Chapter 6

The Human Body

Unit Summary

After students complete this chapter and the related course work, they will be able to describe and apply, in context, the body planes, topographical anatomy, and anatomic position. Students will be able to identify basic anatomic structures and related functions and describe each body system, discussing the roles of the structures within these systems and the interaction of body systems in maintaining the life support chain. Students will be able to discuss possible consequences of illness and injury of these structures and systems on proper functioning of the body.

National EMS Education Standard Competencies

Preparatory

Applies fundamental knowledge of the emergency medical services (EMS) system, safety/well-being of the emergency medical technician (EMT), medical/legal, and ethical issues to the provision of emergency care.

Anatomy and Physiology

Applies fundamental knowledge of the anatomy and function of all human systems to the practice of EMS.

Pathophysiology

Applies fundamental knowledge of the pathophysiology of respiration and perfusion to patient assessment and management.

Knowledge Objectives

1. Identify the body’s topographic anatomy, including the anatomic position and the planes of the body. (pp 179–180)

2. Identify the anatomy and physiology of the skeletal system. (pp 180–181)

3. Describe the anatomy and physiology of the musculoskeletal system. (pp 186–187)

4. Discuss the anatomy and physiology of the respiratory system. (pp 187–196)

5. Discuss the anatomy and physiology of the circulatory system. (pp 196–208)

6. Discuss the anatomy and physiology of the nervous system. (pp 208–212)

7. Describe the anatomy and physiology of the integumentary system. (pp 212–214)

8. Explain the anatomy and physiology of the digestive system. (pp 214–218)

9. Describe the anatomy and the physiology of the lymphatic system. (p 218)

10. Discuss the anatomy and physiology of the endocrine system. (pp 218–220)

11. Describe the anatomy and physiology of the urinary system. (pp 220–221)

12. Discuss the anatomy and physiology of the genital system. (pp 221–223)

13. Describe the life support chain, aerobic metabolism, and anaerobic metabolism. (pp 223–224)

14. Define pathophysiology. (p 224)

Skills Objectives

There are no skills objectives in this chapter.

Readings and Preparation

Review all instructional materials including ***Emergency Care and Transportation of the Sick and Injured***, **Eleventh Edition**, Chapter 6, and all related presentation support materials.

Support Materials

• Lecture PowerPoint presentation

• Case Study PowerPoint presentation

• Several copies of a human body diagram (anterior, posterior, and lateral if possible) for distribution in activities and assessments. Have several copies for each student, as they can serve as a template for many activities and assessments.

• Large (human body size) paper. Leftover newsprint paper works well if you have access to a newsprint facility, or consider taping several large pieces of paper together.

Enhancements

• Direct students to visit Navigate 2.

• **Content connections:** Inform students that a thorough understanding of anatomy and physiology will help them understand and apply concepts of pathophysiology in subsequent lessons. It is also the foundation for determining the possible consequences of the mechanism of injury and the nature of illness as EMTs assess patients in the field.

• **Cultural considerations:** While teaching anatomy and physiology, keep in mind that students may assume that internally all people are the same. Other chapters point out the cultural differences students need to consider to be most effective in assessment and care. While we think of culture as largely a learned set of behaviors, some cultures do have physical differences. Other groups of people, born with physical differences such as dwarfism, Down syndrome, and any of hundreds of other conditions, often form subcultures not only for social support but also for networking and support for specific medical/physical differences and challenges.

Teaching Tips

• Images are integral to the retention of material. Prepare ahead of time and consider incorporating additional visual resources.

• Chapter 6, “The Human Body,” presents students with a lot of new information and details. Choosing a variety of approaches, including charts, interactive exercises, and group and self-assessments, will allow students to organize the new information and identify areas needing more review. Including multiple activities with visual components will reduce learning time and increase retention. See the Student Presentation and Group Activities sections for suggestions. This chapter is particularly “visuals friendly”; with instructor guidance, students can engage in creative, fun learning.

Unit Activities

**Writing assignments:** Using the systems researched in the following Group Activities section, or selecting another system, structure, or organ, have each student or group of students write one or two paragraphs on one illness and one injury that could directly affect this organ/structure. What would they expect to see? Open up the presentations to class discussion if time allows.

**Group activities:**

• *Tracings:* Ask each group to use large paper or sidewalk chalk and the floor to trace the outlines of group members. Ask each group to sketch a specific system or segment of the body within each body outline.

• *The visible system*: Assign a body system to each group with instructions to create a presentation for the whole class on that system. Each group should be given the same guidelines and questions that must be answered within the presentation. Guidelines may include:

* Each group must make a visual representation of their system. Suggestions include a life-size cardboard cutout of a student labeled with that system’s components. Another suggestion might include each group member making a cardboard or paper cutout of one of the organs or structures in their system and “wearing” it or taping it to their clothing in the appropriate place as their group presents their project to the class. Questions to consider include:
	+ Which structures does this system include?
	+ How does each structure work independently? How does each structure interact with the other parts of this system?
	+ Which other systems interact with this system? Describe at least one function that involves another system.

**Medical terminology review:** Distribute a body diagram drawn on an 8.5 × 11-inch piece of paper. Using a prepared list of terms (such as directional terms), have students write the number of the term on the corresponding area of the diagram. For example, one clue might read, “The patient has an injury to the distal end of the left radius. Place an *X* on this location of your body diagram.” Prepare statements such as this for each term. Students can discuss their results with their groups, or this can be reviewed as a whole-class activity.

Pre-Lecture

### You Are the Provider

“You Are the Provider” is a progressive case study that encourages critical thinking skills.

