Review of Human Systems  Lesson Outline

(On exam; Label the entire heart. Label nerve system routes, Label abdominal organs and locations. Label skeletal system)

Introduction

- Human anatomy: the study of how the human body is structurally organized.
- Importance of understanding human anatomy.
- To organize a patient assessment by body region.
- To communicate effectively with medical direction and other members of the health care team.

I. TERMINOLOGY (1 question on exam)

A. Directional Terms

1. Anatomical position: person standing erect with feet and palms facing the examiner.

2. Supine (lying face up).

3. Prone (lying face down).

4. Lateral recumbent (lying on right or left side) – “Recovery Position”.


Regardless of the patient’s actual position, the paramedic should always communicate patient information with reference to the anatomical position.

6. Directional terms: up, down, front, back, right, left.

B. Anatomical Planes

1. Imaginary straight-line divisions of the human body.

Directional terms, such as up or down, front or back, and right or left, also are communicated in anatomical terminology and always refer to the patient, not the examiner (e.g., the patient’s left arm).

2. Sagittal plane.

   a. Runs vertically through the middle of the body, producing right and left sides.
3. Parasagittal plane.
   a. A plane to one side of the midline.

4. Transverse or horizontal plane.
   a. Divides the body into top (superior) and bottom (inferior) sections.

5. Frontal or coronal plane.
   a. Divides the body into front (anterior) and back (posterior) portions.

C. Body Regions (1 question on exam)

1. Human body divided into several regions for the purpose of organizing anatomical structures.

2. Appendicular region.
   a. Includes the limbs or extremities and their girdles.

3. Axial region.
   a. Consists of the head, neck, thorax, and abdomen.

4. Abdominal region/quadrant.
   a. Usually divided into four quadrants by two imaginary divisions that run horizontally through the umbilicus and vertically through the xiphoid process and the symphysis pubis.

D. Body Cavities (1 question on exam)

1. Five major cavities.
   a. Thoracic cavity.
   b. Abdominal cavity.
   c. Pelvic cavity.
   d. Cranium and spine.
   f. Retroperitoneum.
2. Thoracic cavity (1 question on exam)
   a. Divided into two portions by the mediastinum.
   b. Surrounded by the rib cage.
   c. Separated from the abdominal cavity by the diaphragm.
   d. Contains two pleural cavities and a pericardial cavity.

The pleural cavities contain the lungs, and the pericardial cavity contains the heart.

The serous membrane that comes in contact with an organ is visceral, and the serous membrane that comes in contact with a cavity wall is parietal.

The sacral promontory is the projecting portion of the pelvis at the base of the sacrum.

   1) Lined with visceral and parietal serous membranes that produce a thin fluid to reduce friction during movement.

3. Abdominal/pelvic cavity.

Abdominopelvic organs that do not have mesentery or peritoneum are said to be retroperitoneal (behind the peritoneum).

   a. Separated by an imaginary line drawn between the symphysis pubis and the sacral promontory.
   b. Visceral peritoneum covers the abdominal organs.

The abdominal and pelvic cavities often are referred to collectively as the peritoneal or abdominopelvic cavity.

   c. Parietal peritoneum covers the body cavity wall.
   d. Peritoneal organs are held in place by mesentery.

      1) Anchors abdominal organs to the abdominal wall.
      2) Provides pathway for nerves and vessels to reach organs.

   e. Retroperitoneal organs.

      1) Kidneys.
      2) Adrenal glands.
      3) Pancreas.
      4) Portions of the colon.
      5) Urinary bladder.
f. Pelvic cavity is enclosed by bones of pelvis.

II. CELL STRUCTURE

Teaching Tip

Use the simple analogy of a cell being like a town. (Suggestions of what parts of a town with which to compare the various parts of the cell appear throughout this section.)

A. Cells

1. The most basic unit of life.
2. Composed of protoplasm, or living matter.
3. Three main parts of all human cells.
   b. Cytoplasm.
   c. Nucleus.

“The town”

B. Cytoplasmic Membrane

1. Encloses the cytoplasm, forming outer boundary of cell.
   a. Extracellular (substances outside of cells).
   b. Intercellular (substances between cells).
   c. Intracellular (substances inside cells).

2. Functions
   a. To enclose and support cell contents.
   b. To regulate what moves in and out of cells.

“The town’s boundaries.”
C. Cytoplasm

1. Lies between the cytoplasmic membrane and the nucleus.

2. Organelles (“little organs”).
   a. Specialized structures of the cytoplasm that perform functions important to cell survival.

3. Endoplasmic reticulum.
   a. Network of connecting sacs that wind through the cell’s cytoplasm.
      “The town’s subway system.”
   b. Serves as a miniature circulatory system for the cell.
   c. Carries proteins and other substances through the cytoplasm from one area to another.
   d. Smooth endoplasmic reticulum.
      1) Found in cells that handle or manufacture fatty substances.
      2) Participates in detoxification processes.
   e. Rough endoplasmic reticulum.
      1) Found in cells that manufacture proteins to be secreted and used outside the cell.

4. Ribosomes.
   “The town’s brick factory.”
   a. “Factories” in the cell where protein is synthesized.
   b. Macromolecules of protein and ribonucleic acid (RNA) composed of thousands of atoms.
   c. Form complexes with strands of RNA that provide blueprint for new protein.

5. Golgi apparatus (complex).
   “The town’s ‘Mailboxes to Go’ company.”
   a. Concentrates and packages materials for secretion from the cell.

“The town’s sewer system.”

   a. Membranous-walled organelles.

   b. Contain enzymes enabling them to function as intracellular digestive systems.

Cell damage can cause destruction of the lysosome membrane and escape of the enzymes into the cytoplasm. This results in cell digestion (autolysis), or self-destruction.

   c. Also digest organelles of the cell that are nonfunctional (autolysis; autophagia).

7. Mitochondria (1 question on exam).

“The town’s electrical plant.”

   a. “Power plants of the cell” - produces aerobic energy for the cell.

   b. Site of aerobic oxidation.

8. Centrioles

“The town’s singles bar.”

   a. Paired, rod-shaped organelles that lie at right angles to each other in a zone of cytoplasm (centrosome)

(1 question on exam) It is here that energy, derived from the efficient metabolism of nutrients and oxygen via the Krebs cycle, is used to synthesize high-energy triphosphate bonds (e.g., adenosine triphosphate, or ATP). These triphosphate bonds are the energy source for the body’s muscles, nerves, and overall function.

There are no centrioles in mature red blood cells, skeletal muscle, or cardiac muscle cells, or in typical neurons.

   b. Important in the process of cell division.

9. Nucleus

“The town’s city hall complex.”

   a. Largest organelle, which controls all other organelles in the cytoplasm.
b. Location of the genetic material of the cell.

c. Surrounded by a nuclear membrane (nuclear envelope) that encloses the nuceloplasm and its contents.

