anatomy autoimmune disease cardiovascular system digestive system endocrine system external respiration female reproductive **u** immune system integumentary system internal respiration ligaments lymphatic system

male reproductive system

metabolic acidosis metabolic alkalosis muscular system nervous system physiology respiratory acidosis respiratory alkalosis respiratory system skeletal system test panel test profile tendons urinary system



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Learning Outcomes

- 5.1 Describe the functions of the integumentary system, common diseases and disorders that affect this system, and related laboratory tests.
- 5.2 Describe the functions of the skeletal system, common diseases and disorders that affect this system, and related laboratory tests.
- Describe the functions of the muscular 5.3 system, common diseases and disorders that affect this system, and related laboratory tests.
- 5.4 Describe the functions of the lymphatic and immune systems, common diseases and disorders that affect these systems, and related laboratory tests.

- 5.5 Describe the functions of the respiratory system, common diseases and disorders that affect this system, and related laboratory tests.
- 5.6 Describe the functions of the digestive system, common diseases and disorders that affect this system, and related laboratory tests.
- 5.7 Describe the functions of the nervous system, common diseases and disorders that affect this system, and related laboratory tests.
- 5.8 Describe the functions of the endocrine system, common diseases and disorders that affect this system, and related laboratory tests.

Describe the functions of the female and 5.11 male reproductive systems, common diseases and disorders that affect these systems, and related laboratory tests.

5.12 Explain the use of test panels and profiles in the assessment of specific body systems and general health screening.

Related NAACLS Competencies

1.7 Describe how laboratory testing is used to assess body functions and disease.

3.1 Demonstrate basic understanding of the anatomy and physiology of body systems and anatomical terminology in order to relate major areas of the clinical laboratory to general pathologic conditions associated with the body systems.

3.2 Describe the basic functions of each main body system, and demonstrate basic knowledge of the circulatory, urinary, and other body systems necessary to perform assigned specimen collection tasks.

Introduction

Body systems are the organ systems formed when organs join with other organs or structures to carry out vital body functions. For example, the heart and blood vessels unite to form the cardiovascular system. The cardiovascular system's organs circulate blood throughout the body to ensure that all body cells receive enough nutrients.

There are 12 body systems: the integumentary, skeletal, muscular, lymphatic, immune, respiratory, digestive, nervous, endocrine, cardiovascular, urinary, and male and female reproductive systems. The study of the structure of body systems is known as human anatomy. The study of the function of body systems is known as human physiology.

Illness, diseases, and disorders require investigation to determine the cause and/or the best treatment. Illness refers to the subjective symptoms of feeling unwell, whereas diseases have specific, identifiable causes and symptoms, and disorders include specific abnormalities to the body.

The diseases and disorders that affect the human body can be classified according to the body system or systems they affect. For example, a bladder infection can be classified as a disease of the urinary system. Physicians diagnose diseases and disorders by examining the patient's physical symptoms and by ordering laboratory and other diagnostic tests. Therefore, one method of classifying laboratory tests is to organize them according to body system. This chapter contains a brief review of each body system, followed by common diseases and disorders that affect that system and the laboratory tests used to diagnose or monitor them.

5.1 Integumentary System

The **integumentary system** is unique in that it encloses and protects all of the other body systems. It consists of the skin (derm/o, dermat/o, cutane/o), hair (trich/o), nails (onych/o, ungu/o), and sebaceous (oil) and sudoriferous (sweat) glands. The integumentary system provides protection, regulates temperature, and prevents water loss. When sunlight hits the skin, it converts the substance

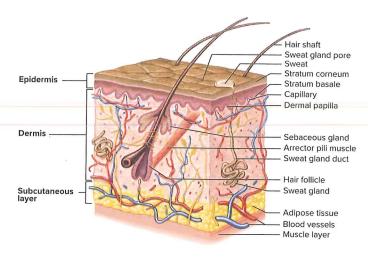


Figure 5-1 The integumentary system.

7-dehydrocholesterol to vitamin D. The skin, which is the largest organ of the body, also helps in sensory perception. Sensory perception is the interpretation or awareness of sensory stimulation. Touch is one of your senses. In the skin, there are nerve endings that create your sense of touch. See Figure 5-1.

Integumentary System Disorders and Associated Lab Tests

Viruses that affect the skin, such as rubella, rubeola, and herpes zoster, which causes chickenpox and shingles, are common integumentary system disorders. Some allergies also cause skin disorders, such as rashes. Fungal infections are a common problem for toenails, fingernails, and skin. One of the more serious integumentary system disorders is skin cancer. The three major types of skin can-

cer are squamous cell carcinoma, basal cell carcinoma, and melanoma. Of the three, melanoma is the most serious. Table 5-1 lists common laboratory tests used to diagnose these and other disorders of the integumentary system.

TABLE 5-1 Tests for Common Integumentary Diseases and Disorders

Tests	Description of Test	Related Diseases and Disorders		
Blood Tests				
Antibody titers	Measures level of antibodies to specific antigens. Commonly used to determine whether a patient has (or has had in the past) certain diseases	Rubella, rubeola, chickenpox, shingles, systemic lupus erythematosus (SLE); also used to check for immune deficiencies and autoimmune disease		
Immunoglobulin levels	Measures immunoglobulin levels; high level of immunoglobulin A (IgA) or E (IgE) indicates an allergic response	Seasonal allergies, immunodeficiencies		
	Other Tests to Assess the Integur	mentary System		
Wet prep	Microscopic evaluation of skin or nail scraping	Fungal infections of the skin or nails		
Culture of scraping	Skin scraping is placed in or on a culture medium that supports the growth of microorganisms. The microorganisms that grow are then examined under a microscope to diagnose infections caused by <i>Staphylococcus aureus</i> and other bacterial, fungal, and parasitic infections	Staphylococcus ("staph") infection Athlete's foot Ringworm Fingernail or toenail infection		
Skin biopsy	Small piece of skin tissue is removed and examined under a microscope	Skin cancer		
Urine melanin	Urine is tested for level of melanin, a skin pigment that may be found in urine if melanoma is present	Skin cancer (melanoma)		



- 1. List at least four functions of the integumentary system.
- 2. List the types of specimens that are commonly tested for integumentary diseases and disorders and the tests performed on each specimen type.

5.2 Skeletal System

The **skeletal system** consists of bones (oste/o), associated cartilages (chondr/o), ligaments, and joints (arthr/o, articul/o). The skeletal system provides the body with protection and support. The ribs protect the heart and lungs. The bones support the soft tissues of the body and provide a place for muscles to attach. They produce blood cells and store minerals and fat. The bones can also store excess calcium (calc/i). See Figure 5-2 for the locations of several major bones of the skeletal system.

Skeletal System Disorders and Associated Lab Tests

Diseases and disorders that affect the skeletal system include osteoporosis, osteoarthritis and rheumatoid arthritis, gout, osteosarcoma (bone cancer), and various disorders related to nutritional deficiencies or poor posture. Many of these disorders are diagnosed based on symptoms and diagnostic images, such as X-rays, but the phlebotomist may be asked to draw blood for several different diagnostic tests, as described in Table 5-2. Phlebotomists may also be trained to assist physicians with collection of bone marrow.

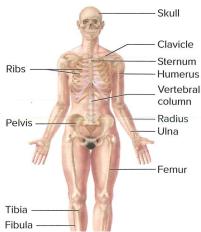


Figure 5-2 The skeletal system.

TABLE 5-2 Tests for Common Skeletal System Diseases and Disorders

Tests	Description of Test	Related Diseases and Disorders
	Blood Tests	
Alkaline phosphatase (ALP)	Screens for abnormal levels of ALP in the blood	Bone tumors, Paget's disease (abnormal bone enlargement and deformation)
Calcium (Ca)	Screens for abnormal blood calcium levels	Rickets (children) or osteomalacia (adults); these diseases involve softening of the bones and serum calcium levels tend to be decreased; increased calcium can be seen in skeletal immobilization
Erythrocyte sedimentation rate (ESR)	Measures the rate at which erythrocytes settle at the bottom of a calibrated tube; elevated levels indicate the presence of inflammation	Some types of arthritis, including rheumatoid arthritis
Phosphorus (P)	Measures phosphorus levels in serum, which contains only 15% of the body's phosphorus; the majority (85%) is stored in the bones	Gastrointestinal problems, malabsorption
Rheumatoid factor (RF)	Tests for the autoantibody that is present in rheumatoid arthritis	Rheumatoid arthritis (but not juvenile-type rheumatoid arthritis)
Uric acid	Measures the level of uric acid in the blood to determine whether the body is breaking it down properly	Gout (a type of arthritis in which the body does not break down uric acid adequately)
Vitamin D Screens for abnormal levels of vitamin D		Bone weakness or malformation or abnormal metabolism of calcium
	Other Tests to Assess the Skeletal	System
Bone marrow biopsy	A needle biopsy to remove bone marrow for diagnostic tests	Multiple myeloma (cancer that starts in bone marrow)
Synovial fluid analysis	Battery of tests that includes visual analysis; microscopic analysis; measurement of glucose proteins, LDH, and uric acid; and bacterial culture	Gout, other types of arthritis, joint infections
Urine uric acid	Screens for excessive uric acid in urine collected over a 24-hour period	Gout



- 1. Which blood tests might be ordered if a healthcare provider suspects that a child has rickets?
- 2. Which tests might be ordered if a patient is suspected of having rheumatoid arthritis?

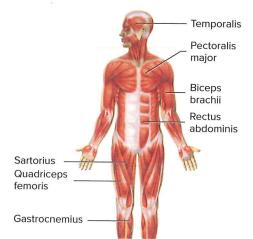


Figure 5-3 The muscular system.