### Instructor Directions

**1.** Direct students to read the “You Are the Provider” scenario found throughout Chapter 6.

**2.** You may wish to assign students to a partner or a group. Direct them to review the discussion questions at the end of the scenario and prepare a response to each question. Facilitate a class dialogue centered on the discussion questions and the Patient Care Report.

**3.** You may also use this as an individual activity and ask students to turn in their comments on a separate piece of paper.

Lecture

I. Introduction

A. A working knowledge of anatomy is important.

B. Knowledge of anatomy helps to communicate correct information:

1. To other medical professionals

2. To others who may not understand medical terms

II. Topographic Anatomy

A. Superficial landmarks serve as guides to structures that lie beneath them.

B. Topographic anatomy applies to the body in the anatomic position so that everyone is referring to the body in the same way.

1. Anatomic position: patient stands facing you, arms at side, palms forward

2. Directional terms are always from the patient’s perspective (eg, left arm).

C. Planes of the body

1. Imaginary straight lines that divide the body

2. Three main areas depending on how the body is divided:

 a. Frontal (coronal) plane: divides the body front and back

 b. Transverse (axial) plane: divides the body top and bottom

 c. Sagittal (lateral) plane: divides the body left and right

3. Midsagittal plane (midline): a special type of sagittal plane where the body is cut in half, leaving equal left and right halves

III. The Skeletal System: Anatomy

A. The skeleton gives us our recognizable human form and protects vital internal organs.

B. Elements of skeleton

1. 206 bones

 a. Constitute structure of skeletal system

 b. Provide a framework for attachment of muscles

2. Ligaments

 a. Fibrous tissues that connect bones to each other

3. Tendons

 a. Ropelike structures that connect muscles to bones

4. Cartilage

 a. Smooth connective tissue that covers the ends of bones at mobile joints

C. The skeletal system is divided into two portions: axial skeleton and appendicular skeleton.

1. Axial skeleton: foundation to which the arms and legs are attached

 a. Skull

 i. Cranium

(a) Protects the brain

(b) Connects to the spinal cord through a large opening at the base of the skull called the foramen magnum

(c) Made up of 4 bones

(1) Posterior of cranium is called the occiput

(2) Lateral portions of cranium are called the temples or temporal bones

(3) Between the temporal regions and occiput are parietal bones

(4) Forehead is frontal bone

 ii. Facial bones

(a) Made up of 14 bones

(1) Upper, nonmovable jawbones (maxillae)

(2) Cheekbones (zygomas)

(3) Lower, movable portion of jaw (mandible)

(4) Orbits (eye sockets) include zygomas, maxillae, and frontal bones of cranium.

(5) Very short bones form the bridge of the nose.

 b. Spinal column

 i. Central supporting structure of the body

 ii. Composed of 33 bones, called vertebrae

 iii. Vertebrae are named according to section of spine in which they lie and numbered from top to bottom.

 iv. The spine is divided into five sections (top to bottom):

(a) Cervical spine (neck)

(1) 7 vertebrae

(2) Attaches to skull

(b) Thoracic spine (upper back)

(1) One pair of ribs is attached to each of 12 vertebrae.

(c) Lumbar spine (lower back)

(1) 5 vertebrae

(d) Sacrum (back wall of pelvis)

(1) 5 vertebrae fused together to form the sacrum

(2) Sacrum joins the pelvis

(e) Coccyx (tailbone)

(1) 4 vertebrae fused together

 v. Vertebrae are connected by ligaments, with intervertebral disks between each vertebra.

 c. Thorax

 i. The thoracic cavity contains the heart, lungs, esophagus, and great vessels (aorta and venae cavae).

 ii. Formed by 12 thoracic vertebrae and 12 pairs of ribs

 iii. Midline of chest is the sternum

(a) The superior border of the sternum forms the easily palpable sternal notch.

(b) Three components:

(1) Manubrium (upper section)

(2) Body

(3) Xiphoid process (narrow, cartilaginous tip)

2. Appendicular skeleton: arms, legs, their connection points, and pelvis

 a. Joints

 i. Occur wherever bones come in contact

 ii. Joints consist of the ends of the bones and the surrounding connecting and supporting tissues.

 iii. Symphysis: a joint with slight, limited motion in which the bone ends are held together by fibrous tissue

 iv. The bone ends of a joint are held together by a fibrous sac called a joint capsule.

1. May be lax and thin (allows motion) or thick (resists stretching or bending)

(b) In moving joints, a thin layer of articular cartilage covers the ends of the bones.

(c) Synovial membrane: inner lining of the joint capsule

 (1) Responsible for making a thick lubricant called synovial fluid

 v. Two types of joints

 (a) Ball-and-socket joint

 (1) Shoulders

 (2) Allows rotation and bending

 (b) Hinge joint

 (1) Fingers, elbows, and knees (largest joints in body)

 (2) Motion is restricted to flexion (bending and extension)

b. Upper extremities

i. Extend from shoulder girdle to fingertips

ii. Composed of arms, forearms, hands, and fingers

 (a) Shoulder girdle is where three bones come together

 (1) Clavicle (collarbone)

 (2) Scapula (shoulder blade)

 (3) Humerus (supporting bone of the arm)

 (b) Arm

 (1) Humerus is the supporting bone

 (2) Forearm consists of radius and ulna

 (3) Radius lies on the lateral, or thumb, side

 (4) Ulna is on the medial, or little finger, side

 (c) Wrist and hand

 (1) Modified ball-and-socket joint formed by the ends of the radius and ulna and wrist bones

 (2) 8 bones in the wrist (carpal bones)

 (3) 5 metacarpals extend from the carpal bones and make up the hand

 (4) Fingers are composed of phalanges

c. Pelvis

i. Closed bony ring consisting of three bones:

 (a) Sacrum

 (b) Two pelvic bones

ii. Each pelvic bone is formed by fusion of the ilium, ischium, and pubis.