   1) Nucleolus.
      a) Consists of RNA and protein.

   2) Chromatin granules.
      a) Threadlike structures made up of proteins and DNA.
      b) Condenses to form 23 pairs of chromosomes during cell division.

d. Primary functions of the nucleus.

   1) Cell division.

   2) Control of genetic information.

D. Major Classes of Cells

The most significant categorizing feature of cells is the presence or absence of a nucleus.

1. Free-living cells of multicellular “social” organisms are subdivided into two major classes by the way their genetic material is organized.

   a. Eukaryotes (“true nucleus”).

   b. Prokaryotes (“before nucleus”).

2. Eukaryotes.

   a. Larger than prokaryotes and have more extensive intracellular anatomy.

   b. Have a separate membrane-bound nucleus that contains genetic material (chromosomes, DNA, etc.).

   c. Fluid filling the eukaryotes is divided into the nucleoplasm (inside the nuclear membrane) and the cytoplasm (outside the nuclear membrane).

   d. Prokaryotes.

      1) Simpler cells.

      2) Genetic material and the enzymes required for energy production, cell growth, and division are contained in the jellylike cytoplasm that is surrounded by the plasma membrane.
3) Simple internal organization.

4) Their DNA is attached to the plasma membrane.

E. Chief Cellular Functions

Through differentiation (maturation), cells become “specialized” in one type of function or act in concert with other cells to perform a more complex task. Examples include RBCs (red blood cells), which only carry out one function (transporting respiratory gases around the body), and the cells in the pancreas, which synthesize and secrete large quantities of digestive enzymes required to break down foods.

1. Seven chief cellular functions.
   a. Movement (muscle cells).
   b. Conductivity (nerve cells).
   c. Metabolic absorption (kidney and intestinal cells).
   d. Secretion (mucous gland cells).
   e. Excretion (all cells).
   f. Respiration (all cells).
   g. Reproduction (most cells).

F. Cell Reproduction

1. All human cells (except sex cells) reproduce by mitosis, in which cells divide to multiply.

2. Many cells divide throughout the life of the organism.
   a. Epithelial cells.
   b. Liver cells.
   c. Bone marrow cells.

3. Other cells divide until near the time of birth.
   a. Nerve cells.
   b. Skeletal muscle cells.
III. TISSUES

Not all cells are capable of continuous division, and some cells (e.g., nerve cells) cannot reproduce.

It is estimated that there are about 200 different specialized types of cells in the human body.

A. Epithelial Tissue (Epithelium)

1. Covers surfaces or forms structures derived from body surfaces.

The epithelium covers the outside of the body and lines the digestive tract, the blood vessels, and many body cavities.

2. Consists mostly of cells with little or no intercellular material between them.

3. Forms continuous sheets that contain no blood vessels.

4. May be classified according to shape.
   a. Squamos (flat and scalelike).
   b. Cuboidal (cube-shaped).
   c. Columnar (more tall than wide).

5. May also be classified according to arrangement.
   a. Simple (single layer of same-shaped cells).
   b. Stratified (multiple layers of same-shaped cells).
   c. Transitional (several layers of different-shaped cells).

B. Connective Tissue

Mast cells are one type of loose areolar connective tissue. Mast cells are found in abundance along blood vessels and may develop from basophils (a type of white blood cell). Mast cells produce histamine, a substance that causes dilation of blood vessels, and heparin, an anticoagulant that prevents blood clotting.

1. Most abundant body tissue.

2. Consists of cells separated by nonliving extracellular matrix, the basis for seven subgroups.
   a. Areolar.
1) Loose tissue of organs and other tissues.

2) Attaches skin to underlying tissues.

3) Contains three major types of protein fibers.
   a) Collagen.
   b) Reticulum.
   c) Elastin.

b. Adipose.

1) Fat tissue that stores lipids.

2) Packing around and between organs, bundles of muscle fibers, nerves, and blood vessels.

3) Functions as insulator, protector, and site for energy storage.

c. Fibrous.

1) Consists mainly of bundles of collagenous fibers arranged in parallel rows (e.g., tendons).

d. Cartilage.

1) Composed of chondrocytes distributed throughout a semirigid matrix.

2) Composition varies by anatomical location and function.

3) Constitutes part of the human skeleton and covers the articulating surfaces of bones.

4) Forms major skeletal tissue of the embryo before its replacement by bony tissue.

5) Has no blood vessels and, therefore, heals slowly after injury.

e. Bone.

1) Consists of living cells and mineralized matrix.
   a) Makeup allows bone to support and protect other tissues and organs.

2) Classified according to shape.
   a) Long bones.

Examples of long bones are the humerus, ulna, radius, femur, tibia, fibula, and phalanges.

b) Short bones.

Short bones are about as broad as they are long. Examples of short bones are the carpal bones of the wrist and the tarsal bones of the ankle.
c) Flat bones.

Examples of flat bones are certain skull bones, ribs, sternum, and scapulae.

d) Irregular bones.

Examples of irregular bones include vertebrae and facial bones.

3) Each growing long bone consists of a diaphysis (shaft), epiphysis at the end of the bone, and an epiphyseal or growth plate (site of bone elongation)

a) Injury to the epiphyseal plate can impair growth if not recognized and treated

4) Bones contain large cavities, such as the medullary cavity in the diaphysis, and smaller cavities, such as in the epiphyses of long bones and throughout the interior of other bones.

a) These spaces are filled with yellow marrow (mainly adipose tissue) or red marrow (the site of blood formation).

5) May be further classified as cancellous (spongy) bone or compact bone.

Blood supply to most bones is excellent, so some bones, such as the tibia and sternum, are suitable choices for venous access via intraosseous infusion (described in later Chapters).

a) Cancellous bone has spaces between the plates.

b) Compact bone is essentially solid.

f. Blood.

1) Connective tissue with liquid matrix.

Unlike cartilage, bone has a rich blood supply and can repair itself much more readily than cartilage.

a) Allows blood to flow rapidly.

b) Transports nutrients, oxygen, waste products, and other materials.

g. Hemopoietic.

1) Found in the marrow cavities of bones and lymphoid organs (spleen, tonsils, lymph nodes).

2) Responsible for formation of blood cells and lymphatic system cells that are important in the body’s defense against disease.

C. Muscle Tissue
1. A contractile tissue responsible for movement.
   a. Able to contract or shorten forcefully.

2. Classified according to anatomical location.
   a. Skeletal.
      1) Attaches bones.
      2) Responsible for movement.
   b. Cardiac.
      1) Muscle of the heart.
   c. Smooth (visceral).
      1) Responsible for a variety of functions (e.g., movement in the digestive, urinary, and reproductive systems).

3. Classified according to function.
   Some muscle is both voluntary and involuntary (e.g., muscles of the eyelids).
   a. Voluntary (consciously controlled).
   b. Involuntary (not normally under conscious control).