5.3 Muscular System

The **muscular system** produces body movements, such as the abduction, adduction, extension, and flexion of the bones in the skeletal system. Muscle (*my/o, muscul/o*) tissue contracts, or shortens, to move parts of the skeleton, vessels, and internal organs (*viscer/o*). Muscles also produce body heat. Some muscles stay partially contracted to help maintain posture. For example, the muscles in the back tighten to keep the spine straight. Muscles receive direction from the nervous system to contract or relax.

The muscular system consists of three types of muscles—cardiac, smooth, and skeletal. Some muscles are voluntary, and others are involuntary. Skeletal muscles produce movement and facial expression. They are voluntary, meaning that you can consciously control them. Smooth muscle and cardiac muscle are both involuntary muscles; they contract without your conscious effort or awareness.

Smooth muscles line the blood vessels and the walls of hollow organs such as the intestines. Cardiac muscles pump blood through the heart.

Connective tissue is necessary for the skeletal and muscular systems to work together. **Tendons** attach muscles to bones and **ligaments** attach bones to other bones. Figure 5-3 shows some of the major skeletal muscles in the muscular system.

Muscular System Disorders and Associated Lab Tests

Muscles are subject to strains and sprains, including some that involve serious muscle damage. Tendonitis is a painful inflammation of a tendon, usually due to either a sports injury or repetitive activities such as using a computer. Other common disorders include torticollis ("wry neck"), fibromyalgia, myasthenia gravis, and muscular dystrophy. Muscles may also become infected by parasites. Laboratory tests used to assess the muscular system are described in Table 5-3.

TABLE 5-3 Tests for Common Muscular System Diseases and Disorders

Tests Description of Test		Related Diseases and Disorders
	Blood Tests	
Aldolase	Screens for blood levels of aldolase, which is used in glycolysis	Muscular dystrophy, muscle cell damage, and infections in muscle tissue
Autoimmune antibodies	Screens for abnormal antibody levels that may indicate various autoimmune diseases	Myasthenia gravis, polymyalgia rheumatica, lupus erythematosis
Creatine kinase (CK)	Measures the level of the enzyme creatine kinase in the blood; CK-MM is specific to skeletal muscle damage, while CK-MB will also be affected by skeletal muscle disorders	General muscle damage, muscular dystrophy, skeletal muscle disease, muscle damage due to myocardial infarction (heart attack)
Lactate/lactic acid	Monitors production of lactic acid during muscle activity or due to certain medications	Heart failure

Body Mechanics

Body mechanics can be defined as the positions and movements used to maintain proper posture and to avoid muscle and bone injuries. Preventing strains helps you avoid injury to the body, especially the back. As a phlebotomist, you will often need to lift, move, and carry objects. On occasion, you may need to lift, transfer, or position patients.

To prevent injury, you should use good body mechanics. Consider the following techniques:

- Maintain good posture: Keep your back straight and your feet about shoulder-width apart.
- Avoid reaching: Move close to the patient or the object you will be lifting.
- Avoid twisting while lifting: Face the patient or object directly.
- Lift correctly: Use the strong muscles of your legs by bending your hips and knees. Avoid using the muscles of your back to lift.
- Carry carefully: Avoid lifting heavy objects or patients. Ask for assistance.
 Carry objects close to your body.
 - 1. Name two autoimmune diseases that affect the muscular system and the blood test that may be ordered to diagnose them.
 - 2. Which tests might be ordered to help determine the extent of a given muscle injury?



Safety &

Infection

Control

5.4 Lymphatic and Immune Systems

The **immune system** (immun/o) is responsible for protecting the body against bacteria, viruses, fungi, toxins, parasites, and cancer. It provides protection by circulating white blood cells (cyt/o) and antibodies throughout the body.

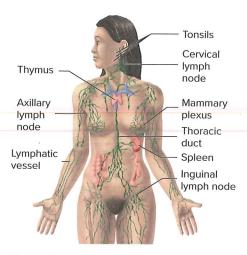


Figure 5-4 Organs of the lymphatic and immune systems.

Antibodies are formed by the white blood cells when a foreign substance (antigen) invades the body. Once produced, the antibodies remain in the body, so if the same foreign substance invades the body a second time, the antibodies are already there to do their job. As a result, if someone gets sick with a disease such as chickenpox, that person typically does not get sick from it again.

There are different immune responses based on the different antigens (enemies) that threaten the body. So, the body's response and the antibodies produced are different for chickenpox than for mononucleosis. The antibody immunoglobulin G (IgG) is most abundant. It is found in all body fluids, and it protects the body from bacterial and viral attacks. Immunoglobulin M (IgM) is found in the lymph fluid and blood and is the first antibody produced when exposure to a particular disease occurs. IgM is temporary, appearing only when exposure occurs. IgG lasts for a lifetime. Testing for immunoglobulins tells a lot about the functioning of the immune system.

The immune system works with the organs of the **lymphatic system** (*lymph/o*) to clear the body of disease-causing agents. It removes foreign substances from the blood and lymph the way a filter removes solids from a liquid. The lymphatic system helps maintain tissue fluid balance and absorbs fats from the digestive tract; it returns excess fluid and proteins from the tissues to the bloodstream. The lymphatic vessels (*angi/o*, *vas/o*, *vascul/o*), lymph nodes, glands (*aden/o*), tonsils, thymus, and spleen make up this system. The organs of the lymphatic and immune systems are shown in Figure 5-4.

Lymphatic and Immune Disorders and Associated Lab Tests

The purpose of the lymphatic and immune systems is to help fight disease, but these systems can be the focus of diseases and disorders, just like all the other body systems. Mononucleosis, chronic fatigue syndrome, HIV/AIDS, and lymphedema (blockage of the lymphatic vessels) are examples of disorders associated with these systems. Allergies are the result of an immune response to dust, smoke, pollen, or hundreds of other stimulants.

In some cases, the immune system malfunctions and attacks the body itself. This is known as an **autoimmune disease**. Rheumatoid arthritis, ulcerative colitis, and myasthenia gravis are examples of autoimmune diseases. Common laboratory tests related to the lymphatic and immune systems are described in Table 5-4.

TABLE 5-4 Tests for Common Lymphatic and Immune System Diseases and Disorders

Tests Description of Test		Related Diseases and Disorders
	Blood Tests	
Antinuclear antibody panel (ANA)	Measures levels of the antibodies produced by the immune system that attack body tissues	Rheumatoid arthritis, systemic lupus erythematosus, scleroderma, thyroid disease
Complete blood count (CBC)	Count of red and white blood cells and platelets, amount of hemoglobin in the blood, and hematocrit (the fraction of blood composed of red blood cells); often performed with a differential (CBC/diff) to count the various types of white blood cells	Allergies, infections, anemia

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- 1. Briefly describe how the lymphatic and immune systems work together to protect the body from harmful microorganisms.
- 2. What is an autoimmune disease? Give three examples and list laboratory tests that may be performed to identify each example.



5.5 Respiratory System

The **respiratory** (*pneum/o*, *pneumon/o*, *pneumat/o*) system provides oxygen (ox/o, oxia), or O_2 , to body cells and removes carbon dioxide (capnia), or CO_2 . Respiration, or breathing (pnea, spir/o), is the process of taking in oxygen and giving off carbon dioxide. Oxygen enters the lungs and is transferred to hemoglobin on the red blood cells. The red blood cells transport the oxygen to the tissues of the body. The blood also picks up waste gases, including carbon dioxide, in the tissues and carries them to the lungs (pulm/o, pulmon/o). The gases leave the blood cells and are removed from the body when the person exhales. Internal respiration is the gas exchange between the tissue cells and the blood. External respiration is the exchange of gases between the blood and the lungs (pulm/o, pulmon/o). Ventilation is the mechanism of breathing that exchanges gases between the lungs and the external environment.

The respiratory system includes the lungs and the airways (trachea, bronchi, and bronchioles) as well as the nasal and oral cavities. The lungs are surrounded by a cavity enclosed in a membrane. This cavity normally contains a small amount of fluid, called pleural fluid. These structures are shown in Figure 5-5.

Respiratory System Disorders and Associated Lab Tests

Many diseases and disorders can impact the respiratory system. They include mild problems such as upper respiratory infections, laryngitis, bronchitis, and sinusitis as well as more serious diseases. Influenza (FluA, FluB, and H1N1—a type of FluA), COVID-19 (caused by the novel coronavirus SARS-CoV-2), respiratory syncytial virus (RSV), asthma, pneumonia, tuberculosis, chronic obstructive pulmonary disease (COPD, which includes chronic bronchitis and emphysema), Legionnaire's disease, cystic fibrosis, tuberculosis (TB), and lung cancer are examples of serious respiratory disorders.

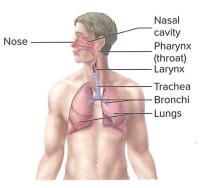


Figure 5-5 The respiratory system.

Atelectasis, or collapsed lung, generally occurs as a result of trauma but can be the result of COPD or other medical problems.

The respiratory system, along with the urinary system, maintains the balance between O₂ and CO₂ and regulates the pH of the blood. If the lungs do not adequately remove CO₂ from the blood, the increase in CO₂ level makes the blood more acidic (a lower pH). This can result in a serious condition known as **respiratory acidosis**. The reverse occurs when too much CO₂ is expelled from the blood, as in hyperventilation. Because of the relatively higher levels of O₂, the blood becomes more alkaline (a higher pH). This can result in **respiratory alkalosis**.

Diagnostic tests of the respiratory system are generally related to the presence of various gases in the blood, most notably oxygen and carbon dioxide, or the identification of disease-causing microorganisms. Table 5-5 describes laboratory tests related to the respiratory system.