 (a) These three bones are joined posteriorly by the sacrum.

 (b) Anteriorly, the right pubis and left pubis are joined by the pubic symphysis—a hard bony and cartilaginous joint with minimal motion.

 (c) The leg connects to the hip joint at the acetabulum—the part of the pelvis where the ilium, ischium, and pubic bones meet.

d. Lower extremities

i. Femur (thighbone)

 (a) Longest and one of the strongest bones in the body

 (b) At the superior head of the bone is the femoral head—a round ball-like structure.

 (c) The femoral head connects to the acetabulum (the pelvic girdle) by a ball-and-socket joint.

 (d) The femoral head attaches to the shaft of the femur through the femoral neck.

 (e) Two projections where major muscles of the thigh connect to the femur:

 (1) Greater trochanter (lateral/superior)

 (2) Lesser trochanter (medial/inferior)

ii. Knee

 (a) Connects upper leg to lower leg

 (b) Hinge joint

 (c) Specialized bone called the patella (knee cap)

iii. Lower leg

 (a) Tibia

 (1) Shinbone

 (2) Lies on the anterior of the leg

 (b) Fibula

 (1) Lies on the lateral side of the leg

iv. Ankle

 (a) Hinge joint

 (b) Allows flexion and extension of the foot

v. Foot

 (a) Contains 7 tarsal bones

 (b) Talus and calcaneus are the largest bones

 (c) Talus joins with the distal tibia and fibula to form the ankle joint

 (d) Calcaneus forms prominence of heel

 (e) 5 metatarsal bones form the substance of the foot

 (f) Plantar surface: the bottom surface of the foot

 (g) Dorsum: the top of the foot

 (h) 5 toes formed by 14 phalanges

 (1) 2 phalanges in the great toe

 (2) 3 phalanges in each of the smaller toes

IV. The Skeletal System: Physiology

A. The skeletal system:

1. Gives the body its shape

2. Protects fragile organs

3. Allows for movement

4. Stores calcium

5. Helps create blood cells

V. The Musculoskeletal System: Anatomy

A. The musculoskeletal system provides:

1. Form

2. Upright posture

3. Movement

4. Protection of vital internal organs

B. Three types of muscles: skeletal, smooth, and cardiac

1. Skeletal muscle attaches to the bones of the skeleton and forms the major muscle mass of the body.

a. Also called voluntary muscle, because it is under direct voluntary control of the brain

b. Movement of the body results from skeletal muscle contraction or relaxation.

c. Most muscles of the body operate on the principle of antagonistic parts.

 i. Example: The biceps works to slow the movement of the triceps as the arm is extended.

2. Smooth muscle is found within blood vessels and intestines.

3. Cardiac muscle is found only within the heart.

VI. The Musculoskeletal System: Physiology

A. Contraction and relaxation of the system make it possible to move and manipulate the environment.

1. A by-product of this movement is heat.

2. When you get cold, you shiver (involuntarily shake muscles) to produce heat.

B. Another function of muscles is to protect the structures under them.

VII. The Respiratory System: Anatomy

A. The respiratory system consists of structures of the body that contribute to the process of breathing (respiration).

B. Upper airway

1. Nose

2. Mouth (oral cavity)

3. Tongue

4. Jaw (mandible)

5. Larynx (voice box)

a. Dividing line between the upper and lower airway

b. Complex arrangement of tiny bones, cartilage, muscles, and vocal cords

6. Pharynx

 a. Nasopharynx

 b. Oropharynx (throat)

 c. Laryngopharynx

 i. At the base of the laryngopharynx are the trachea and the esophagus posteriorly.

7. Trachea (windpipe)

 a. Located at the bottom of the pharynx

 b. Semi-rigid, enclosed air tube made up of rings of cartilage

8. Epiglottis

 a. Thin, leaf-shaped flap that prevents food and liquid from entering the trachea

9. Esophagus

 a. Immediately posterior to the trachea

b. Food and liquids enter the pharynx and pass into the esophagus, which carries them to the stomach.

C. Lower airway

1. Thyroid cartilage (Adam’s apple): forms the anterior part of the larynx

 a. Tiny muscles open and close the vocal cords and control tension.

 b. Sounds are created as air is forced past the vocal cords, making them vibrate.

2. Cricoid cartilage: immediately below the thyroid cartilage

3. Cricothyroid membrane: between the thyroid and cricoid cartilage

4. Trachea: below the cricoid cartilage

 a. The trachea ends at the carina.

b. It divides into two tubes, the right and left main stem bronchi, which enter the lungs and branch into smaller airways.

D. Lungs

1. The two lungs are held in place by:

 a. Trachea

 b. Arteries and veins

 c. Pulmonary ligaments

2. Each lung is divided into lobes.

 a. The right lung has upper, middle, and lower lobes.

 b. The left lung has upper and lower lobes.

3. Within the lobes are the bronchi and bronchioles, which end in small grape-like sacs called alveoli.

 a. Alveoli allow for gas exchange (oxygen and carbon dioxide).

4. Pleura: a layer of smooth, glistening tissue that covers each lung and lines the chest cavity

 a. Between the two layers is a small amount of fluid that allows the tissues to glide smoothly.

E. Muscles involved in breathing

1. Diaphragm

a. Primary muscle of breathing

b. Divides the thorax from the abdomen

c. Its automatic function is breathing.

2. Intercostal muscles

a. During inhalation, the diaphragm and intercostal muscles contract, moving the ribs up and out, enlarging the chest cavity, decreasing the pressure in the lungs, and moving air in.

b. During exhalation, the diaphragm and intercostal muscles relax, decreasing the chest cavity, increasing the pressure in the lungs, and moving air out.