4. Classified according to appearance.
   a. Striated.
      1) Voluntary skeletal muscle.
      2) Involuntary cardiac muscle.
   b. Nonstriated.
      1) Involuntary (smooth) muscle.

D. Nervous Tissue (1 question on exam)
   1. Conducts electrical signals (action potentials).
2. Consists of neurons and neuroglia.

3. Neurons (nerve cells).
   a. Actual conducting cells of nervous tissue.
   b. Cell body.
      1) Contains the nucleus.
      2) Site of general cell functions.
   c. Dendrite.
      1) Receives electrical impulses and conducts them toward the cell body.
   d. Axon.
      1) Conducts impulses away from the cell body.

4. Neuroglia
   a. Supports the cells of the brain, spinal cord, and peripheral nerves.
   b. Divided into subgroups that nourish, protect, and insulate neurons.

IV. ORGAN SYSTEMS

A. Definitions
   1. Organ: A structure made up of two or more kinds of tissues organized to perform a more complex function than any one tissue can alone.
   2. System: A group of organs arranged to perform a more complex function than any one organ can alone.
   3. Eleven major organ systems compose the human body.

B. Integumentary System
   1. Largest organ system of the body.

   2. Functions
      a. Protection against injury.
b. Prevention of dehydration.

c. Defense against infection.

d. Aids in temperature regulation.

3. Skin

Ask students for an example of an injury to this system and what effects it might have on function (e.g., a burn).

a. Epidermis.
   1) Outermost layer.
   2) Consists of tightly packed epithelial cells.
   3) Has ability to undergo mitosis and can repair itself if injured.

b. Dermis.
   1) Thick layer composed of collagenous and elastic fibers.
   2) Contains nerves and nerve endings to provide sensory information.
      a) Pain.
      b) Pressure.
      c) Touch.
      d) Temperature.
   3) Contents of various levels.
      a) Muscle fibers.
      b) Hair follicles.
      c) Sweat and sebaceous glands.
      d) Many blood vessels.
   4) Supported by a thick layer of subcutaneous tissue.
      a) Insulates body from temperature extremes.
      b) Serves as source for stored energy.
      c) Acts as a shock absorber for the body.
4. Hair

Smooth muscles known as arrector pili are associated with each hair follicle. Movement of the hair follicle by the arrector pili produces a pressure on the skin (“goose bumps”) and pulls the hairs upward.

a. Hair follicle—located in the dermis.

b. Hair papilla—cluster of cells where hair growth begins.

c. Root—lies hidden in follicle.

d. Shaft—visible part of hair.

5. Nails

a. Produced by cells in the epidermis.

b. Nail body—Visible part of nail.

c. Cuticle—fold of skin that encloses the nail root.

d. Lunula—crescent-shaped white area of nail.

e. Nail bed.

   1) Abundant in blood vessels.

   2) Appears pink in healthy people.

6. Glands

a. Sebaceous.

   1) Most are located in the dermis.

   2) Secrete sebum for the hair and skin.

   3) Prevent drying and protect against some bacteria.

b. Ceruminous.

   1) Located in the external auditory meatus.

   2) Secrete cerumen (earwax).

c. Mammary.
d. Sweat (sudoriferous).

1) Most numerous skin glands.

2) Merocrine glands.
   a) Open directly onto skin surface through sweat pores.
   b) Fluid contains salts, ammonia, urea, uric acid, and lactic acid.
   c) Cool the body through sweating as body temperature rises.

3) Apocrine glands.
   a) Usually open into hair follicles.
   b) Found in the axillae, genitalia, and around the anus.
   c) Responsible for body odor.

C. Skeletal System

1. Composition
   a. Bones
   b. Connective tissues (1 question on exam)
      1) Cartilage.
      2) Tendons - muscle to bone.
      3) Ligaments - bone to bone.

2. Contains 206 individual bones.

3. Axial skeleton.
   a. Skull
      1) 28 separate bones.
         a) Auditory ossicles. (6)
         b) Cranial vault. (8)
c) Facial bones. (14)

b. Hyoid bone

The parietal and temporal bones are paired.

1) Floats in the superior aspect of the neck, just below the mandible.

2) Serves as the attachment point for neck and tongue muscles.

c. Vertebral column.

The hyoid bone is unique because it has no articulations with other bones.

Vertebrae

1) Consists of 26 bones divided into 5 regions.

   a) Cervical vertebrae (7).

   b) Thoracic vertebrae (12).

   c) Lumbar vertebrae (5).

   d) Sacral bone (1; 5 fused vertebrae).

   e) Coccygeal bone (1; 5 fused vertebrae).

2) Body—weight-bearing portion of the vertebrae.

A total of 34 vertebrae originally form during development, but the 5 sacral vertebrae fuse to form 1 bone, as do the 4 or 5 coccygeal bones.

3) Intervertebral disks.

   a) Serve as shock absorbers.

   b) Provide additional support.

   c) Prevent friction between vertebral bodies.

4) Vertebral arch—protects spinal cord.

5) Transverse process extends laterally from each side of the arch.

6) Spinous process is located at the point of junction .

This is the palpable part of the spinal column.

d. Thoracic cage.
1) Protects vital organs in the thorax.

2) Prevents collapse of the thorax during respiration.

3) Ribs (12 pairs).
   a) Superior (7; true ribs) articulate with the thoracic vertebrae and attach directly to the sternum.
   b) Inferior (5; false ribs) do not attach directly to the sternum.
   c) Ribs 11 and 12 are “floating ribs”.

Floating ribs have no anterior attachment.

   e. Sternum (1 question on exam).
      1) Divided into three parts.
         a) Manubrium.
         b) Body.
         c) Xiphoid process.
      2) Jugular notch—superior margin of the manubrium.

The jugular notch (also called the suprasternal notch) is the point at which the manubrium and clavicle (collarbone) articulate.

   3) Sternal angle (angle of Louis)—the point at which the manubrium joins the body of the sternum.

The second rib is found lateral to the sternal angle and is used as a starting point for counting the other ribs.

4. Appendicular skeleton.
   a. Consists of the bones of the upper and lower extremities and their girdles.
   b. Pectoral girdle.
      1) Comprised of the scapula (shoulder blade) and clavicle.

The clavicle is easily fractured.

Each pectoral girdle consists of two bones—the clavicle and the scapula. The pectoral girdle serves to attach the arm to the axial skeleton. The clavicle serves as attachment for certain muscles of the neck, thorax, back, and arm.
2) Attaches upper limbs to the axial skeleton.

c. Humerus.

1) Second largest bone in the body.

2) Head of humerus is attached to the scapula.

3) Greater and lesser tubercles function as sites of muscle attachments.

4) Articulates with the radius and ulna at its distal end.

d. Radius/ulna.

The ulna is the forearm bone on the medial side and the radius on the lateral (thumb) side.

1) Structural relationship between the olecranon process and the olecranon fossa allows for joint movement.