TABLE 5-5 Tests for Common Respiratory Diseases and Disorders

Tests	Description of Test	Related Diseases and Disorders	
	Blood Tests		
Arterial blood gases (ABG)	Measures levels of oxygen, carbon dioxide, and bicarbonate (HCO ₃) as well as the pH (acidity or alkalinity) in arterial blood	Respiratory acidosis, respiratory alkalosis, emphysema, chronic obstructive pulmonary disease (COPD)	
Complete blood count (CBC)	Count of red and white blood cells and platelets, amount of hemoglobin in the blood, and hematocrit (the fraction of blood composed of red blood cells)	Respiratory tract infections elevate the WBC count; an increased RBC count may indicate that the body is trying to compensate for a lack of oxygen	
COVID-19	Detects antibodies to SARS-CoV-2 infection or vaccination	May indicate a certain level of immunity	
DNA study	Analyzes DNA sample to look for genetic sequences that suggest specific diseases affecting the respiratory system	Cystic fibrosis	
Electrolytes (Na, K, Cl, CO ₂) Measures blood levels of sodium, potassium, chloride, and carbon dioxide (in the form of bicarbonate [HCO ₃ —])		Cushing's syndrome, COPD, and acute disorders such as ketoacidosis, methanol poisoning, or aspirin overdose	
	Other Tests to Assess the Respirator	y System	
Bronchial washing	The patient's respiratory tract is flushed with a saline solution, which is then analyzed and examined under a microscope for the presence of foreign particles	Asbestosis and other environment- related respiratory disorders; lung cancer	
Respiratory pathogen panel	Nasopharyngeal swabs are tested using DNA probes and polymerized chain reaction (PCR) to detect various viral infections	Influenza, H1N1, RSVa, RSVb, SARS-CoV-2	
Pleural fluid analysis	Analysis of fluid that has collected in the pleural cavity Lung cancer, infection		
Rapid tests	Nares swabs, nasopharyngeal swabs, and throat swabs are used to perform rapid testing for the presence of various pathogens.	SARS-CoV-2, FLU and RSV, and Group A Streptococcus, respectively	
Sputum culture	Secretions from the lungs and bronchi are placed on a culture medium; any microbial growth is examined microscopically; often includes sensitivity testing (culture and sensitivity or C&S) to determine effectiveness of various antibiotics	Bronchitis, lung abscess, pneumonia, tuberculosis	
Throat culture	Material swabbed from the back of the patient's throat is placed on a culture medium; any microbial growth is examined microscopically; often includes sensitivity testing	Various bacterial infections, including strep	

- 1. What is the difference between internal respiration and external respiration?
- 2. Which four electrolyte levels are most commonly tested to detect an electrolyte imbalance that could indicate a respiratory disease?



5.6 Digestive System

The **digestive system** is responsible for the intake and digestion of food, the absorption of nutrients, and the removal of solid waste. The organs of the digestive system can be divided into two categories: organs of the alimentary canal and accessory organs. The alimentary canal is the long tube that transports what we eat. The organs of the alimentary canal extend from the mouth (or/o) to the anus (an/o). They are the mouth, pharynx (pharyn/o), esophagus, stomach, small intestine, large intestine, rectum, and anus. The accessory organs are the teeth, tongue, salivary glands, liver, gallbladder, and pancreas.

Digestion is the chemical and mechanical breakdown of foods into forms that your body can absorb (nutrients). Chemical digestion starts when the enzyme amylase, secreted in the mouth, begins breaking down food. The tongue (gloss/o) and teeth (odent/o, dent) assist in the mechanical breakdown of food. Pepsin/pepsinogen in the stomach also provide chemical breakdown. Nutrients are passed to various body cells and waste products are removed through the rectum. Nutrients and waste are both products of digestion. The organs of the digestive system are shown in Figure 5-6.

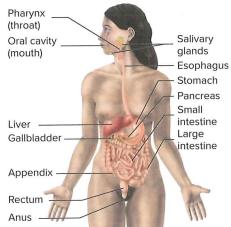


Figure 5-6 The digestive system.

Digestive System Disorders and Associated Lab Tests

Many digestive system disorders are specific to individual organs. For example, Type 1 diabetes mellitus is a disorder in which the pancreas does not produce enough insulin. Ulcers generally occur in the stomach (gastr/o) or intestines. Hepatitis is an inflammation of the liver. Other disorders involve more than one organ or even the digestive system in general. For example, gastroesophageal reflux disease (GERD) affects both the stomach and the esophagus. Because all of the organs of the digestive system work together in the digestive process, laboratory tests are frequently needed to isolate the cause of symptoms related to this system. Table 5-6 describes some of these tests.

TABLE 5-6 Tests for Common Digestive Diseases and Disorders

Tests Description of Test		Related Diseases and Disorders
	Blood Tests	
Albumin	Measures the amount of albumin in the blood	Malnutrition, malabsorption, chronic inflammatory diseases, chronic liver diseases
Aldolase	Screens for blood levels of aldolase, which is used in glycolysis	Chronic hepatitis, obstructive jaundice
Alkaline phosphatase (ALP)	Screens for abnormal levels of ALP in the blood	Biliary cirrhosis, bile duct obstruction, liver disease
Ammonia (NH ₃)	Measures ammonia buildup in the blood	Hepatic encephalopathy

TABLE 5-6 Tests for Common Digestive Diseases and Disorders (Continued)

Tests	Description of Test	Related Diseases and Disorders
	Blood Tests	
Amylase	Measures the amount of the enzyme amylase in the blood	Pancreatic disorders, perforated bowel
Carcinoembryonic antigen (CEA)	Detects CEA in the blood; CEA is an antigen that is found in the blood when certain types of cancers are present	Intestinal, pancreatic, thyroid, lung, and breast cancer, as well as cancers of the reproductive and urinary tracts
Carotene	Determines the level of carotene in the blood	Vitamin A deficiency
Glucose	Measures the amount of glucose (sugar) in the blood	Type 2 diabetes, overactive or underactive thyroid gland, pancreatic cancer, pancreatitis
Glucose tolerance test (GTT)	Measures the amount of glucose (sugar) in the blood over a specific length of time after ingestion of a specific dose of glucose	Type 2 diabetes, gestational diabetes, Cushing's syndrome
Hemoglobin A1c	Measures the average blood sugar over the past 2 to 3 months	Type 2 diabetes, prediabetes
Lipase	Measures the amount of the enzyme lipase in the blood	Pancreatic disorders
Liver function tests (hepatic function panel)	See Table 5-13	Hepatitis, cirrhosis, other chronic liver diseases
Magnesium (Mg)	Measures the amount of magnesium in the blood	Malnutrition, malabsorption, alcoholism, diabetic acidosis
Methylenetetrahydrofolate reductase (MTHFR) test	Detects genetic mutation of the MTHFR gene	Enzyme deficiency, causing poor folate metabolism
Nutritional analysis	Measures the blood levels of various vitamins	Malnutrition, nutritional imbalance or deficiency
Potassium (K)	Measures the amount of potassium in the blood	Cushing's syndrome, gastrointestinal disorders
Triglycerides	Measures the blood level of triglycerides	Decreased in malnutrition, malabsorption; increased in glycogen storage disease, high-carbohydrate diets, uncontrolled diabetes
Vitamins	Measures the levels of various vitamins (A, B, C, etc.) in the blood	Malnutrition, malabsorption, nutritional imbalance related to specific enzyme deficiencies
Zinc	Measures the blood level of zinc	Deficiency can cause stunted growth, diarrhea, increased infections
	Other Tests to Assess the Digestive	e System
Biopsies of various gastrointestinal organs	Removal of a small piece of tissue through a biopsy needle for examination	Cancers associated with the individual organs
Fecal fat	Measures amount of fat in the feces to determine how well fat is being absorbed by the body	Pancreatitis, gallstones, Crohn's disease, pancreatic cancer, celiac disease
Fecal occult blood	Determines whether blood is present in the stool	Colon cancer, other gastrointestinal cancers, esophagitis, gastritis, hemorrhoids, inflammatory bowel disease
Fecal white blood cells	Checks for white blood cells in the feces to help determine the cause of inflammatory diarrhea	Ulcerative colitis, salmonellosis, shigellosis

Tests Description of Test		Related Diseases and Disorders
	Other Tests to Assess the Digestive	System
Gastric fluid analysis	Determines the pH and content of residual gastric fluid in the stomach	Gastric ulcer, gastric cancer, tuberculosis, pernicious anemia
Gastrointestinal pathogen panel	A stool sample is analyzed for the RNA or DNA of various known gastrointestinal pathogens.	Gastrointestinal (GI) infection by viral and/ or bacterial pathogens
Peritoneal fluid analysis	Examines fluid taken from the abdominal cavity (peritoneal space) for presence of albumin, protein, and red and white blood cells	Peritonitis, cirrhosis of the liver, lymphoma, other gastrointestinal cancers
Stool culture	Stool sample is placed on culture medium; any microbial growth is examined microscopically	Bacterial gastroenteritis, infections caused by <i>E. coli, C. difficile</i> , and other bacteria
Stool for ova and parasites (O&P)	Stool specimen is examined microscopically to determine whether certain parasites or their ova (eggs) are present	Amebiasis, giardiasis, and other parasitic infections
Urine chemistries	Measure levels of glucose, ketones, protein, and other chemicals in the urine	Gastrointestinal infections, type 1 diabetes, anorexia, malnutrition, hyperthyroidism

- 1. Name the organs of the digestive system and the accessory organs.
- 2. What tests are generally included in a hepatic function panel?



