main ways: through anatomical barriers, phagocytosis, antimicrobial substances, and inflammatory response. Anatomical barriers prevent the passage of microbes from one section of the body to another. For example, the skin functions as an extremely effective anatomical barrier to many infections, and the mucous membranes lining the nose and mouth (as well as other cavities that are open to the environment) also provide protection.

Phagocytosis is the process by which certain white blood cells (called phagocytes) ingest microbes. Phagocytes are usually overproduced when there is a bodily infection, so that sufficient numbers can be sent to the site of infection to ingest the foreign particles.

Antimicrobial substances are chemicals mobilized by the body to kill invading microorganisms. One that has received particular attention in cancer research is interferon, an antiviral protein secreted by cells exposed to a viral antigen to protect neighboring uninfected cells from invasion. Hydrochloric acid and enzymes such as lysozyme are other antimicrobial substances that help destroy invading microorganisms.

The inflammatory response is a local reaction to infection. At the site of infection, the blood capillaries first enlarge, and a chemical called histamine is released into the area. This chemical causes an increase in capillary permeability, allowing white blood cells and fluids to leave the capillaries and enter the tissues; consequently, the area becomes reddened and fluids accumulate. The white blood cells attack the microbes, resulting in the formation of pus. Temperature increases at the site of inflammation because of the increased flow of blood. Usually, a clot then forms around the inflamed area, isolating the microbes and keeping them from spreading to other parts of the body. Familiar examples of the inflammatory response are the reddening, swelling, discharge, and clotting that result when you accidentally lacerate your skin and the sneezing, runny nose, and teary eyes that result from an allergic response to pollen.

Specific immunity is acquired after birth and differs from nonspecific immunity in that it protects against particular microorganisms and their toxins. Specific immunity may be acquired by contracting a disease or through artificial means, such as vaccinations. It operates through the antigen-antibody reaction. Antigens are foreign substances whose presence stimulates the production of antibodies in the cell tissues. Antibodies are proteins produced in response to stimulation by antigens, which then combine chemically with the antigens to overcome their toxic effects.

Humoral and Cell-Mediated Immunity

There are two basic immunologic reactions—humoral and cell mediated. **Humoral immunity** is mediated by B lymphocytes. The functions of B lymphocytes include providing protection against bacteria, neutralizing toxins produced by bacteria, and preventing viral reinfection. B cells confer immunity by the production and secretion of antibodies.

When B cells are activated, they differentiate into two types: mature, antibody-secreting plasma cells and resting, nondividing, memory B cells, which differentiate into antigen-specific plasma cells only when reexposed to the same antigen. Plasma cells produce antibodies or immunoglobulins, which are the basis of the antigen-specific reactions. Humoral immunity is particularly effective in defending against bacterial infections and against viral infections that have not yet invaded the cells.

Cell-mediated immunity, involving T lymphocytes from the thymus gland, is a slower-acting response. Rather than releasing antibodies into the blood, as humoral immunity does, cell-mediated immunity operates at the cellular level. When stimulated by the appropriate antigen, T cells secrete chemicals that kill invading organisms and infected cells.

There are two major types of T lymphocytes: cytotoxic T (T_C cells) and helper T (T_H cells). T_C cells respond to specific antigens and kill by producing toxic substances that destroy virally infected cells. T_H cells enhance the functioning of T_C cells, B cells, and macrophages by producing cytokines. T_H cells also serve a counterregulatory immune function, producing cytokines that suppress certain immune activities. Cell-mediated immunity is particularly effective in defending the body against fungi, viral infections that have invaded the cells, parasites, foreign tissue, and cancer.