3. Neck (cervical muscles)

4. Abdominal muscles

5. Pectoral muscles

VIII. The Respiratory System: Physiology

A. The respiratory system’s function is to provide the body with oxygen and eliminate carbon dioxide.

B. Ventilation and respiration are two separate, yet interdependent functions of the respiratory system.

1. Respiration

 a. Respiration: the exchange of oxygen and carbon dioxide in the alveoli and in tissues of the body

 b. Provides much-needed oxygen to the cells and removes the waste carbon dioxide

 c. Oxygen passes from the blood through the capillaries to tissue cells, and carbon dioxide passes back.

 d. Diffusion: the passive process in which oxygen molecules move from an area with a higher concentration of molecules to an area of lower concentration.

 e. The brain stem automatically controls breathing if the level of carbon dioxide or oxygen in arterial blood is too high or too low.

 i. The medulla oblongata senses pH changes in the cerebrospinal fluid and signals the diaphragm.

 ii. The hypoxic drive is the backup system that controls breathing.

(a) It is less sensitive and less powerful than the carbon dioxide sensors in the brain stem.

 f. The medulla keeps us breathing so we do not have to think about it.

 i. Initiates the ventilation cycles

 ii. Stimulated by high carbon dioxide levels

 iii. Sets the base pattern for respirations

g. Pons

 i. Has two areas that help augment respirations during emotional or physical stress

 ii. Involved in changing the depth of inspiration, expiration, or both.

2. Ventilation

 a. Ventilation: simple movement of air into and out of the lungs

 b. Requires chest rise and fall

 c. You provide ventilation when you assist a patient with a bag-valve mask.

 d. Tidal volume: the amount of air that is moved into or out of the lungs during a single breath

 e. Inspiratory reserve volume: the deepest breath you can take after a normal breath

 f. Expiratory reserve volume: the maximum amount of air you can forcibly breathe out after a normal breath

 g. Residual volume: the gas that remains in the lungs to keep the lungs open

 h. Dead space: the portion of the respiratory system that has no alveoli and, therefore, where little or no exchange of gas between air and blood occurs

 i. Minute volume: the amount of air that moves in and out of the lungs in 1 minute minus the dead space

 j. Respiratory rate × tidal volume = minute volume

 k. Always evaluate the amount of air being moved with each breath when assessing a patient’s respirations.

C. Normal breathing

1. Normal rate and depth (tidal volume)

2. Regular rhythm or pattern of inhalation and exhalation

3. Clear, audible breath sounds on both sides of chest

4. Regular rise and fall movement on both sides of the chest

5. Movement of the abdomen

D. Inadequate breathing patterns

1. Labored breathing

 a. Requires effort and may involve accessory muscles

 b. Much slower or faster breathing than usual

2. Muscle retractions above the clavicles, between the ribs, and below the rib cage, especially in children

3. Pale or cyanotic (blue) skin

4. Cool, damp (clammy) skin

5. Patient in the tripod position (leaning forward on arms stretched forward)

6. Agonal gasps

 a. Gasping breaths after the heart has stopped (cardiac arrest)

IX. The Circulatory System: Anatomy

A. The circulatory system (cardiovascular system) is a complex arrangement of connected tubes.

1. Arteries, arterioles, capillaries, venules, and veins

B. Two circuits

1. Systemic circulation (body)

a. Carries oxygen-rich blood from the left ventricle through the body and back to the right atrium

2. Pulmonary circulation (lungs)

a. Carries oxygen-poor blood from the right ventricle through the lungs and back to the left atrium

C. Heart

1. Hollow muscular organ that is approximately the size of an adult’s clenched fist

2. Made of specialized cardiac muscle (myocardium)

3. Works as two paired pumps

 a. Septum divides right and left sides

4. Each side is divided into:

 a. Atrium (upper chamber)

 b. Ventricle (lower chamber)

5. Circulation

 a. The heart receives its blood from the aorta.

 b. The right side of the heart receives blood from the veins of the body.

i. The blood enters from the superior and inferior venae cavae into the right atrium and fills the right ventricle.

ii. As the right ventricle contracts, blood flows into the pulmonary artery and the pulmonary circulation system.

 c. Oxygenated blood returns from the lungs through the pulmonary veins into the left atrium and passes through a valve into the left ventricle.

i. When the left ventricle contracts, the blood is pumped into the aorta and then to the arteries of the body.

 d. A one-way valve governs the exit of blood from each of the four heart chambers.

 e. One-way valves prevent backflow of blood.

i. When a valve controlling the entry to a heart chamber is open, the valve that controls the exit is shut, and vice versa.

6. Normal heart rate (HR)

 a. Normal pulse rate for an adult is 60–100 beats/min

 b. Stroke volume (SV): the amount of blood moved by one beat

 c. Cardiac output (CO): the amount of blood moved in 1 minute.

i. CO = HR × SV

 d. In 1 minute, the body’s entire blood volume (5–6 L) is circulated through all the vessels.

7. Electrical conduction system

 a. A network of specialized tissue that is capable of conducting electrical current runs throughout the heart.

 b. The flow of electrical current causes smooth, coordinated heart contractions.

 c. The contractions produce the pumping action of the heart.

 d. Each mechanical contraction is associated with two electrical processes.

 i. Depolarization: electrical charges on the surface of the muscle cell change from positive to negative

 ii. Repolarization: the heart returns to its resting state, and the positive charge is restored to the surface

 e. Electrical impulses begin high in the atria at the sinoatrial node, travel to the atrioventricular node and bundle of His, and then move through the Purkinje fibers to the ventricles.

 f. This movement produces a smooth flow of electricity, leading to a coordinated pumping action.

 g. When the conduction system is injured, the heart will not beat properly.