5.7 Nervous System

The **nervous system** is responsible for conscious actions, such as voluntary muscle movements, and unconscious actions, such as breathing. The two major divisions are the central nervous system (CNS) and the peripheral nervous system (PNS). The CNS consists of the brain (*encephal/o*) and the spinal cord (*myel/o*), whereas the cranial (*crani/o*) nerves (*neur/o*) and the spinal nerves make up the PNS. The nervous system functions by transmitting electrical impulses.

Neurons, or nerve cells, make up the conducting tissue of the nervous system. There are three types of neurons: sensory neurons, motor neurons, and interneurons. Sensory neurons in the PNS are responsible for taking stimuli from the environment or inside the body to the CNS. Interneurons, located in the brain and spinal cord, interpret the information from the sensory neurons and pass it on to the motor neurons. Motor neurons take the interpreted information from the CNS to the PNS and then to a muscle or gland to react to the stimuli.

An example of how the nervous system works would be seeing a red light while driving. The sensory neurons in your eyes note the color and send the information to the brain, where the interpretation takes place. Interneurons pick up the signal, interpret it, and send the information to motor neurons that you are supposed to stop your vehicle, which in turn sends the instructions to your right foot to step on the brake pedal of your vehicle. This entire transaction, of course, takes place in milliseconds, allowing you to stop in time.

The tissue that supports and protects the nervous tissue is the neuroglia, which forms a web around nervous tissue. The nervous system includes the brain, spinal cord, and peripheral nerves. See Figure 5-7.

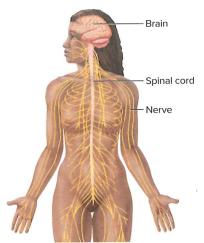


Figure 5-7 The nervous system.

Nervous System Disorders and Associated Lab Tests

Diseases and disorders of the nervous system range from trauma to headaches to complex conditions such as epilepsy and amyotrophic lateral sclerosis (ALS, Lou Gehrig's disease). Some, such as cerebrovascular accident (CVA, stroke), Alzheimer's disease, and meningitis, are associated specifically with the brain. Other disorders, including multiple sclerosis, sciatica, and Guillain-Barré syndrome, are linked with the nerve cells. Table 5-7 describes laboratory tests used to diagnose or monitor diseases and disorders of the nervous system.

TABLE 5-7 Tests for Common Nervous System Diseases and Disorders

Tests	Description of Test	Related Diseases and Disorders
	Blood Tests	
Acetylcholine receptor antibody	Determines presence or absence of acetylcholine receptor antibody	Myasthenia gravis
Creatine kinase brain/smooth muscle isoenzyme (CK-BB)	Measures the level of the creatine kinase BB isoenzyme in the blood	Cerebrovascular accident (CVA, stroke), lung cancer
Drug levels	Measures the blood levels of various therapeutic drugs to monitor patient response and to help determine therapeutic levels	Epilepsy, other brain disorders
Zinc	Measures the blood level of zinc	Mental confusion, depression
	Other Tests to Assess the Nervous Syste	m ·
Cerebrospinal fluid (CSF) analysis	Measures levels of proteins, glucose, antibodies, and other components in CSF (components tested vary)	Meningitis, encephalitis, cancer, Reye's syndrome
CSF culture	CSF is placed on culture medium; any microbial growth is examined microscopically; often includes sensitivity (C&S)	Aseptic meningitis, tuberculosis, cryptococcosis, fungal infections
CSF immunoglobulin levels	Measures immunoglobulin G (IgG) level in the CSF	Acute bacterial meningitis



- 1. Name two diseases or disorders associated specifically with the brain and two that are associated with the nerve cells.
- 2. Which isoenzyme of creatine kinase may be ordered if a patient shows signs and symptoms of stroke?

5.8 Endocrine System

The **endocrine system** (*endo*, "within," and *crine*, "to secrete") includes the organs of the body that secrete hormones directly into body fluids, including the blood. It controls the functions of organs and tissues at the cellular level. Unlike the nervous system, which controls the body immediately through nerves, the endocrine system controls the body over time using hormones. Hormones are chemicals secreted by a cell that affect the functions of other

cells. The endocrine system is made up of glands that secrete various hormones (Figure 5-8).

Hormones help regulate the chemical reactions within cells. Once released, most hormones enter the bloodstream, which transports them to their target cells. A hormone's target cells are those that contain the receptors for the hormone. A hormone cannot affect a cell unless the cell has receptors for it, in much the same way that a locked door needs the key specifically cut to open its lock. The receptors are stimulated or inhibited by the hormone, and the tissue reacts accordingly. For example, the hormone insulin is secreted by the pancreas to cause a decrease in blood glucose level. The hormone oxytocin is secreted by the pituitary gland when a woman is breast-feeding, causing milk to be released from the breast. Table 5-8 describes the hormones secreted by the glands of the endocrine system.

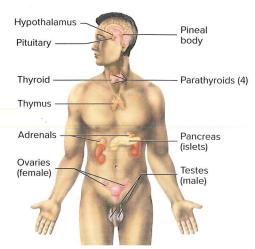


Figure 5-8 The endocrine system.

TABLE 5-8 Endocrine Glands: Their Hormones and Actions

Gland	Hormone	Action Produced
Hypothalamus (produces)	Antidiuretic hormone (ADH)	Stored and released by posterior pituitary; stimulates kidneys to retain water
	Oxytocin (OT)	Stored and released by posterior pituitary; stimulates uterine contraction for labor and delivery
Anterior pituitary	Growth hormone (GH)	Promotes growth and tissue maintenance
	Melanocyte-stimulating hormone (MSH)	Stimulates pigment regulation in epidermis
	Adrenocorticotropic hormone (ACTH)	Stimulates adrenal cortex to produce its hormones
	Thyroid-stimulating hormone (TSH)	Stimulates the thyroid to produce its hormones
	Follicle-stimulating hormone (FSH)	(F) Stimulates ovaries to produce ova and estrogen (M) Stimulates testes to produce sperm and testosterone
	Luteinizing hormone (LH)	(F) Stimulates ovaries for ovulation and estrogen production (M) Stimulates testes to produce testosterone
	Prolactin (PRL)	(F) Stimulates breasts to produce milk (M) Works with and complements LH
Posterior pituitary	Antidiuretic hormone (ADH)	Stimulates kidneys to retain water
(releases)	Oxytocin (OT)	Stimulates uterine contraction for labor and delivery Promotes lactation by moving milk into the breast during breastfeeding
Pineal body	Melatonin	Regulates biological clock; links to onset of puberty
Thyroid	Triiodothyronine (T3) and thyroxine (T4)	Protein synthesis and increased energy production for all cells
	Calcitonin	Increases bone calcium and decreases blood calcium
Parathyroid	Parathyroid hormone (PTH)	Agonist to calcitonin; decreases bone calcium/increases blood calcium
Thymus	Thymosin and thymopoietin	Both hormones stimulate the production of T-lymphocytes
Adrenal cortex	Aldosterone	Stimulates body to retain sodium and water

TABLE 5-8 Endocrine Glands: Their Hormones and Actions (Continued)

Gland	Hormone	Action Produced
	Cortisol	Decreases protein synthesis; decreases inflammation
Adrenal medulla	Epinephrine and norepinephrine	Prepares body for stress; increases heart rate, respiration, and blood pressure
Pancreas (islets of Langerhans)	Alpha cells: glucagon	Increases blood sugar; decreases protein synthesis
	Beta cells: insulin	Decreases blood sugar; increases protein synthesis
Gonads: ovaries (female)	Estrogen and progesterone	Secondary sex characteristics; female reproductive hormone
Gonads: testes (male)	Testosterone	Secondary sex characteristics; male reproductive hormone

Endocrine System Disorders and Associated Lab Tests

Most endocrine disorders are caused by glands either oversecreting or undersecreting their hormones. Probably the most common and best-known endocrine disorder is diabetes mellitus. In type 1 diabetes, the pancreas does not produce insulin. In type 2 diabetes, either the body does not produce enough insulin or the body cells do not use it efficiently. A third type of diabetes—gestational diabetes—occurs only during pregnancy.

Other endocrine disorders include oversecretion or undersecretion of growth hormone, resulting in giantism or dwarfism, and oversecretion or undersecretion of ACTH, resulting in Addison's disease and Cushing's syndrome, respectively. Table 5-9 lists commonly ordered laboratory tests for the endocrine system.