2) Biceps brachii are attached to the radial tuberosity.

3) Distal end of the ulna articulates with both the radius and wrist bones.

e. Wrist (carpus).

1) Composed of 8 carpal bones.

2) Metacarpals (5) attach to carpal bones to make up the hand.

3) Phalanges (28) make up the 10 digits of the hands.
   a) 2 phalanges for each thumb.
   b) 3 phalanges for each finger.

f. Pelvic girdle (1 question on exam).

The pelvic girdle transmits the weight of the trunk to the lower limbs and protects the abdominal and pelvic organs.

1) Attaches legs to trunk.

2) Consists of two hip bones (coxae).
   a) Each coxa surrounds a large obturator foramen through which muscles, nerves, and blood vessels pass to the leg.
   b) Each coxa is formed by the fusion of the ilium, ischium, and pubis.
      (1) Superior portion of the ilium is the iliac crest.

The iliac crest can be felt when you place your hand on your hip.
3) Acetabulum
   a) Located on the lateral surface of each cox.
   b) Point of articulation of the lower limbs with the girdle.

4) Femur
The femur has a rich blood supply. Fractures can result in substantial blood loss.
   a) Longest, strongest, and heaviest bone in the skeleton.
      b) Head articulates with the acetabulum.
      c) Proximal shaft has two tuberosities.
         (1) Greater trochanter lateral to the neck.
         (2) Lesser trochanter inferior and posterior to the neck.
         (3) Both trochanters are attachment sites for muscles that attach the hips to the thigh.
      d) Medial and lateral condyles at distal end of femur articulate with the tibia.
      e) Medial and lateral epicondyle are the sites of muscle and ligament attachment.
      f) Distally, the femur articulates with the patella.
         (1) Patella is located in major tendon of thigh muscle.
         (2) Patella allows tendon to turn corner over knee.

5) Tibia
The tibia is the medial bone of the lower leg. The fibula is the lateral bone of the lower leg.
   a) Larger than fibula and supports most of the leg’s weight
   b) Distal end forms medial malleolus, forming the medial side of the ankle joint

6) Fibula
The fibula is the slenderest bone of the body, proportional to its length. It is not involved in weight bearing. Its purpose is to increase the available area for muscle attachments in the leg.
   a) Does not articulate with the femur
   b) Does articulate with tibia
   c) Distal end forms lateral malleolus, forming the lateral aspect of the ankle

7) Foot
a) Consists of tarsals, metatarsals, and phalanges

b) Talus articulates with tibia and fibula

c) Calcaneus
   (1) Located inferior and lateral to talus
   (2) Easily identified as the heel

d) Ligaments and leg muscle tendons hold foot bones in their arched position

Lesson Plan (2 of 5)

C. Skeletal System (cont’d)

1. Every bone (except the hyoid bone) connects to at least one other bone

2. Classification of joints
   a. Fibrous joints
   b. Cartilagenous joints
   c. Synovial joints

3. Fibrous joints
   a. Consist of two bones, united by fibrous tissue, that have little or no movement
   b. Sutures (seams between flat bones)
      1) Located in skull
      2) May be completely immobile in adults
      3) Fontanelles
         a) Gaps between sutures in newborns
         b) Allow “give” in skull during birth and growth
c. Syndesmoses

1) Joints in which the bones are separated by a greater distance than with a suture and are joined by ligaments

2) Example: joint that binds the radius and ulna (radioulnar syndesmosis)

d. Gomphoses

1) Joints that consist of a peg that fits into a socket

2) Example: joints between the teeth and the dental alveoli

4. Cartilaginous joints

a. Unite two bones by means of hyaline cartilage (synchondroses) or fibrocartilage (symphysis)

b. Synchondrosis

1) Allows only slight joint movement

2) Example: epiphyseal plate

c. Symphysis

1) Slightly movable because of flexible structure of fibrocartilage

2) Example: junction between the manubrium and body of adult sternum

5. Synovial joints

a. Contain synovial fluid

1) Allows considerable movement between articulating bones

b. Account for most joints of appendicular skeleton

c. Six types

1) Plane or gliding joints (e.g., articular process between vertebrae)

2) Saddle joints (e.g., carpometacarpal joint of the thumb)

3) Hinge joints (e.g., joints of the elbow and knee)

4) Pivot joints (e.g., joint of the radius and ulna)

5) Ball-and-socket joints (e.g., shoulder and hip joints)
6) Ellipsoid joints (e.g., atlantooccipital joint)

6. Types of body movement
   a. Body movement may be described in relation to the anatomical position.

D. Muscular System

1. Functions
   a. Movement
   b. Postural maintenance
   c. Heat production

2. Types of muscle
   a. Skeletal
   b. Cardiac
   c. Smooth

3. Physiology of skeletal muscle
   A typical skeletal muscle consists of hundreds or thousands of long, cylindrical cells called muscle fibers. These fibers contain myofibrils that consist of thick (composed mainly of the protein myosin) and thin (composed of the protein actin) filaments. The filaments are arranged into sarcomeres.

   a. Consists of contractile cells (muscle fibers)
      1) Contracts in response to electrochemical stimuli
   b. Each skeletal muscle fiber is filled with thick and thin myofilaments
   c. A sarcomere is a contractile unit of skeletal muscle
   d. Contraction process
      1) Energy obtained from ATP (Adenosine Triphosphate) molecules allows the thick and thin myofilaments to slide toward each other
2) Sarcomere shortens
3) Entire muscle shortens

4. Neuromuscular junction
   a. Nerve impulse enters the muscle fiber through a specialized nerve known as a motor neuron
   b. Point of contact between the nerve ending and the muscle fiber is the neuromuscular junction (synapse)
   c. Each muscle fiber receives a branch of an axon
      1) Each axon innervates more than one muscle fiber
   d. When a nerve impulse passes through this junction, specialized chemicals (acetylcholine) are released, causing the muscle to contract

5. Skeletal muscle movement

Some muscles are not attached to bone at both ends. For example, on the face, muscle is attached to the skin, which moves when the muscle contracts.

   a. Results from muscle contraction by pulling a bone toward another across a movable joint
   b. The points of attachment of each muscle are its origin and insertion
      1) Origin—the end of the muscle attached to the more stationary bone
      2) Insertion—the end of the muscle attached to the bone undergoing the greatest movement
      3) Synergists—muscles that work in cooperation with one another to produce movement
      4) Antagonists—muscles that work in opposition, moving the structure in an opposite direction
      5) Prime mover—the muscle that is primarily responsible for a particular movement

6. Types of muscle contraction
   a. Isometric—the length of the muscle does not change but the amount of tension increases during the contraction process
   b. Isotonic—the amount of tension produced by the muscle is constant during contraction, but the muscle length changes
   c. Most muscle movement is a combination of both isometric and isotonic contraction
7. Postural maintenance

Even when muscles are at rest, a certain amount of tautness usually remains. This is called muscle tone.

   a. Results from extended periods of muscle tension

   b. Functions of muscle tone

Have students compare energy use (work) when walking versus crawling (abnormal posture). Have a student walk slowly around the room twice; check their pulse. Repeat using a crawling motion. What happens to the pulse?