D. Arteries

1. Carry blood from the heart to all body tissues

a. Contract to accommodate loss of blood and increase blood pressure, so as to supply tissues as needed

2. Aorta

 a. Main artery leaving the left side of the heart and carrying freshly oxygenated blood to the body

 b. Has many branches that supply the vital organs

 i. Coronary arteries supply the heart.

 ii. Carotid arteries supply the head.

 iii. Hepatic arteries supply the liver.

 iv. Renal arteries supply the kidneys.

 v. Mesenteric arteries supply the digestive system.

 c. Divides at the level of the umbilicus into two iliac arteries

3. Pulmonary artery

 a. Originates at the right ventricle

 b. Carries oxygen-poor blood to the lungs

4. Arteries branch into smaller arteries, and then into arterioles.

a. Arterioles branch into a series of increasingly smaller vessels until they connect to the vast network of capillaries.

5. Pulse

a. Palpated most easily at the neck, wrist, or groin

b. Created by the forceful pumping of blood out of the left ventricle and into the major arteries

E. Capillaries

1. Tiny blood vessels that connect arterioles to venules

2. Allow contact between blood and the cells of the tissues

3. Oxygen and nutrients pass from blood cells and plasma in the capillaries to individual tissue cells through the very thin walls of capillaries.

4. There are billions of capillaries in body.

F. Veins

1. Return oxygen-depleted blood to the heart

2. Blood moves from venules to the heart via a network of larger and larger veins.

3. Major veins

a. The superior vena cava carries blood returning from the head, neck, shoulders, and upper extremities.

b. The inferior vena cava carries blood from the abdomen, pelvis, and lower extremities.

c. The superior and inferior vena cavae join at the right atrium

G. Spleen

1. Solid organ located under the rib cage in left upper part of abdomen

2. Filters worn-out blood cells, foreign substances, and bacteria from the blood

3. Highly vascular and is particularly susceptible to injury from blunt trauma

 a. Can lead to severe internal bleeding

H. Blood composition

1. Plasma (the liquid portion of blood) contains:

 a. Water (primary component)

 b. Proteins (primary component)

 c. Oxygen

 d. Carbon dioxide

 e. Nitrogen

 f. Nutrients

 g. Cellular wastes

2. Red blood cells (erythrocytes)

 a. Contain hemoglobin (gives blood its color)

 b. Carry oxygen

3. White blood cells (leukocytes)

 a. Play a role in the body’s immune defense to fight infection

4. Platelets

 a. Essential in the initial formation of a blood clot

X. The Circulatory System: Physiology

A. Blood pressure: pressure that blood exerts against the walls of arteries

B. Systole: When the left ventricle of heart contracts, it pumps blood from the ventricle into the aorta.

C. Diastole: When the muscle of the ventricle relaxes, the ventricle fills with blood.

D. Forceful ejection of blood from the left ventricle into the aorta is transmitted through the arteries as a pulsatile pressure wave.

1. Can be measured with a blood pressure cuff (sphygmomanometer)

2. Systolic blood pressure: high point of wave as heart is contracting

3. Diastolic blood pressure: low point of wave as heart is in relaxation phase)

4. Expressed in millimeters of mercury (mm Hg)

E. Normal circulation in adults

1. Automatically adjusted and controlled

2. Perfusion: the circulation of blood in an organ or tissue in adequate amounts to meet the current needs of the cells

3. Blood enters organs and tissues through the arteries and leaves through the veins.

F. Inadequate circulation in adults

1. The system can adjust to compensate for a small blood loss.

 a. Vessels constrict.

 b. The heart pumps more rapidly.

2. With a large loss, adjustment fails, and the patient goes into shock.

3. Can be expressed by the following formula:

a. Mean arterial pressure = (heart rate × stroke volume) × systemic vascular resistance

b. MAP = (HR × SV) × SVR

G. Functions of blood

1. Perfusion

2. Transporting oxygen

3. Transporting carbon dioxide

4. Transporting wastes and nutrients

5. Clotting (coagulation)

H. Nervous system control of the cardiovascular system

1. The sympathetic nervous system is responsible for the fight-or-flight response.

a. Sends commands to adrenal glands

b. Epinephrine and norepinephrine are secreted to stimulate heart and blood vessels.

i. The popular names of these hormones are adrenaline and noradrenaline.

(a) Blood vessels have alpha-adrenergic receptors.

(1) When stimulated, blood vessels constrict, increasing blood pressure.

(b) The heart and lungs have beta-adrenergic receptors.

(1) When stimulated, heart rate increases.

(2) Bronchi in the lungs dilate, allowing more air to be inhaled and exhaled.

2. The parasympathetic nervous system addresses actions that do not require an immediate response.

a. When stimulated, this system causes the heart to slow and beat more weakly.

3. The opposition between the sympathetic and parasympathetic nervous systems allows the body to respond appropriately.

XI. The Nervous System: Anatomy and Physiology

A. The nervous system is perhaps the most complex organ system in the body.

B. Divided into two main portions

1. Central nervous system (CNS): the brain and spinal cord

a. The brain is the controlling organ of the body.

b. Major subdivisions of the brain

i. Cerebrum

(a) Largest part of the brain

(b) Four lobes (frontal, parietal, temporal, and occipital), each responsible for a specific function such as sight, hearing, balance, and speech

(c) Controls activities on the opposite side of the body

ii. Cerebellum

1. Coordinates body movements

iii. Brain stem

(a) Controls body functions necessary for life, including cardiac and respiratory functions and regulation of consciousness

(b) Three areas:

(1) Midbrain

(2) Pons

(3) Medulla oblongata

c. The spinal cord is an extension of the brain stem.

i. Made up of nerve fibers that extend from the cells of the brain and join together below the brain stem to from the spinal cord

ii. Transmits messages between the brain and the body

iii. Encased within the spinal canal

iv. Cerebrospinal fluid (CSF) cushions the brain and spinal cord.