What, then, does the integrated immune response look like? When a foreign antigen enters the body, the first line of defense involves mechanistic maneuvers, such as coughing or sneezing. Once the invader has penetrated the body's surface, the phagocytes, such as the macrophages, attempt to eliminate it by phagocytosis (engulfing and digesting the foreign invader). Macrophages also release interleukin-1 and display part of the antigen material on their surface as a signal to the T_H cells. These, in turn, secrete interleukin-2, which promotes the growth and differentiation of the T_C cells. Other types of T helper cells secrete substances that promote the development of antigen-specific B cells into antibody-producing plasma cells, which then assist in destroying the antigen. T_H cells also secrete gamma-interferon, which enhances the capacities of the macrophages. Macrophages and natural killer (NK) cells also secrete various types of interferon, which enhance the killing potential of the natural killer (NK) cells and inhibit viral reproduction in uninfected cells. In addition, macrophages, NK cells, and T_C cells directly kill infected cells. During this process, the T_H cells regulate and eventually turn off the immune response.

The Lymphatic System's Role in Immunity

The **lymphatic system,** which is a drainage system of the body, is involved in important ways in immune functioning. There is lymphatic tissue throughout the body, consisting of lymphatic capillaries, vessels, and nodes. Lymphatic capillaries drain water, proteins, microbes, and other foreign materials from spaces between the cells into lymph vessels. This material is then conducted in the lymph vessels to the lymph nodes, which filter out microbes and foreign materials for ingestion by lymphocytes. The lymphatic vessels then drain any remaining substances into the blood.

The spleen, tonsils, and thymus gland are important organs in the lymphatic system. The spleen aids in the production of B cells and T cells and removes old red blood cells from the body. The spleen also helps filter bacteria and is responsible for the storage and release of blood. Tonsils are patches of lymphoid tissue in the pharynx that filter out microorganisms that enter the respiratory tract. Finally, the thymus gland is responsible for helping T cells mature; it also produces a hormone, thymosin, which appears to stimulate T cells and lymph nodes to produce the plasma cells that, in turn, produce antibodies.

Additional discussion of immunity may be found in Chapter 14, where we will consider the rapidly developing field of psychoneuroimmunology and the role of immunity in the development of AIDS. As we will see in that context, health psychologists are identifying the importance of stress and other psychological factors in the functioning of the immune system.

Disorders Related to the Immune System

The immune system and the tissues of the lymphatic system are subject to a number of disorders and diseases. One very important one is AIDS, which is a progressive impairment of immunity. Another is cancer, which is now believed to depend heavily on immunocompromise. We defer extended discussion of AIDS and cancer to Chapter 14.

Some diseases of the immune system result when bacteria are so virulent that the lymph node phagocytes are not able to ingest all the foreign matter. These diseases include lymphangitis, an inflammation of the lymphatic vessels that results from interference in the drainage of the lymph into the blood, and lymphadenitis, an inflammation of the lymph nodes associated with the phagocytes' efforts to destroy microbes.

A number of infections attack lymphatic tissue. Elephantiasis is a condition produced by worms; it stems from blockage in the flow of lymph into the blood. Massive retention of fluid results, especially in the extremities. Splenomegaly is an enlargement of the spleen that may result from various infectious diseases. It hinders the spleen's ability to produce phagocytes, antibodies, and lymphocytes. Tonsillitis is an inflammation of the tonsils that interferes with their ability to filter out bacteria. Infectious mononucleosis is a viral disorder marked by an unusually large number of monocytes; it can cause enlargement of the spleen and lymph nodes, as well as fever, sore throat, and general lack of energy.

Lymphoma is a tumor of the lymphatic tissue. Hodgkin's disease, a malignant lymphoma, involves the progressive, chronic enlargement of the lymph nodes, spleen, and other lymphatic tissues. As a consequence, the nodes cannot effectively produce antibodies, and the phagocytic properties of the nodes are lost. If untreated, Hodgkin's disease can be fatal.