TABLE 5-9 Tests for Common Endocrine System Diseases and Disorders

Tests	Description of Test	Related Diseases and Disorders
	Blood Tests	
A1c (glycated hemoglobin)	Determines the patient's average blood glucose level over the past 2 to 3 months	Types 1 and 2 diabetes mellitus, prediabetes
Adrenocorticotropic hormone (ACTH)	Measures the level of the ACTH hormone in the blood	Addison's disease, Cushing's syndrome, tumor of the adrenal gland, hypopituitarism
Antidiuretic hormone (ADH)	Measures the blood level of ADH, which is produced by the hypothalamus in the brain	Diabetes insipidus, primary polydipsia, brain tumor, brain infection, certain types of lung cancer, stroke
Aldosterone (Ald)	Measures the level of aldosterone in the blood	Addison's disease, congenital adrenal hyperplasia
Calcitonin	Measures blood levels of calcitonin	Thyroid tumors, pancreatic tumors, hyperparathyroidism, thyroiditis
Cortisol	Measures the level of the steroid hormone cortisol in the blood	Addison's disease, Cushing's syndrome, tumor of the adrenal gland, hypopituitarism, acute adrenal crisis
Fasting blood glucose (also called fasting blood sugar or FBS)	Measures the level of glucose in the blood after the patient has fasted for at least 8 hours	Prediabetes, type 2 diabetes, overactive or underactive thyroid gland, pancreatic cancer, pancreatitis

Tests	Description of Test	Related Diseases and Disorders
	Blood Tests	
Follicle-stimulating hormone (FSH)	Measures the level of FSH in the blood	Female: menopause, polycystic ovary syndrome, ovarian cysts, infertility, anorexia, Turner's syndrome Male: Klinefelter's syndrome, infertility
Luteinizing hormone (LH)	Measures the level of LH in the blood	Female: menopause, polycystic ovary syndrome, ovarian cysts, Turner syndrome Male: anorchia, hypogonadism, Klinefelter's syndrome
Glucagon	Measures the level of the hormone glucagon in the blood	Diabetes, Cushing's syndrome, cirrhosis of the liver, hypoglycemia, pancreatitis
Glucose tolerance test (GTT)	Determines how well the body breaks down glucose over a 2- to 3-hour period	Prediabetes, type 2 diabetes, gestational diabetes
Growth hormone (GH)	Measures the level of GH in the blood	Acromegaly, giantism, dwarfism, pituitary tumor
Insulin	Measures the level of insulin in the blood	Diabetes
Renin	Measures the level of renin in the blood	Hypertension (high blood pressure), kidney disorders
Thyroid function panel	Measures the level of T3, T4, and TSH; often includes a thyroid scan with a radioactive iodine tracer as well	Thyroid cancer, goiter, overactive or underactive thyroid gland, Graves' disease, hypopituitarism, thyroid nodule
Zinc	Measures blood level of zinc	Low thyroid hormones, insulin-like growth factor, low testosterone
	Other Tests to Assess the Er	ndocrine System
Urine ketones	Measures the level of ketones in the urine	Type 2 diabetes
Tissue biopsy of individual glands	Removal of a small piece of tissue through a biopsy needle for examination	Cancer of the various glands

- 1. What is the major function of the endocrine system?
- 2. Name four blood tests that might be ordered to diagnose or monitor diabetes mellitus.



5.9 Cardiovascular System

The **cardiovascular system**, sometimes called the *circulatory system*, is responsible for sending blood to the lungs to pick up oxygen and to the digestive system to collect nutrients and then for delivering the oxygen and nutrients throughout the body. It also gathers waste products throughout the body and delivers them to the organ systems that remove them from the body. For example, urea is a waste product that forms when the body breaks down proteins. The blood collects urea throughout the body and circulates it through the kidneys, where it is separated from the blood and eliminated from the body in urine.

The cardiovascular system consists of the heart (cardi/o) and the blood vessels. Blood (hem/o, hemat/o) travels through the vessels (angi/o, vas/o, vascul/o) to take oxygen (ox/o, oxia) and food to all the cells. Figure 5-9 shows the major vessels of the cardiovascular system.

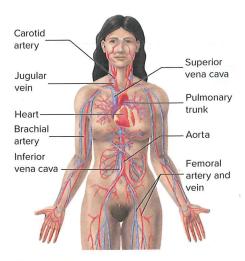


Figure 5-9 The circulatory system.

The Cardiovascular System chapter includes more detailed information about this system and how it works.

Cardiovascular System Disorders and Associated Lab Tests

Diseases and disorders of the cardiovascular system include those related to the heart as well as those related to the vascular system, or blood vessels. Laboratory tests are commonly performed to assess three major aspects of cardiovascular health:

- Heart and circulation
- Blood vessels and hemostasis (control of blood flow in blood vessels)
- Blood cells
 - Red blood cells (RBCs)
 - Concentration as determined by the red blood cell count and hematocrit, which is the portion or percentage of RBCs in whole blood
 - Size as reported by the mean corpuscular volume (MCV)
 - Hemoglobin, the oxygen-carrying protein found in RBCs, which is measured directly and its value used to calculate the mean corpuscular hemoglobin (MCH), the amount of hemoglobin in an average RBC, and the mean corpuscular hemoglobin concentration (MCHC), which reflects how "full" the RBC is of hemoglobin
 - RBC distribution width (RDW), a measure of the difference in size from the patient's smallest RBC to the patient's largest RBC
 - RBC morphology, the blood smear observation of RBC size and shape variation
 - White blood cells (WBCs)
 - Concentration as determined by the WBC count
 - Differential count of the various types of WBCs
 - Platelets
 - Concentration as determined by the platelet count
 - Platelet morphology, the blood smear observation of platelet size variation

Table 5-10 describes tests that are commonly performed to diagnose or monitor diseases and disorders of the cardiovascular system.

TABLE 5-10 Tests for Cardiovascular Diseases and Disorders

Tests	Description of Test	Related Diseases and Disorders		
Blood Tests Related to the Heart and Circulation				
Arterial blood gases	Measures level of oxygen (O_2) , carbon dioxide (CO_2) , and bicarbonate (HCO_3-) as well as the pH (acidity or alkalinity) of arterial blood	Hypoxia, COPD		
Aspartate aminotransferase (AST)	Measures the amount of AST in the blood	Myocardial infarction, cardiac operations and cauterizations, angioplasty		
B-type natriuretic peptide (BNP)	Determines the blood level of B-type natriuretic peptide	Heart failure		
Creatine kinase (CK)	Measures the level of CK-MB (the creatine kinase isoenzyme found mostly in the heart)	Myocardial infarction, heart trauma, myocarditis		

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Tests	Description of Test	Related Diseases and Disorders
	Blood Tests Related to the Heart and Circuit	lation
Lipid profile	Measures levels of total cholesterol, including its components of • low-density lipoprotein (LDL) • high-density lipoprotein (HDL) • very low-density lipoprotein (VLDL) Triglycerides are also part of the lipid profile	Heart disease, cerebrovascular accident (stroke), and conditions related to blocked arteries
Troponin I, Troponin T, (hs) Troponin	Measures the amount of troponin in the blood, which elevates when the heart muscle is damaged	Myocardial infarction
В	lood Tests Related to the Blood Vessels and H	emostasis
Clotting factor assays	Determines the levels of specific clotting proteins; performed when PT or APTT test results are abnormal	Hemophilia, von Willebrand's disease
Clotting inhibitor and antibody studies	Detects and measures inhibitors to various coagulation (clotting) factors in the blood	Congenital factor deficiencies, cancer, immunologic disorders
D-dimer and other fibrin degradation/split products (FDP/FSP)	Measures the blood levels of the byproducts generated when the body breaks down blood clots	Deep vein thrombosis, pulmonary embolism, hypercoagulability
Electrolytes (Na, K, Cl, CO ₂)	Measures blood levels of sodium, potassium, chloride, and carbon dioxide (in the form of bicarbonate)	Congestive heart failure; monitoring of diuretic medications
Fibrinogen	Measures the amount of fibrinogen in the blood	Afibrinogenemia, fibrinolysis, disseminated intravascular coagulation
Homocysteine	Measures the amount of homocysteine in the blood	Risk factor for atherosclerotic vascular disease
Methylenetetrahydrofolate reductase (MTHFR) test	DNA test for mutation of MTHFR gene	Failure to metabolize homocysteine
Platelet count	Determines the number of platelets in the blood	Disseminated intravascular coagulation thrombocytosis, thrombocytopenia, various anemias and leukemias
Platelet function studies	Assess various functions of the platelets	Inherited and acquired platelet function problems
Prothrombin time (PT), (activated) partial thromboplastin time (PTT/ APTT), and international normalized ratio (INR)	Measure the time it takes blood plasma to clot	Clotting factor deficiencies, vitamin K deficiency, disseminated intravascular coagulation, monitoring of anticoagulant therapy
	Blood Tests Related to the Blood Cells	
ABO, Rh factor	Determines the presence of specific antigens on red blood cells	Blood group and typing (performed when transfusions are needed)
Complete blood count (CBC)	Measures the following components of the blood: White blood cells (WBCs) Red blood cells (RBCs) Hemoglobin (Hgb) Hematocrit (Hct) Mean corpuscular volume (MCV) Mean corpuscular hemoglobin (MCH) Red cell distribution width (RDW) Platelet count (PLT)	Blood clotting problems, anemia, systemic lupus erythematosus, leukemia and other blood cancers

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TABLE 5-10 Tests for Cardiovascular Diseases and Disorders (Continued)

Tests	Description of Test	Related Diseases and Disorders
	Blood Tests Related to the Heart and Circu	ulation
Differential .	Determines the percentage of individual types of white blood cells—neutrophils, lymphocytes, monocytes, eosinophils, and basophils—as well as hematopoietic cells such as nucleated RBCs and early stages of WBCs	Benign and malignant causes for imbalance of cell distributions: infections, inflammation, anemia, leukemia, lymphoma, myeloma
Erythrocyte sedimentation rate (ESR)	Measures the rate at which red blood cells fall to the bottom of a specially calibrated tube; an increase of plasma proteins during times of inflammation and other disorders causes RBCs to fall more quickly	Anemia, lymphoma, multiple myeloma, autoimmune disorders, infections, inflammation, arthritis
Flow cytometry	Used to detect cell identification proteins on the surface of blood cells known as cluster designation (CD) markers	Leukemia, lymphoma, myeloma
Hemoglobin electrophoresis (HbEP)	Used to detect abnormal forms of hemoglobin	Various hemoglobinopathies and thalassemia
Iron studies (Fe and TIBC)	Series of tests to measure the level of iron in the serum, the blood's total iron-binding capacity, unsaturated iron-binding capacity, and the amount of iron stored in the body	Iron deficiency, iron-deficient anemia
Malaria test	Microscopic examination of the blood to detect malaria parasites; in some cases, the individual species of parasite is determined	Malaria
Reticulocyte count (Retic)	Measures the percentage of immature red blood cells (reticulocytes) in the blood	Bone marrow failure, erythroblastosis fetalis, hemolytic anemia, aplastic anemia, pernicious anemia, vitamin B ₁₂ deficiency
Sickle cell screening	Screens for abnormal hemoglobin S	Sickle cell anemia, sickle cell disease
	Other Tests to Assess the Cardiovascular Sy	/stem
Blood culture	Determines whether bacteria or other microorganisms are present in the blood	Septicemia
Bone marrow analysis	Ordered when blood counts are abnormal	Anemia, leukopenia, leukocytosis, polycythemia, thrombocytopenia, cancer of the blood or bone marrow, hemochromatosis
Pericardial fluid analysis	Evaluates pericardial fluid (the fluid in the pericardium that lubricates the movement of the heart) to determine the cause of increased fluid levels	Congestive heart failure, lymphoma, mesothelioma, metastatic cancer, pericarditis



- 1. What three aspects of cardiovascular health do laboratory tests generally measure?
- 2. Which blood tests are included in a lipid profile?