2. Peripheral nervous system

a. Nerves outside the brain and spinal cord that link the CNS to various organs of the body

b. Consists of long fibers that extend from the cell body out through openings in the bony covering to form a cable of nerve fibers that link the CNS to the various organs of the body

c. Divisions of the peripheral nervous system:

 i. Somatic nervous system (voluntary)

 (a) Transmits signals from the brain to voluntary muscles

 (b) Allows for activities such as walking, talking, and writing

 ii. Autonomic nervous system (involuntary)

 (a) Controls involuntary actions necessary for basic body functions

 (b) Digestion, dilation, constriction of blood vessels, and sweating

 (c) Split into two areas:

 (1) Sympathetic nervous system, which is responsible for the fight-or-flight response

 (2) Parasympathetic nervous system, which slows down the body

d. Two types of nerves within peripheral nervous system

i. Sensory nerves carry information from the body to the CNS, constantly providing information to the brain about what different parts of the body are doing in relation to their surroundings.

 ii. Motor nerves carry information from the brain to muscles.

 (a) Each muscle in the body has its own motor nerve.

 (b) Electrical impulses produced by cell bodies in the spinal cord are transmitted along the motor nerves to the muscle, causing it to contract.

XII. The Integumentary System (Skin): Anatomy

A. Two layers of skin

1. Epidermis (superficial)

 a. Sealed to form a watertight, protective covering

 b. Varies in thickness in different areas of the body

 c. Composed of several layers of cells

 i. Germinal layer: produces new cells

 ii. Stratum corneal layer: surface layer of dead cells

 iii. Skin cells are constantly being replaced

2. Dermis (deeper)

 a. Contains special structures of the skin

 i. Sweat glands produce sweat for cooling the body.

 ii. Sebaceous glands secrete sebum, which provides waterproofing and softening.

 iii. Hair follicles are small organs that produce hair.

 iv. Blood vessels provide nutrients and oxygen to the skin.

 v. Mucous membranes cover bodily orifices such as the mouth, nose, and vagina.

 (a) Provide a protective barrier like skin

 (b) Secrete mucus, a watery substance that lubricates the openings

 (c) Mucus membranes are moist, whereas the skin is dry.

B. Below the skin lies subcutaneous tissue, a layer of fat that serves as an insulator and as an energy reservoir.

XIII. The Integumentary System (Skin): Physiology

A. The skin is the largest single organ in the body.

B. Three major functions:

1. Protects the body in the environment

 a. Protects the body from infectious organisms

2. Regulates body temperature

 a. Sweat is secreted to the skin surface from the sweat glands.

3. Transmits information from the environment to the brain

 a. The skin reacts to pressure, pain, and pleasurable stimuli.

XIV. The Digestive System: Anatomy

A. Digestion: the processing of food that nourishes the individual cells of the body

1. Digestive system is also called the gastrointestinal system

**B. Components of the digestive system:**

 1. Abdomen

 a. Second major body cavity

 b. Contains major organs of digestion and excretion

 c. Quadrants are easiest way to identify areas.

 i. Right upper (RUQ): contains the liver, gallbladder, and a portion of the colon

 ii. Left upper (LUQ): contains the stomach, spleen, and a portion of the colon

 iii. Right lower (RLQ): contains two portions of the large intestine (cecum and ascending colon)

 (a) The appendix is attached to the lower cecum.

 iv. Left lower (LLQ): contains the descending and sigmoid portions of the colon

 d. Quadrants refer to the patient’s right and left.

 e. The small intestine, pancreas, large intestine, and urinary bladder lie in more than one quadrant.

 f. The kidneys and pancreas lie behind the abdominal cavity.

2. Mouth

 a. Consists of lips, cheeks, gums, teeth, and tongue

 b. Salivary glands

 i. Two sets: on each side of the mouth and in front of each ear

 ii. Saliva serves as a binder for chewed food and as a lubricant.

3. Oropharynx

 a. Tubular structure

 b. Extends from the back of the mouth to the esophagus and trachea

4. Esophagus

 a. Collapsible tube about 10 inches long

 b. Extends from the end of the pharynx to the stomach

 c. Muscles in the wall of the esophagus propel food to the stomach.

5. Stomach

 a. Hollow organ in LUQ

 b. Receives food, stores it, and provides for its movement into the bowel

6. Pancreas

 a. Flat, solid organ that lies below and behind the liver and stomach

 b. Two portions: exocrine and endocrine

 i. Exocrine portion secretes pancreatic juice containing enzymes that aid in digestion of fat, starch, and protein.

 ii. Endocrine portion (islets of Langerhans) produces insulin and glucagon.

7. Liver

a. Large, solid organ immediately beneath the diaphragm in the RUQ, extending into the LUQ

b. Largest solid organ in the abdomen, made up of a large mass of blood vessels and cells

c. The liver has many functions:

 i. Filtering harmful substances

 ii. Forming the factors needed for blood clotting and normal plasma production

 iii. Principal organ for storing sugar or starch for immediate use by the body for energy

d. Bile ducts

 i. The major function of bile is the digestion of fat.

 ii. Bile ducts connect the liver to the intestine.

 iii. The gallbladder is a small pouch extending from the bile ducts that serves as a reservoir and concentrating organ for bile produced in the liver.

8. Small intestine

 a. Major hollow organ of the abdomen

 b. Produces enzymes and mucus to aid in digestion

 c. Composed of the duodenum (receives food from the stomach), jejunum, and ileum

 d. More than 90% of the products of digestion are absorbed across the wall of the small intestine into veins.