Infectious disorders were at one time thought to be acute problems that ended when their course had run. A major problem in developing countries, infectious disorders were thought to be largely under control in developed nations. Now, however, some important developments with respect to infectious diseases merit closer looks (Morens, Folkers, & Fauci, 2004). First, as noted in the discussion of asthma, the control of at least some infectious disorders through hygiene may have paradoxically increased the rates of allergic disorders. A second development is that some chronic diseases, once thought to be genetic in origin or unknown in origin, are now being traced back to infections. For example, Alzheimer's disease, multiple sclerosis, schizophrenia, and some cancers appear to have infectious triggers, at least in some cases (Zimmer, 2001). The fact that multiple sclerosis shows outbreaks in particular locations is strongly suggestive of an infectious pattern. Ulcers, once thought to be the result of stress, were traced in the 1980s to a microbe known as Helicobacter pylori; cases of ulcers and even gastric cancers that were once thought to be difficult to treat can now be cured through antibiotics (Zimmer, 2001). Increasingly, biologists are suggesting that pathogens cause or actively contribute to many if not most chronic diseases. Finally, of considerable concern is the development of bacterial strains that are increasingly resistant to treatment. The overuse of antibiotics is thought to be an active contributor to the development of increasingly lethal strains.

Infectious agents have also become an increasing cause for concern in the war on terrorism, as the possibility that smallpox and other infectious agents may be used as weapons becomes increasingly likely (Gruman, 2003).

The inflammatory response that is so protective against provocations ranging from mosquito bites and sunburn to gastritis in response to spoiled food is now coming under increasing investigation as a potential contributor to chronic disease. The destructive potential of inflammatory responses has long been evident in diseases such as rheumatoid arthritis and multiple sclerosis, but researchers are now coming to believe that inflammation underlies many other chronic diseases including athlersclerosis, diabetes, Alzheimer's disease, and osteoporosis. Inflammation is also implicated in asthma, cirrhosis of the liver, some bowel disorders, cystic fibrosis, heart disease, and even some cancers (Duenwald, 2002) (Table 2.1).

The inflammatory response, like stress responses more generally, likely evolved in humans' early prehistory and was selected because it was adaptive. For example, among hunter-gatherer societies, natural selection would have favored people with vigorous inflammatory responses because life expectancy was fairly short. Few people would have experienced the long-term costs of vigorous or long-lasting inflammatory responses, which

TABLE 2.1 | Some Consequences of Chronic Low-Level Inflammation.

Inflammation is believed to play an important role in several diseases of aging. They include:

- Heart Disease
- Stroke
- Diabetes
- Alzheimer's Disease (and cognitive decline more generally)
- Cancer
- Osteoporosis
- Depression

now seem to play such an important role in the development of chronic diseases. Essentially, an adaptive pattern of earlier times has become maladaptive as life expectancy has lengthened (Duenwald, 2002).

Autoimmunity is a condition characterized by a specific humoral or cell-mediated immune response that attacks the body's own tissues. Autoimmunity is implicated in certain forms of arthritis, a condition characterized by inflammatory lesions in the joints that produce pain, heat, redness, and swelling. We will discuss arthritis more fully in Chapter 14. Multiple sclerosis is also an autoimmune disorder. One of the most severe autoimmune disorders is systemic lupus erythematosis, a generalized disorder of the connective tissue, which primarily affects women and which in its severe forms can lead to eventual heart or kidney failure, causing death.

In autoimmune disease, the body fails to recognize its own tissue, instead interpreting it as a foreign invader and producing antibodies to fight it. Approximately 14–22 million Americans suffer from autoimmune diseases. Women are more likely than men to be affected; some estimates are that 78% of those affected are women (Fairweather & Rose, 2004). Although the causes of autoimmune diseases are not fully known, researchers have discovered that a viral or bacterial infection often precedes the onset of an autoimmune disease.

Many of these viral and bacterial pathogens have, over time, developed the ability to fool the body into granting them access by mimicking basic protein sequences in the body. This process of molecular mimicry eventually fails but then leads the immune system to attack not only the invader but also the corresponding self-component. A person's genetic makeup may exacerbate this process, or it may confer protection against autoimmune diseases (Steinman, 1993). Stress may aggravate autoimmune disease.