5.10 Urinary System

The kidneys (nephr/o, ren/o), ureters (ureter/o), bladder (cyst/o, vesic/o), and urethra (urethr/o) make up the **urinary system**. The urinary (ur/o, uria) system is responsible for

- Removing metabolic waste from the blood
- Maintaining proper balance of water (*hydro*), salts, and acids in the body fluids
- Removing excess fluids from the body

The kidneys are the functional units of the urinary system. They filter and remove metabolic waste products from the blood, such as the urea produced during protein metabolism. The kidneys combine these metabolic wastes with water and ions to form urine (*urin/o*). The urine is transported through the ureters to the bladder, where it is stored until it is excreted. The bladder empties into the urethra, which transports the urine outside the body. Figure 5-10 shows the major organs of the urinary system.

The kidneys also produce hormones such as erythropoietin, which stimulates the bone marrow to produce red blood cells; the hormone renin, which helps regulate blood pressure; and vitamin D, which has many functions throughout the body. The functions of the kidneys are important in maintaining a balanced, stable state in the body's internal environment, a state called homeostasis.



Most of the metabolic processes that take place in the body result in waste products. Because the purpose of the urinary system is to remove wastes from the body, diseases and disorders associated with the urinary system may result in an increase in waste products in the blood. Examples of urinary system disorders include acute or chronic renal (kidney) failure, polycystic kidney disease, kidney stones, glomerulonephritis, pyelonephritis, and cystitis (bladder infection).

If the body retains acids or if the kidneys eliminate too much bicarbonate, it makes the blood more acidic (a lower pH), resulting in a serious condition known as **metabolic acidosis**. The reverse occurs when too much bicarbonate is retained by the body. The blood becomes more alkaline (a higher pH), which can result in a condition known as **metabolic alkalosis**. The urinary system, along with the respiratory system, maintains this balance between O_2 and CO_2 and regulates the pH of the blood. Laboratory tests that are commonly ordered to diagnose or monitor diseases and disorders of the urinary system are listed in Table 5-11.

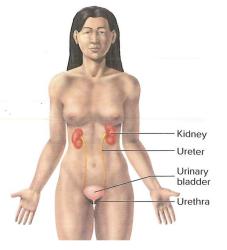


Figure 5-10 The urinary system.

TABLE 5-11 Tests for Common Urinary System Diseases and Disorders

Tests	Description of Test	Related Diseases and Disorders	
	Blood Tests		
Albumin	Measures the level of albumin in blood serum	Chronic renal failure, glomerulonephritis	,
Arterial blood gases	Measures levels of oxygen (O_2), carbon dioxide (CO_2), and bicarbonate (HCO_3), as well as the pH (acidity or alkalinity) of arterial blood	Metabolic acidosis, metabolic alkalosis	

TABLE 5-11 Tests for Common Urinary System Diseases and Disorders (Continued)

Tests	Description of Test	Related Diseases and Disorders
	Blood Tests	
Blood urea nitrogen (BUN)	Measures the level of urea nitrogen in the blood; urea nitrogen is formed when proteins break down	Glomerulonephritis, acute tubular necrosis, pyelonephritis, kidney failure, urinary tract obstruction, acute nephritic syndrome, medullary cystic kidney disease
Creatinine	Measures the level of creatinine in the blood; creatinine is formed when creatine phosphate in the muscles breaks down and is filtered and eliminated by the kidneys	Acute tubular necrosis, glomerulonephritis, urinary tract obstruction, diabetic nephropathy, hemolytic-uremic syndrome
Electrolytes (Na, K, Cl, CO ₂)	Measures blood levels of sodium, potassium, chloride, and carbon dioxide (in the form of bicarbonate (HCO ₃ -)	Decreased levels in chronic renal insufficiency; increases in body water, diuretic administration
Glomerular filtration rate	Provides an estimate of how much blood passes through the glomeruli in the kidneys per minute; glomeruli are the structures in the kidneys that filter waste products from the blood	Chronic renal failure, acute renal failure
Renin	Screen for abnormal levels of the hormone renin in the blood	Renal hypertension, renal tumors
Serum osmolality	Measures the amounts of chemicals in blood serum to determine water balance in the body	Uremia
	Other Tests to Assess the Uring	ary System
Creatinine clearance	Compares the level of creatinine in the blood and urine; requires both a blood sample and a urine sample	Acute tubular necrosis, bladder obstruction, end-stage renal failure, glomerulonephritis, renal ischemia
Renal stone analysis	Stones and crystals passed in the urine are examined and chemically identified	Nephrolithiasis
Urine culture	Urine is placed in a culture medium; any microbial growth is examined microscopically; often includes sensitivity (C&S)	Urinary tract infections
Urinalysis	Examination of physical and chemical properties of urine, including microscopic examination	General health exam; acute nephritic syndrome, acute tubular necrosis, kidney stones, chronic glomerulonephritis, chronic renal failure, cystinuria, enuresis, acute pyelonephritis, urethritis



- 1. Name the three main functions of the urinary system.
- 2. What tests might be ordered if a physician suspects that a patient has glomerulonephritis?

5.11 Female and Male Reproductive Systems

The **female reproductive system** consists of the ovaries, vagina, uterus, mammary glands, and associated structures. This system produces oocytes, which develop into female sex cells called *ova* (eggs; singular: *ovum*), and is the site of fertilization and fetal development. It produces milk for the newborn and hormones that influence sexual function and behaviors. If an ovum is fertilized by a male sex cell (sperm), the female system nurtures the fertilized ovum until birth. Figure 5-11 shows the organs of the female reproductive system.

In the male, several organs are parts of both the reproductive and the urinary systems. The organs in the **male reproductive system** include the testes, accessory structures, ducts, and penis. The male reproductive system produces and transports sperm. It also generates hormones that influence sexual functions and behaviors. Figure 5-12 shows the organs of the male reproductive system.

Reproductive System Disorders and Associated Lab Tests

Disorders of the reproductive systems include infertility, sexually transmitted infections (STIs), and infections as well as cancers of the various reproductive organs. Some diseases, such as epididymitis, prostate cancer, and ovarian cancer, are sex-specific. Others, including most STIs, can occur in both males and females. STIs include chlamydia, gonorrhea, syphilis, herpes simplex, HIV/AIDS, trichomoniasis, and condyloma acuminatum (genital warts). Table 5-12 lists laboratory tests that are commonly ordered to diagnose diseases and disorders of the reproductive systems.

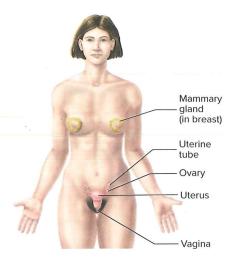


Figure 5-11 The female reproductive system.

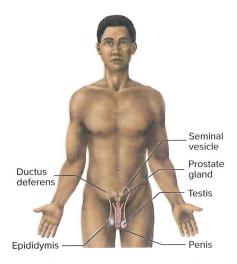


Figure 5-12 The male reproductive system.

TABLE 5-12 Tests for Common Reproductive System Diseases and Disorders

Tests	Description of Test	Related Diseases and Disorders
	Blood Tests	
Acid phosphatase	Measures the amount of acid phosphatase in the blood	Prostate cancer, prostatic hypertrophy, prostatitis
Cancer antigens .	Detects the presence of cancer antigen CA-15-3 or CA-125	Breast cancer, ovarian cancer
Estradiol	Measures the amount of estradiol (a form of estrogen) in the blood	Abnormal sexual development, ovarian cancer, menstrual abnormalities, Turner's syndrome
Follicle-stimulating hormone (FSH)	Measures the level of FSH in the blood	Abnormal sexual development, menopause, polycystic ovary syndrome, ovarian cysts, infertility
Human chorionic gonadotropin (hCG)	Qualitative test determines whether the hormone is present; quantitative test measures the level of hCG in the blood	Normal pregnancy, miscarriage, ectopic pregnancy, ovarian cancer, hydatidiform mole of the uterus, uterine cancer, testicular cancer

TABLE 5-12 Tests for Common Reproductive System Diseases and Disorders (Continued)