9. Large intestine

 a. Major hollow organ consisting of the cecum, colon, and rectum

 b. The major function of the colon is to absorb the final 5–10% of digested food and water from the intestine to form solid stool.

10. Appendix

 a. A 3- to 4-inch-long tube that opens into the cecum (first part of large intestine) in the RLQ of the abdomen

 b. It may easily become obstructed, inflamed, or infected (appendicitis).

 c. Appendicitis is one of the major causes of severe abdominal distress.

11. Rectum

 a. Lowermost end of the colon

 b. Large, hollow organ adapted to hold quantities of feces until it is expelled

 c. At its terminal end is the anus.

 d. Both the rectum and the anus have sphincters—complex circular muscles that control the escape of liquids, gases, and solids from the digestive tract.

XV. The Digestive System: Physiology

A. Digestion is a complicated chemical process.

1. Enzymes are added to food by the salivary glands, stomach, liver, pancreas, and small intestine.

2. Food is converted into basic sugars, fatty acids, and amino acids.

3. These basic products of digestion are carried across the wall of the intestine to the liver and processed further and stored or transported to the heart.

4. Circulated via blood throughout body

XVI. The Lymphatic System: Anatomy and Physiology

**A. Elements of lymphatic system:**

 1. Spleen

 2. Lymph nodes

 3. Lymph

 4. Lymph vessels

 5. Thymus gland

 6. Other components

**B. Supports the circulatory system and immune system**

**C. Lymph is a thin, straw-colored fluid that carries oxygen, nutrients, and hormones to the cells and waste products of metabolism away from the cells to be excreted.**

1. Lymph vessels form a network throughout the body that serves as an auxiliary to the circulatory system.

2. Relies on muscle contractions and movements of the body for lymph to flow

3. Lymph nodes are tiny, oval-shaped structures that filter lymph.

**D. Helps to rid the body of toxins and other harmful materials**

XVII. The Endocrine System: Anatomy and Physiology

A. The endocrine system is a complex message and control system.

1. Integrates many body functions

B. Endocrine glands release hormones directly into the bloodstream.

1. Examples: epinephrine, norepinephrine, insulin

2. Each endocrine gland produces one or more hormones.

C. Each hormone has a specific effect on some organ, tissue, or process.

1. Adrenal: regulates stress response, fight-or-flight response

2. Ovary: regulates sexual function, characteristics, and reproduction in women

3. Pancreas: regulates glucose metabolism and other functions

4. Parathyroid: regulates serum calcium

5. Pituitary: regulates all other endocrine glands

6. Testes: regulate sexual function, characteristics, and reproduction in men

7. Thyroid: regulates metabolism

D. The brain controls the release of hormones.

1. Hormones can have a stimulating or an inhibiting effect on the body’s organs and systems.

E. The tightly controlled communication system uses primary and secondary feedback loops to keep the body in balance.

F. Excesses or deficiencies in hormones can cause disease processes, such as diabetes.

XVIII. The Urinary System: Anatomy and Physiology

A. The urinary system controls the discharge of certain waste materials filtered from the blood by the kidneys.

 1. The kidneys are solid organs.

 2. The ureters, bladder, and urethra are hollow organs.

B. Main functions of the urinary system:

1. Control fluid balance in the body

2. Filter and eliminate wastes

3. Control pH balance

C. The body has two kidneys that lie in the retroperitoneal space.

1. Kidneys rid the blood of toxic waste products and control the balance of water and salt.

2. Waste products and water are constantly filtered from the blood to form urine. The kidneys concentrate this filtered urine by reabsorbing the water as it passes through a system of specialized tubes.

3. A ureter passes from each kidney to drain into the urinary bladder.

D. The urinary bladder is located immediately behind the pubic symphysis in the pelvic cavity.

1. The bladder empties to the outside of the body through the urethra.

XIX. The Genital System: Anatomy and Physiology

A. The genital system controls the reproductive processes by which life is created.

B. The male reproductive system consists of the testicles, epididymis, vasa deferentia, prostate gland, seminal vesicles, and penis.

1. Lies outside the pelvic cavity (except for the prostate gland and seminal vesicles)

2. Produces sperm and sex hormones

3. Penis is also part of the urinary system (contains the urethra)

C. The female reproductive system consists of the ovaries, fallopian tubes, uterus, cervix, and vagina.

1. Contained entirely within the pelvic cavity (except the clitoris and labia)

2. Produces egg cells (ovum) and sex hormones

XX. Life Support Chain

A. Cells are the foundation of the human body.

1. All cells in the body require oxygen, nutrients, and removal of waste.

2. The respiratory and circulatory systems are the carrier of these supplies and wastes.

3. If interference occurs, cells become damaged and die.

B. Cells use oxygen to take available nutrients and turn them into chemical energy through metabolism.

1. Adenosine triphosphate (ATP)

a. Used to store energy

2. Aerobic metabolism uses oxygen.

a. The brain and heart require constant supplies of oxygen.

3. Most cells switch to anaerobic metabolism when oxygen is limited.

a. Lactic acid is a damaging waste product of this process.

4. Movement of oxygen, waste, and nutrients occurs by diffusion.

C. pH is critical to diffusion.

1. pH is a measure of acidity or alkalinity.