   1) Keeping back and legs straight
   2) Keeping head upright
   3) Keeping abdomen flat

8. Heat production

   a. Chemical reaction from the breakdown of ATP during muscle contraction results in some energy being lost as heat

      1) Largely responsible for normal body temperature

   b. Shivering

Ask students why shivering may not be desirable in a patient who is hypoxic or in shock.

      1) Involves rapid contractions of skeletal muscle to produce shaking
      2) Can increase heat production up to 18 times that of resting levels
      3) Helps raise body temperature to normal range

SESSION TWO A&P

E. Nervous System

1. A major regulatory and coordinating system of the body
2. Rapidly transmits information by means of nerve impulses from one body area to another

3. Divisions
   a. Single nervous system is subdivided according to structural and functional features
   b. Central nervous system (CNS)
      1) Consists of the brain and spinal cord, which are continuous with each other
   c. Peripheral nervous system (PNS)
      1) Consists of nerves and ganglia
      2) 43 pairs of nerves originate from the CNS to form the PNS
         a) 12 pairs (cranial nerves) originate from the brain
         b) 31 pairs (spinal nerves) originate from the spinal cord
      3) Afferent division—transmits action potentials from sensory organs to the CNS
      4) Efferent division
         a) Transmits action potentials from the CNS to effector organs such as muscles and glands
         b) Somatic nervous system—transmits impulses from the CNS to skeletal muscle
         c) Autonomic nervous system—transmits action potentials from the CNS to smooth muscle, cardiac muscle, and certain glands

4. Central nervous system
   a. Components
      1) Brain
         a) Brain stem
            (1) Medulla oblongata
            (2) Pons
            (3) Midbrain
         b) Diencephalon
            (1) Thalamus
(2) Hypothalamus
c) Cerebrum
d) Cerebellum

2) Spinal cord

b. Brain stem
1) Comprises the medulla, pons, and midbrain
2) Connects the spinal cord to the remainder of the brain
3) All but 2 of the 12 cranial nerves enter or exit the brain through the brain stem
4) Medulla (1 question on exam)
   a) Most inferior portion of brain stem
   b) Conduction pathway for both ascending and descending nerve tracts
   c) Functions include regulation of the following:
      (1) Heart rate
      (2) Blood vessel diameter
      (3) Breathing
      (4) Swallowing
      (5) Vomiting
      (6) Coughing
      (7) Sneezing

5) Pons
   a) Contains ascending and descending nerve tracts and relays information from the cerebrum to the cerebellum
   b) Houses the sleep center and respiratory center
   c) Along with the medulla, helps control breathing

6) Midbrain (mesencephalon)

Other parts of the midbrain help regulate the automatic functions that require no conscious thought (e.g., coordination of motor activities and muscle tone).
a) Smallest region of the brain stem

b) Functions:

(1) Hearing through audio pathways in the CNS

(2) Visual reflexes (e.g., visual tracking of moving objects, turning of the eyes)

7) Reticular formation

The RAS is stimulated by incoming sensory impulses from the eyes, ears, and skin. For example, we awaken to the sound of an alarm clock. A coma after a head injury results from damage to the RAS.

a) A group of nuclei scattered throughout the brain stem

(1) Neurons of the reticular formation involved in motor control of the visceral organs

b) Part of the reticular activating system (RAS)

(1) Involved in sleep-awake cycle

(2) Important in arousing and maintaining consciousness

c. Diencephalon

1) Located between the brain stem and the cerebrum

2) Major components are the thalamus and hypothalamus

3) Thalamus

a) Largest portion (about 4/5) of the diencephalons

b) Functions as a “relay station,” receiving sensory input from various sense organs and relaying information to the cerebral cortex

c) Influences mood and general body movements associated with strong emotions (e.g., fear or rage)

4) Hypothalamus

a) An area of the brain that controls many body functions

b) Serves as a “gatekeeper” to the cerebrum

c) Areas of activity

Sensory input from both the internal and external environment ultimately reaches the hypothalamus.

(1) Emotions (pain, pleasure, excitement, rage)

(2) Hormonal cycles
(3) Sexual activity

d. Cerebrum

1) Largest portion of the brain

2) Also called the cerebral cortex

3) Composed of two (right and left) cerebral hemispheres

The left hemisphere controls the right side of the body, and the right hemisphere controls the left side of the body.

In most people the left hemisphere of the brain is important for spoken and written language, numerical and scientific skills, logic, and reasoning. The right hemisphere is important for space and pattern perception, creativity, musical and artistic awareness, and the generation of mental images of sight, sound, touch, taste, and smell to compare relationships.

a) Each hemisphere is divided into lobes named for the bones that lie over them

4) Frontal lobe (1 question on exam)

a) Areas of activity

(1) Voluntary motor function

(2) Motivation

(3) Aggression

(4) Mood

5) Parietal lobe—major center for reception and evaluation of sensory information

6) Occipital lobe

a) Functions in reception and integration of visual input

b) Is not distinctly separate from other lobes

7) Temporal lobe (1 question on exam)

a) Receives and evaluates olfactory and auditory input

b) Plays an important role in memory

8) Limbic system

a) Consists of portions of the cerebrum and the diencephalons

b) Areas of activity
(1) Emotions (and visceral responses)

(2) Motivation

(3) Mood

(4) Sensations of pain and pleasure

e. Cerebellum

1) Second largest part of the human brain

2) Major functions:
   a) Maintenance of posture
   b) Helps maintain equilibrium
   c) Compares impulses from the motor cortex with those from moving structures
   d) Compares the intended movement with the actual movement
   e) Responsible for fine coordination and precise control of muscle movements

f. Spinal cord

1) Location and function
   a) Lies within the spinal column
   b) Extends from the occipital bone to the level of the second lumbar vertebra
   c) Central gray portion (gray matter) consists of nerve cell bodies and dendrites
   d) Peripheral white portion (white matter) consists of nerve tracts
   e) Dorsal root conveys afferent nerve processes to the cord
   f) Ventral root conveys efferent nerve processes away from the cord
   g) Spinal ganglia (dorsal root ganglia) contain the cell bodies of sensory neurons

2) Primary reflex center of the body
   a) Many reflexes are autonomic or visceral
      
      (1) Increased heart rate in response to decreased blood pressure
      
      (2) Stretch reflex ("knee-jerk reflex")
      
      (3) Withdrawal reflexes
b) Carries impulses to the brain in afferent, ascending tracts

c) Carries motor impulses from the brain in efferent, descending tracts

g. Meningeal coverings

1) Meninges
   a) Tough, fluid-containing membranes
   b) Cover organs of the nervous system

2) Surrounded by bone with three connective tissue layers

3) Dura mater

Teaching Tip

Memory aid—PAD: Pia, Arachnoid, Dura (dura is Latin for “tough,” as in “durable”).

   a) Most superficial and thickest layer
   b) Consists of two layers around the brain and one layer around the spinal cord

Meninges cover the brain and spinal cord in a single piece much like pantyhose cover the legs and hips.