Tests	Description of Test	Related Diseases and Disorders
	Blood Tests	
Luteinizing hormone (LH)	Measures the level of LH in the blood	Males: anorchia, hypogonadism, Klinefelter's syndrome
		Females: menopause, polycystic ovary disease, Turner's syndrome
Progesterone	Measures the level of progesterone in the blood	Pregnancy, ovarian cancer, amenorrhea, ectopic pregnancy, adrenal cancer
Prolactin	Measures the level of prolactin in the blood	Galactorrhea, headaches, infertility, erectile dysfunction
Prostate-specific antigen (PSA)	Measures the level of PSA in the blood	Prostate cancer
Rapid plasma reagin (RPR) and VDRL tests	Determine whether antibodies are present to Treponema pallidum, the organism that causes syphilis	Syphilis
Testosterone	Measures the level of testosterone in the blood	Cancer of the testes or ovaries
	Other Tests to Assess the Reproduc	ctive Systems
DNA probes	Cervical swabs, thin preps, and urethral swabs are tested for microorganism DNA such as Neisseria gonorrhea and Chlamydia trachomatis	Sexually transmitted infections
Human papillomavirus (HPV)	Detects the presence of HPV in cells swabbed or scraped from the cervix. The test is performed using DNA probes and polymerized chain reaction (PCR).	Sexually transmitted infection associated with cervical cancer
Microbiology cultures	Performed on semen and other secretions to isolate and identify infection-causing bacteria	Cystitis, epididymitis, other reproductive system infections
Pap smear	Cells scraped from the opening of the cervix are examined microscopically	Cervical cancer
Rapid vaginosis panel	Vaginal swabs	Infections with Candida, Gardnerella, or Trichomonas
Semen analysis	Measures the amount and quality of semen and sperm	Infertility, Klinefelter's syndrome
Tissue biopsy	Removal of a small piece of tissue through a biopsy needle for examination	Cancer of various reproductive organs
Tumor markers	Determines whether substances called tumor markers are present in blood or body fluids that indicate a specific type of tumor	Cancer of various reproductive organs



- 1. List the organs of the male and female reproductive systems.
- 2. Which laboratory tests might be ordered if a female shows signs of abnormal sexual development?

5.12 Test Panels and Profiles

In order to provide efficiency in test ordering, most laboratories offer test panels and profiles. A **test panel** usually consists of laboratory tests associated with one organ or body system, whereas a **test profile** is a group of laboratory tests that provide assessment over at least two body systems. An example of a panel of tests is the hepatic panel, which includes several tests to determine liver function. A metabolic profile is a common example of a profile. A *basic* metabolic profile (BMP) tests only the analytes needed to make an initial assessment. A *comprehensive* metabolic profile (CMP) provides additional tests to assess more body systems.

The laboratory tests included in test panels and test profiles are based on the diagnostic needs of the laboratory's physician clients. In addition, test profiles and panels may change in response to changes in physicians' needs and changes in industry standards. Therefore, the examples of test profiles and panels in Table 5-13 may not be identical to those in the test panels and profiles available at every laboratory.

TABLE 5-13 Common Test Panels and Profiles

Name of Panel or Profile	Included Tests
	Test Panels
Coagulation panel	(Activated) partial thromboplastin time (APPT, PTT) Fibrinogen (Fibr) Prothrombin time (PT) Platelet count
Hepatitis panel	Hepatitis A virus antibody, IgM Hepatitis B virus core antibody, IgM Hepatitis B virus surface antigen Hepatitis C virus antibody
Hypercoagulation panel	All tests in the coagulation panel, plus: Anticardiolipin antibody APC resistance Inhibitor status (ATIII, protein C, protein S) Factor assays (V, VIII) Gene mutation studies (prothrombin, Factor V Leiden) Homocysteine Lupus anticoagulant studies Methyltetrahydrofolate reductase (MTHFR)
Lipid panel	Cholesterol (Chol) HDL LDL VLDL Triglycerides (Trig)
Liver panel	Albumin Alkaline phosphatase (ALP) Alanine aminotransferase (ALT) Aspartate aminotransferase (AST) Gamma-glutamyltransferase (GGT) Bilirubin (total and direct) Total protein

Name of Panel or Profile Included Tests		
	Test Panels	
Obstetrics (OB) panel	ABO group/Rh type Antibody screen Complete blood count (CBC, including differential) Cystic fibrosis gene mutation (according to family history) Hepatitis B surface antigen Rapid plasma reagin (RPR) Rubella IgG	
Renal panel	Albumin Blood urea nitrogen (BUN) Calcium Creatinine Glucose Electrolytes (CI, CO ₂ , Na, K) Phosphorus	
Respiratory virus panel	Adenovirus Coronaviruses (HKU1, NL63, 229E, OC43) Human rhinovirus/enterovirus Influenza (A, A/H1, A/H3, B, H1N1) Parainfluenza virus (1, 2, 3, 4) Respiratory syncytial virus (A, B)	
	Test Profiles	
Basic metabolic profile (BMP)	Blood urea nitrogen (BUN) Calcium (Ca) Carbon dioxide (CO ₂) in the form of bicarbonate (HCO ₃ ') Chloride Creatinine Glucose Potassium (K) Sodium (Na)	
Comprehensive metabolic profile (CMP)	All tests in the basic metabolic profile, plus: Albumin Alanine aminotransferase (ALT) Alkaline phosphatase (ALP) Asparate amino transferase (AST) Bilirubin Total protein	



- 1. What is the difference between a profile and a panel?
- 2. Look again at the digestive system information earlier in the chapter. What tests may be included in a panel designed to determine if patients have malabsorption?

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Learning Outcome	Summary	Related NAACLS Competency
5.1 Describe the functions of the integumentary system, common diseases and disorders that affect this system, and related laboratory tests.	The integumentary system consists of the skin, hair, and nails. Common disorders include viruses that affect the skin, allergies, and cancer. Commonly ordered laboratory tests are listed in Table 5-1.	1.7, 3.1, 3.2
5.2 Describe the functions of the skeletal system, common diseases and disorders that affect this system, and related laboratory tests.	The skeletal system consists of bones, associated cartilages, ligaments, and joints. Common disorders include osteoporosis, osteoarthritis and rheumatoid arthritis, gout, osteosarcoma, and nutritional deficiencies. Commonly ordered laboratory tests are listed in Table 5-2.	1.7, 3.1, 3.2
5.3 Describe the functions of the muscular system, common diseases and disorders that affect this system, and related laboratory tests.	The muscular system consists of the muscles and connective tissue, including tendons and ligaments. Common disorders include strains and sprains, tendonitis, torticollis, fibromyalgia, myasthenia gravis, and muscular dystrophy. Commonly ordered laboratory tests are listed in Table 5-3.	1.7, 3.1, 3.2
5.4 Describe the functions of the lymphatic and immune systems, common diseases and disorders that affect these systems, and related laboratory tests.	The organs of the lymphatic and immune systems include the thymus, lymph nodes, lymphatic vessels, glands, tonsils, and spleen. The immune system protects the body against harmful microorganisms by producing antibodies against specific antigens. The lymphatic system removes foreign substances from the blood and lymph. Mononucleosis, HIV/AIDS, and lymphedema are examples of diseases that affect these systems. Commonly ordered laboratory tests are listed in Table 5-4.	1.7, 3.1, 3.2
5.5 Describe the functions of the respiratory system, common diseases and disorders that affect this system, and related laboratory tests.	The respiratory system includes the lungs, trachea, bronchi, bronchioles, and nasal and oral cavities. Common disorders include upper respiratory infections, bronchitis, pneumonia, lung cancer, and chronic obstructive pulmonary disease (COPD). Commonly ordered laboratory tests are listed in Table 5-5.	1.7, 3.1, 3.2
5.6 Describe the functions of the digestive system, common diseases and disorders that affect this system, and related laboratory tests.	The digestive system organs are the mouth, pharynx, esophagus, stomach, small intestine, large intestine, rectum, and anus; the accessory organs are the teeth, tongue, salivary glands, liver, gallbladder, and pancreas. Common disorders include diabetes mellitus, ulcers, gastroesophageal reflux disease (GERD), and hepatitis. Commonly ordered laboratory tests are listed in Table 5-6.	1.7, 3.1, 3.2
5.7 Describe the functions of the nervous system, common diseases and disorders that affect this system, and related laboratory tests.	The central nervous system consists of the brain and the spinal cord; the peripheral nervous system consists of the cranial nerves and spinal nerves. Disorders of the nervous system include cerebrovascular accident (CVA, stroke), Alzheimer's disease, and sciatica. Commonly ordered laboratory tests are listed in Table 5-7.	1.7, 3.1, 3.2
5.8 Describe the functions of the endocrine system, common diseases and disorders that affect this system, and related laboratory tests.	The endocrine glands include the hypothalamus, pituitary, pineal body, thyroid, parathyroid, thymus, adrenal cortex, adrenal medulla, pancreas, ovaries, and testes. Most disorders of the endocrine system are caused by glands either oversecreting or undersecreting their hormones. Commonly ordered laboratory tests are listed in Table 5-9.	1.7, 3.1, 3.2
5.9 Describe the functions of the cardiovascular system, common diseases and disorders that affect this system, and related laboratory tests.	The cardiovascular system consists of the heart and the blood vessels. Common diseases and disorders include heart failure, myocardial infarction (heart attack), and coronary artery disease. Commonly ordered laboratory tests are listed in Table 5-10.	1.7, 3.1, 3.2

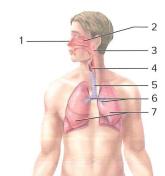
Learning Outcome	Summary	Related NAACLS Competency
5.10 Describe the functions of the urinary system, common diseases and disorders that affect this system, and related laboratory tests.	The urinary system includes the kidneys, bladder, ureters, and urethra. Common diseases and disorders include renal failure, glomerulonephritis, urinary tract infections, kidney stones, and cystitis. Commonly ordered laboratory tests are listed in Table 5-11.	1.7, 3.1, 3.2
5.11 Describe the functions of the female and male reproductive systems, common diseases and disorders that affect these systems, and related laboratory tests.	The female reproductive system consists of the ovaries, vagina, uterus, mammary glands, and associated structures. The male reproductive system consists of the testes, accessory structures, ducts, and penis. Common diseases and disorders include infertility, sexually transmitted infections (STIs), and cancer of the various organs. Commonly ordered laboratory tests are listed in Table 5-12.	1.7, 3.1, 3.2
5.12 Explain the use of test panels and profiles in the assessment of specific body systems and general health screening.	Test panels are groups of laboratory tests ordered together to assess a single organ or body system. Test profiles are similar, but are used to assess two or more body systems.	1.7, 3.1, 3.2

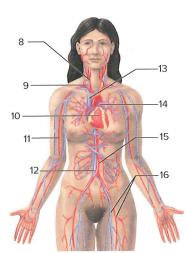
Chapter Review

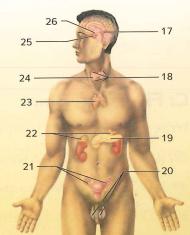
A: Labeling

Label the parts of the respiratory, cardiovascular, and endocrine systems in the following images.