2. The body expends a large amount of energy to maintain normal pH.

XXI. Pathophysiology

A. Pathophysiology is the study of functional changes that occur when the body reacts to disease.

B. Many diseases can occur in patients.

1. Diabetes is a disease of the pancreas.

2. Stroke is a disease of the brain.

3. Pneumonia is a disease of the lungs.

C. Respiratory compromise is the inability of the body to move gas effectively

1. Can lead to:

 a. Hypoxia: decreased level of oxygen in the body

 b. Hypercarbia: elevated level of carbon dioxide in the body

 2. Factors that impair ventilation:

 a. Blocked airway

 b. Impairment of the muscles of breathing

 c. Airway is obstructed physiologically (eg, asthma attack)

 d. Numerous other factors

i. Drug overdose

ii. Trauma to chest wall

iii. Allergic reaction

 3. Factors that impair respiration:

 a. Change in the atmosphere

 b. High altitudes

 c. Impaired movement of the gas across the cell membrane

 4. Ventilation/perfusion mismatch

a. The V/Q ratio describes how much gas is being moved effectively through the lungs and how much blood is flowing around the alveoli where gas exchange (perfusion occurs).

 i. A mismatch occurs when one of those two variables is abnormal.

 ii. Respiratory compromise can occur.

 5. Effects of respiratory compromise on the body:

a. Oxygen levels throughout the body fall and carbon dioxide levels rise.

b. The brain detects an increase in carbon dioxide levels.

c. The body increases its respiratory rate in an attempt to return the carbon dioxide levels to normal.

d. If increased respiratory does not occur or is not effective in returning the carbon dioxide levels to normal, the blood will become more acidic.

e. Similarly, blood oxygen levels will begin to fall. This will cause the brain to issue further commands to breathe.

**D. Shock**

1. A condition in which organs and tissue receive an inadequate flow of blood and oxygen (perfusion)

2. Can occur due to inadequacy of the central or peripheral circulation.

3. Impaired oxygen delivery causes cellular hypoxia.

a. Leads to anaerobic metabolism, lactic acid production, and organ dysfunction.

 4. Shock is categorized into several types depending on the cause.

**E. Effects of shock on the body**

 1. Similar to the effects of respiratory compromise

 2. The level of oxygen supplied to the tissues falls.

 3. Cells engage in anaerobic metabolism.

 a. Results in lactic acid production

4. Severe metabolic acidosis ensues, leading to increased levels of carbon dioxide within the blood.

5. Baroreceptors detect decreased blood pressure and initiate the release of epinephrine and norepinephrine.

6. The heart rate increases, the heart beats more forcefully, and blood vessels constrict.

7. Interstitial fluid moves into the capillaries.

8. Once a certain level of tissue hypoperfusion is reached, cell damage proceeds in a similar manner regardless of the underlying cause of the shock.

**F. Impairment of cellular metabolism results in the inability to properly use oxygen and glucose at the cellular level.**

1. When there is inadequate oxygen, cells will create energy through anaerobic metabolism.

 a. Serves as a temporary backup system

 b. Can result in metabolic acidosis

 c. Requires more energy than when using glucose for fuel

 i. More wastes to remove from the body

 ii. Body must work harder

 d. Decreased ability of the blood to effectively carry oxygen to the cells

 e. Overall decreased functioning of oxygen within the cell

 f. Brain cells cannot use alternative fuels.

i. Rely on a constant supply of glucose to function

ii. If the supply of available glucose is dramatically decreased, brain cells will quickly become damaged or die.

g. Cellular injury, up to a point, may be repairable if normal tissue perfusion is restored.

i. When irreversible injury occurs, no treatment will help.

Post-Lecture

This section contains various student-centered end-of-chapter activities designed as enhancements to the instructor’s presentation. As time permits, these activities may be presented in class. They are also designed to be used as homework activities.

## Assessment in Action

This activity is designed to assist the student in gaining a further understanding of issues surrounding the provision of prehospital care. The activity incorporates both critical thinking and application of basic EMT knowledge.

### Instructor Directions

**1.** Direct students to read the “Assessment in Action” scenario located in the Prep Kit at the end of Chapter 6.

**2.** Direct students to read and individually answer the quiz questions at the end of the scenario. Allow approximately 10 minutes for this part of the activity. Facilitate a class review and discussion of the answers, allowing students to correct responses as may be needed. Use the quiz question answers noted below to assist in building this review. Allow approximately 10 minutes for this part of the activity.

**3.** You may wish to ask students to complete the activity on their own and turn in their answers on a separate piece of paper.

### Answers to Assessment in Action Questions

1. **Answer:** A Coronal

2. **Answer:** B Carotid

3. **Answer:** C Femur

4. **Answer:** D Calcium

5. **Answer:** A Zygoma

6. **Answer:** C Radius

7. **Answer:** A Hinge

8. **Answer:** Respiratory compromise is the inability of the body to move gas effectively. It occurs when either ventilation or respiration is impaired. The heart and brain cells cannot survive without a constant supply of oxygen, and will die in minutes.

 Decreased oxygen levels force cells to move from aerobic metabolism to anaerobic metabolism. Cellular functions become impaired. Lactic acid is created as a by-product of anaerobic metabolism. Once too much lactic acid is created, the pH of the blood will drop, and cells will die.

9. **Answer:** The brain stem is the control center that regulates a person’s level of consciousness and vital signs. The brain stem is composed of three smaller components: the midbrain, medulla, and pons. The midbrain is responsible for a person’s level of consciousness, whereas the pons and the medulla regulate and maintain the blood pressure, heart rate, and respiratory rate.

10. **Answer:** The autonomic nervous system is divided into two halves−the parasympathetic nervous system that dominates during periods of rest and relaxation, and the sympathetic nervous system that takes over in times of stress. When the body recognizes that irregularities are occurring, the sympathetic nervous system kicks into action and increases the vital signs to help the body adapt and attempt to reestablish normal function. The brain stem also helps to control the heart rate.

## Assignments

A. Review all materials from this lesson and be prepared for a lesson quiz to be administered (date to be determined by the instructor).

B. Read Chapter 7, “Life Span Development,” for the next class session.