4) Arachnoid layer
   a) Second meningeal layer
   b) Space between layers (subdural space) contains a small amount of serous fluid

5) Pia mater
   a) Third meningeal layer
   b) Space between pia matter and arachnoid space) is filled with blood vessels and cerebrospinal fluid

6) Cerebrospinal fluid
   a) Similar to plasma and interstitial fluid
   b) Functions
      (1) Bathes the brain and spinal cord
      (2) Acts as a protective cushion around the CNS
      (3) Formed continually in the choroids plexus
(4) Fills the ventricles of the brain, subarachnoid space, and the central canal of the spinal cord

5. Peripheral nervous system
   a. Collects information from both inside the body and the body surface
      1) Relays information by afferent fibers to the CNS
      2) Relays information by efferent fibers from the CNS to various parts of the body
   b. Spinal nerves
      1) Arise from rootlets along the dorsal and ventral surfaces of the spinal cord
      2) All 31 pairs (except the first pair of spinal nerves and the spinal nerves in the sacrum) exit the vertebral column through adjacent vertebrae
         a) The first pair exists between the skull and the first cervical vertebra
         b) Spinal nerves in the sacrum exit the bone
         c) Eight pairs exit in the cervical region
         d) Twelve pairs exit in the thoracic region

A plexus is a network of nerve fibers. The cervical plexus innervates the neck muscles and the skin of the head, neck, and chest. The most important nerve in the cervical plexus is the phrenic nerve, which supplies the diaphragm.

The brachial plexus supplies the upper limb and some muscles of the neck and shoulder.

The lumbar plexus innervates the skin and muscles of the abdominal wall, the thigh, and the external genitalia. The largest nerve of the lumbar plexus is the femoral nerve. The largest nerve of the sacral plexus is the sciatic nerve. The sacral plexus innervates the lower limbs, buttocks, and perineal region. The coccygeal plexus supplies the coccygeal region.

   e) Five pairs exit in the lumbar region
   f) Five pairs exit in the sacral region
   g) One pair exits in the coccygeal region

3) Each spinal nerve (except C1) has a specific cutaneous sensory distribution
   a) Dermatome refers to the skin surface area supplied by a single spinal nerve
   b) An important assessment when dealing with a spine-injured patient
   c. Cranial nerves (1 question on exam)
Cranial nerves are designated by Roman numerals and by name. Some cranial nerves contain only sensory fibers, but most contain both sensory and motor fibers.

Because cranial nerves control eye movements, injury to or pressure on the cranial nerves can influence pupil response or extraocular movements.

1) Sensory functions
   a) Special senses (vision)
   b) General senses (touch, pain)

2) Somatomotor functions
   a) Control skeletal muscles through motor neurons

3) Proprioception functions
   a) Provide the brain with information about position of the body and its various parts, including joints and muscles

4) Parasympathetic functions

The vagus nerve (cranial nerve X) is both a motor and a sensory nerve. Its motor neurons originate in the medulla and innervate almost all of the thoracic and abdominal organs. Sensory neurons carry information from the pharynx, larynx, trachea, esophagus, heart, and abdominal viscera to the medulla and pons.

   a) Regulation of glands, smooth muscle, and cardiac muscle (functions of the autonomic nervous system)

6. Autonomic nervous system
   a. Afferent neurons
      1) Carry action potentials from the periphery to the CNS
      2) Provide information to the CNS that may stimulate both somatomotor and autonomic reflexes
   b. Efferent neurons
      1) Carry action potentials from the CNS to the periphery
      2) Somatomotor neurons
         a) Innervate skeletal muscles
         b) Play an important role in locomotion, posture, and equilibrium
         c) Movements are usually considered to be conscious movements
3) Autonomic neurons
   a) Innervate smooth muscle, cardiac muscle, and glands
   b) Effects are usually considered to be unconsciously controlled
   c) Sympathetic division
      “Fight or flight” response.
      1) Generally prepares a person for physical activity
   d) Parasympathetic division
      The parasympathetic division works to conserve and restore energy.
      1) Activates vegetative functions such as digestion, defecation, and urination

c. Functions
   1) To maintain or quickly restore homeostasis
   2) Sympathetic and parasympathetic impulses affect the body in antagonistic ways

F. Endocrine System

Endocrine glands have no ducts. They secrete hormones directly into the tissue fluid that surrounds their cells. Exocrine glands (such as the salivary glands) secrete their products into ducts.

   1. Composed of glands that secrete hormones into the circulatory system

   2. Overlaps with the nervous system in function and anatomy
      a. Some neurons secrete into the circulatory system regulatory chemicals (neurohormones) that function as hormones

Some hormones affect all or almost all the cells of the body. For example, growth hormone (from the anterior pituitary gland) causes growth in all or most parts of the body, and thyroid hormone increases the rates of most chemical reactions in almost all of the body’s cells. Other hormones affect only specific tissues (target tissues), because only these cells have the specific target-cell receptors that will bind the hormones to initiate their actions.

   b. Other neurons innervate endocrine glands and influence their secretory activity
c. Some hormones secreted by the endocrine glands affect the nervous system

3. Hormone classifications
   a. Proteins
   b. Polypeptides
   c. Derivatives of amino acids
   d. Lipids

4. Some hormones are dissolved in blood plasma and are quickly distributed throughout the body
   a. The amount of hormone that reaches the target tissue directly correlates with the concentration of the hormone in the blood

Some hormones, such as epinephrine and norepinephrine, are secreted within seconds after stimulation of the endocrine gland. These hormones may develop full action within a few seconds to minutes. Other hormones, such as growth hormone or thyroxine, may require months for full effect.

Each hormone has its own characteristic onset and duration of action, which are tailored to perform its specific control function.

Lesson Plan (3 of 5)

G. Circulatory system

1. Blood
   a. Functions
      1) Transports nutrients and oxygen to tissues
      2) Carries carbon dioxide and waste products away from tissues
      3) Carries hormones produced in endocrine glands to target tissues
      4) Aids in temperature regulation and fluid balance, and protects the body from bacteria and foreign substances
b. Components

1) Plasma

   a) Pale yellow fluid

      (1) 92% water

      (2) 8% dissolved or suspended molecules

   b) Plasma proteins compose 7% of plasma

      (1) Albumin (55% to 60% of the plasma proteins)

         Albumin exerts considerable osmotic pressure, which helps maintain the water balance between blood and tissues and regulate blood volume. Albumin also functions as the transport protein for several steroid hormones.