- 1. [LO 5.5] _____
- **2.** [LO 5.5] _____
- **3.** [LO 5.5] _____
- 4. [LO 5.5] _____
- **5.** [LO 5.5] _____
- 6. [LO 5.5] _____
- **7.** [LO 5.5] _____
- 8. [LO 5.9]
- 9. [LO 5.9] _____
- **10.** [LO 5.9] _____
- **11.** [LO 5.9] _____
- **12.** [LO 5.9] _____
- **13.** [LO 5.9] _____
- 14. [LO 5.9] _____
- **15.** [LO 5.9] _____
- **16.** [LO 5.9] _____
- **17.** [LO 5.8] _____
- **18.** [LO 5.8]
- **19.** [LO 5.8] _____
- **20.** [LO 5.8] _____
- **21.** [LO 5.8] _____
- **22.** [LO 5.8] _____
- **23.** [LO 5.8] _____
- **26.** [LO 5.8] _____







B: Matching		
Match each organ with its corres [LOs 5.1, 5.2, 5.3, 5.4, 5.5, 5.6, 5.5]	sponding body system. Some organs may belong to mo .7, 5.8, 5.9, 5.10, 5.11]	re than one system.
27. adrenals	a. cardiovascular	
28. biceps	b. digestive	
29. bladder	c. endocrined. integumentary	
30. brain	e. lymphatic	
31. epididymis	f. muscularg. nervous	
32. femur	h. reproductive	
33. hair	i. respiratoryj. skeletal	
34. heart	k. urinary	
35. larynx		
36. liver		
37. penis		
38. pharynx		
39. quadriceps		
40. salivary glands		
41. skull		
42. spinal cord		
43. spleen		
44. tonsils		
45. ureter		
46. uterus		
47. vagina		
C: Fill in the Blank		
Write in the word(s) to complete	each statement.	
48. [LO 5.5] The organ in which g	gas exchange takes place is the	
49. [LO 5.10] Liquid wastes are st	ored in and eliminated by the	The COLUMN
50. [LO 5.1] The largest organ in t		

51. [LO 5.11] Reproductive organs specific to the female include the ______.

52. [LO 5.11] Reproductive organs specific to the male include the ______.

D: Sequencing

Indicate the sequence through which food passes through the digestive system (from 1 through 7).

53. [LO 5.6] _____ anus

54. [LO 5.6] ______ esophagus

55. [LO 5.6] _____ large intestine

56. [LO 5.6] _____ oral cavity

57. [LO 5.6] ______ rectum

58. [LO 5.6] _____ small intestine

59. [LO 5.6] _____ stomach

E: Case Studies/Critical Thinking

- 60. [LO 5.7] A patient cannot feel any pain when you draw her blood. She explains that she does not feel light sensations or pressure when touched on her arms or legs. A disorder in which body system(s) may be causing this issue?
- 61. [LO 5.3] An elderly patient, living a sedentary lifestyle (lack of activity), is feeling very cold and does not produce much of his own body heat. Explain which body system may be contributing to this and why.
- 62. [LO 5.1, 5.3, 5.7, 5.9] Which body systems does a phlebotomist use when drawing blood? Explain the reasons for each system in your answer.
- 63. [LO 5.1, 5.7, 5.9] When drawing blood on a patient, with which of the patient's body systems does the equipment come in contact?
- 64. [LO 5.11] A 35-year-old female patient has been trying to get pregnant since she got married two years ago. She does not have children and she would like to have a child before her biological clock stops ticking. The physician needs to determine what might be the cause of her infertility (inability to get pregnant). What system of the body needs to be evaluated and what related laboratory tests would most likely need to be drawn for the patient and her husband?
- 65. [LO 5.9] A 65-year-old male presents in the emergency room with chest pain, shortness of breath, and profuse sweating. What system of the body needs to be evaluated and what laboratory tests would most likely be drawn stat (immediately)?

F: Exam Prep

Choose the best answer for each question.

- 66. [LO 5.6] Which of the following blood tests aids in the evaluation of the digestive system?
 - a. Albumin
 - b. Creatinine
 - c. Hemoglobin
 - d. Uric acid

- 67. [LO 5.10] The renal tubules are part of which body system?
 - a. Cardiovascular
 - **b.** Digestive
 - c. Respiratory
 - d. Urinary

- **68.** [LO 5.5] One of the blood tests used primarily to evaluate the respiratory system is abbreviated
 - a. ABG.
 - b. BNP.
 - c. CBC.
 - d. EPO.
- **69.** [LO 5.2] Cartilage and ligaments are part of which body system?
 - a. Cardiovascular
 - b. Muscular
 - c. Respiratory
 - d. Skeletal
- **70.** [LO 5.3] Connective tissue and tendons are part of which body system?
 - a. Cardiovascular
 - b. Muscular
 - c. Respiratory
 - d. Nervous
- **71.** [LO 5.5] *Oxia, capnia, pnea,* and *spiro* are word parts that refer to which body system?
 - a. Cardiovascular
 - b. Endocrine
 - c. Respiratory
 - d. Urinary
- **72.** [LO 5.6] The liver and gallbladder are part of which body system?
 - a. Digestive
 - b. Endocrine
 - c. Respiratory
 - d. Urinary
- **73.** [LO 5.6] A panel of tests used to assess liver function may include all of these *except*
 - a. ammonia.
 - b. bilirubin.
 - c. creatine kinase.
 - d. lactate dehydrogenase.
- 74. [LO 5.8] Laboratory tests used to assess the endocrine system include all of these *except*
 - a. aldosterone.
 - b. B-type natriuretic peptide.
 - c. cortisol.
 - d. erythropoietin.

- **75.** [LO 5.7] Word parts that refer to the nervous system include all of these *except*
 - a. cranio-.
 - b. encephalo-.
 - c. myo-.
 - d. neuro-.
- 76. [LO 5.1] Regulation of body heat occurs in the
 - a. cardiovascular system.
 - b. digestive system.
 - c. integumentary system.
 - d. muscular system.
- 77. [LO 5.2] You receive an order to draw blood on a patient for alkaline phosphatase, calcium, phosphorus, and vitamin D. The physician is most likely concerned about the patient's
 - a. cardiovascular system.
 - b. digestive system.
 - c. muscular system.
 - d. skeletal system.
- 78. [LO 5.5] The trachea and bronchi are part of the
 - a. cardiovascular system.
 - b. lymphatic system.
 - c. respiratory system.
 - d. skeletal system.
- **79.** [LO 5.5] A sputum culture will detect infections in the
 - **a.** digestive system.
 - **b.** endocrine system.
 - c. lymphatic system.
 - **d.** respiratory system.
- **80.** [LO 5.9] The body system responsible for carrying oxygen, nutrients, and waste products is the
 - a. cardiovascular system.
 - **b.** digestive system.
 - c. respiratory system.
 - d. urinary system.
- **81.** [LO 5.8] Other body systems are influenced by chemicals and hormones produced in the organs of the
 - a. cardiovascular system.
 - b. endocrine system.
 - c. lymphatic system.
 - d. respiratory system.

- **82.** [LO 5.7] Providing communication via a series of electrical impulses is the main function of the
 - a. digestive system.
 - b. integumentary system.
 - c. muscular system.
 - d. nervous system.
- **83.** [LO 5.10] Maintaining a balance of water, salts, and acids is the function of the
 - a. digestive system.
 - b. integumentary system.
 - c. respiratory system.
 - d. urinary system.
- **84.** [LO 5.1] Dermatitis and athlete's foot are disorders of the
 - a. digestive system.
 - b. integumentary system.
 - c. reproductive system.
 - d. skeletal system.
- **85.** [LO 5.10] If the function of the urinary system is in question, the tests that would be most helpful include all of these *except*
 - a. BUN.
 - b. creatinine.
 - c. glucose.
 - d. osmolality.
- **86.** [LO 5.12] A test panel that includes a platelet count, fibrinogen, prothrombin time, and activated partial thromboplastin time is most likely which of the following?
 - a. Hepatitis panel
 - b. Basic metabolic profile
 - c. Coagulation panel
 - d. Renal panel

- **87.** [LO 5.12] A series of tests that includes creatinine, blood urea nitrogen, albumin, glucose, and total protein is most likely which of the following?
 - a. Obstetrics panel
 - b. Liver panel
 - c. Basic metabolic profile
 - d. Comprehensive metabolic profile
- 88. [LO 5.5] H1N1 virus is a type of:
 - a. COVID-19
 - b. FLU
 - c. RSV
 - d. SARS
- 89. [LO 5.5] COVID-19 is caused by
 - a. FluA/B
 - b. H1N1
 - c. RSVa/b
 - d. SARS-CoV-2
- **90.** [LO 5.5] Active respiratory infections can be tested for by all of the following except?
 - a. Antibody tests
 - b. PCR tests
 - c. Rapid tests
 - d. Throat culture



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