         (2) Globulins (30% of plasma proteins)

            (a) Alpha and beta globulins function to transport iron, fat, and fat-soluble vitamins in the blood

            (b) Gamma globulins are antibodies and function in immunity

      (3) Fibrinogen (4% of plasma proteins)

      Plasma proteins are the only component of plasma that cannot pass through the capillary membrane to reach the cells.

         (a) Essential role in blood clotting

   c) Nutrients absorbed from the digestive tract, including amino acids (from proteins), glucose (from carbohydrates), and fatty acids and glycerol (from triglycerides)

      Plasma also contains nutrients, blood gases, electrolytes, hormones, enzymes, minerals, vitamins, and waste products.

         d) Blood gases including oxygen, carbon dioxide, and nitrogen

         Whereas there is more oxygen associated with hemoglobin inside red blood cells, there is more carbon dioxide dissolved in plasma.

         e) Electrolytes including sodium, potassium, calcium, magnesium, chloride, bicarbonate, phosphate, and sulfate ions

2) Formed elements (1 question on exam)

   a) Erythrocytes (red blood cells)

   b) Leukocytes (white blood cells)

      (1) Granular leukocytes (granulocytes)
(a) Neutrophils
(b) Eosinophils
(c) Basophils

(2) Agranular leukocytes (agranulocytes)

(c) Thrombocytes (platelets)

3) Erythrocytes (2 question on exam)

a) Main component is hemoglobin, which gives blood its red color
b) Most numerous formed elements of blood
c) Primary functions
   1) Transport oxygen from the lungs to tissues
   2) Transport carbon dioxide from the tissues to the lungs
   3) Under normal conditions, approximately 2.5 million erythrocytes are destroyed and replaced by the body each second
   4) Average erythrocyte circulates for 120 days

4) Leukocytes (1 question on exam)

a) Clear white blood cells that do not contain hemoglobin
b) Protect the body against invading microorganisms
c) Remove dead cells and debris
d) Neutrophils
   1) Most common leukocyte (40% to 70% of leukocytes)
   2) Very mobile and phagocytic

Normally, infection or tissue damage results in an increase in the number of leukocytes.

   3) Number increases rapidly during short-term or acute infections
   4) Arrive at infected tissue to destroy certain bacteria, viruses, and other agents

e) Eosinophils (1% to 4% of leukocytes)
   1) Increase during allergic reactions to combat effects of histamine
(2) Combat parasitic worms

(3) Number of eosinophils decreases during prolonged stress

f) Basophils
   (1) Least common leukocyte (less than 1%)
   (2) Develop into mast cells that release heparin (perhaps to prevent intravascular blood clots) and histamine (possibly to increase blood flow to injured tissues) in allergic reactions that intensify the inflammatory response

g) Lymphocytes (20% to 45% of leukocytes)
   (1) Smallest leukocytes
   (2) Originate in bone marrow
   (3) Most abundant in lymphatic tissues
   (4) Lifespan may reach several years
   (5) B-lymphocytes
      (a) Differentiate into plasma cells in response to the presence of foreign substances that produce antibodies

Teaching Tip

In leukemia, huge numbers of leukocytes are rapidly produced. These “new” leukocytes are immature and incapable of carrying out their normal protective functions. As a result, the body becomes prone to disease-causing bacteria and viruses.

   (b) Antibodies attach to the antigen and render it harmless
   (c) Combat infection and provides immunity

(6) T-lymphocytes destroy foreign substances directly
   (a) Responsible for rejection of transplanted tissue
   (b) Involved in fighting tumors and viruses
   (c) Activate B-lymphocytes

h) Monocytes (4% to 8% of leukocytes)
   (1) Largest leukocytes
   (2) Enter the blood from the bone marrow and circulate for about 72 hours
      (a) They then enter the tissues and become tissue macrophages
(b) Their lifespan in the tissues is unknown but is thought to be 3 months

(3) Very mobile and phagocytic

(4) Long-term “clean-up” team

(5) Increase in number during chronic infections

5) Platelets (1 question on exam)

Platelets initiate the clotting cascade. Many middle-aged people now regularly take aspirin (an antiplatelet medication) to reduce the risk of coronary clots that lead to myocardial infarction.

   a) Produced within bone marrow

   b) Needed for normal blood clotting

   c) Initiate clotting cascade by clinging to broken area

   d) Help to control blood loss from broken blood vessels

   c. Cardiovascular system

   1) Anatomy of the heart

   a) Muscular pump consisting of four chambers

      (1) Two atria

      (2) Two ventricles

   b) Cone-shaped, approximately the size of a closed fist

   c) Located in the mediastinum of the thoracic cavity in the pericardial cavity

      (1) Blunt, rounded point of the heart is the apex

      (2) Larger, flat portion at opposite end is the base

The base of the heart is directed toward the right shoulder. The apex is directed toward the left hip.

   (3) Two thirds of the heart’s mass lies to the left of the midline of the sternum

   2) Pericardium

The pericardium is a loose-fitting double-walled sac that encloses the heart and great blood vessels. It is attached to the diaphragm, sternum, and the pleurae that enclose the lungs.

   a) Fibrous outer layer and thin inner layer that surrounds the heart

      (1) Fibrous pericardium is the outer layer

      (2) Serous pericardium is the inner layer (1 question on exam)
(a) Parietal pericardium—portion of serous pericardium that lines the fibrous pericardium

(b) Visceral pericardium (epicardium)—portion of serous pericardium that covers heart surface

i. Cavity between parietal and visceral pericardium normally contains a small amount of pericardial fluid

ii. Pericardial fluid reduces friction as the heart moves within the pericardial sac

3) Coronary vessels

a) Seven large veins normally carry blood to the heart

(1) Four pulmonary veins carry blood from the lungs to the left atrium

Teaching Tip

Blood flows through the coronary arteries primarily during relaxation of the heart muscle (diastole) because the coronary vessels are compressed during contraction (systole).

(2) The superior and inferior venae cavae carry blood from the body to the right atrium

(3) The coronary sinus carries blood from the walls of the heart to the right atrium

b) Two arteries exit the heart

(1) The aorta carries blood from the left ventricle to the body

(2) The pulmonary trunk carries blood from the right ventricle to the lungs

c) The right and left coronary arteries exit the aorta and supply the heart muscle with oxygen and nutrients

4) Heart chambers and valves

a) Right and left chambers are separated by a septum

(1) Interatrial septum separates the right and left atria

(2) Interventricular septum separates the two ventricles

b) Atrioventricular valves (1 question on exam)

(1) Allow blood to flow from the atria into the ventricles

(2) Prevent blood from flowing back to the atria

(3) Tricuspid valve—located between the right atrium and right ventricle

(4) Mitral (bicuspid) valve—located between the left atrium and the left ventricle
c) Semilunar valves
   
   (1) Aortic and pulmonary semilunar valves

   (2) Meet in the center of the artery to block blood flow

   (3) Blood flowing out of the ventricle pushes against each valve, forcing it open

   (4) Blood flowing back from the aorta or pulmonary trunk toward the ventricles causes the valves to close

d. Conduction system of the heart

   1) Four specialized structures provide for spontaneous, rhythmic self-excitation

      a) Sinoatrial node (SA node)

      b) Atrioventricular node (AV node)

      c) Bundle of His

      d) Purkinje fibers

   2) Sequence of normal impulse conduction

      a) SA node

      b) Both atria

      c) Atrial contraction

      d) AV node

      e) Bundle of His

      f) Purkinje fibers

      g) Both ventricles

      h) Ventricular contraction

      e) Route of blood flow through the heart

         1) Blood enters the right atrium from systemic circulation via the inferior and superior venae cavae and from the heart via the coronary sinus

         The pathway of blood to and from the lungs is called the pulmonary circuit. The pathway to and from the rest of the body is called the systemic circuit.

         2) Blood passes into the right ventricle
Pulmonary circuit: Right atrium—tricuspid valve—right ventricle—pulmonary semilunar valve—pulmonary trunk—right and left pulmonary arteries—lung capillaries—pulmonary veins—left atrium.

3) Ventricles push blood against the tricuspid and semilunar valves
4) Blood enters the pulmonary trunk
5) Pulmonary arteries carry blood to the lungs

Systemic circuit: Left atrium—mitral (bicuspid) valve—left ventricle—aortic semilunar valve—aortic trunk—body regions and organs.

a) Carbon dioxide is released
b) Oxygen is picked up
6) Blood enters the left atrium through the pulmonary veins
7) The left atrium contracts and fills the ventricles
8) Blood enters the aorta and is distributed throughout the body

2. Peripheral circulation

a. Flow of blood
   1) Ventricles
   2) Arteries
   3) Arterioles
   4) Capillaries
   5) Venous system

b. Capillary network
   1) Blood is supplied to each capillary network by arterioles
   2) Blood flows through the network into venules
   3) Flow is regulated by smooth muscle cells (precapillary sphincter)
   4) Nutrient and product waste exchange is the major function of capillaries

c. Arteries and veins
   1) Three layers of elastic tissue compose all blood vessel walls (except capillaries and venules)
      a) Tunica intima (inner layer)
b) Tunica media (middle layer)

c) Tunica adventitia (outer layer)

2) Types of arteries

An aneurysm is a thin, weakened area of the wall of an artery or vein that bulges outward, forming a balloon-like sac.

a) Conducting arteries (large elastic arteries)

b) Distributing arteries (small to medium-sized arteries)

c) Arterioles (smallest arteries)

3) Venules

a) Similar in structure to capillaries

b) Collect blood from capillaries and transport blood to small veins

c) Nutrient exchange occurs across the walls of venules

4) Veins

a) Their walls are a continuous layer of smooth muscle cells

b) Medium-sized and large veins carry blood to venous trunks and then to the heart

c) Large veins have valves that allow blood to flow to but not from the heart

(1) Prevent backflow of blood, especially in dependent tissues

5) Arteriovenous anastomoses (AV shunts)

Ask students for examples of conditions that result from venous valve failure (varicose veins, hemorrhoids, among others)

a) Allow blood to flow from arteries to veins without passing through capillaries

b) Natural AV shunts occur in the sole of the foot and the nail beds, where they regulate body temperature

c) Pathological shunts may result from injury or tumors

d. Pulmonary circulation

1) Blood from the right ventricle is pumped into the pulmonary trunk

2) Bifurcates into the right and left pulmonary arteries

a) Transport blood to respective lungs
3) Exchange of oxygen and carbon dioxide
   
a) Two pulmonary veins exit each lung and enter the left atrium

e. Systemic circulation
   
1) Blood enters the heart from the pulmonary veins
   
a) Passes through the left atrium into the left ventricle and then into the aorta
   
b) From the aorta, blood is pumped throughout the body

2) Arteries of systemic circulation
   
a) Aorta
   
b) Coronary arteries
   
c) Arteries to the head and neck
   
d) Arteries of the upper and lower limbs
   
e) Thoracic aorta and its branches
   
f) Arteries of the pelvis

3) Veins of systemic circulation
   
The hepatic portal circulation detours venous blood from the organs of the gastrointestinal system and spleen through the liver before it returns to the heart. The term “portal system” refers to the mechanism that carries blood between two capillary networks, from one body location to another, without passing through the heart.
   
a) Coronary veins
   
b) Veins of the head and neck
   
c) Veins of the upper and lower limbs
   
d) Veins of the thorax
   
e) Veins of the abdomen and pelvis
   
f) Veins of the hepatic portal system

H. Lymphatic System

1. Overview
a. Considered part of the circulatory system

b. Consists of a moving fluid that comes from the body and returns to the blood

c. Unlike the circulatory system, the lymphatic system only carries fluid away from tissues

The tonsils are thought to protect against the invasion of foreign substances that are inhaled or ingested.

2. Components (1 question on exam)

   a. Lymph

Discuss why tonsils are not routinely removed today.

   b. Lymphocytes
   
   c. Lymph nodes
   
   d. Tonsils
   
   e. Spleen

The spleen is the largest mass of lymphatic tissue in the body. Its main function is to remove bacteria and worn-out or damaged erythrocytes and platelets. The spleen also stores and releases blood in times of demand, such as during hemorrhage. In cases of abdominal trauma, the spleen is the most commonly injured organ. Rupture of the spleen can cause intraperiotoneal hemorrhage and shock. In such situations, surgical removal of the spleen may be necessary.

   f. Thymus gland

3. Basic functions

   a. Maintenance of fluid balance in tissues
   
   b. Absorption of fats and other substances from the digestive tract
   
   c. Active in the body’s immune system

4. Lymph capillaries

   a. Present in almost all tissues of the body (except CNS, bone marrow, and tissues without blood vessels)
   
   b. Join to form larger lymph capillaries that resemble small veins
5. Lymph nodes
   a. Distributed along various lymph vessels
   b. Remove microorganisms to prevent them from entering general circulation
   c. Three major collections are located on each side of the body
      1) Inguinal nodes
      2) Axillary nodes
      3) Cervical nodes
   Ask students to palpate their cervical nodes.
   d. Become swollen and tender during disease or inflammation

6. Lymph circulation

The lymphatic system picks up excess fluid that is left behind in the tissue spaces and returns it to the bloodstream.
   a. Lymph capillaries
   b. Lymph nodes
   c. Lymph ducts
   d. Right and left subclavian veins

   1) All fluid drained from the tissue spaces eventually returns to the venous circulation by way of subclavian veins

SESSION THREE A&P

Lesson Plan (4 of 5)

I. Respiratory System (1 question on exam; trace a drop of air through the respiratory system)

   1. Function
      a. Transports oxygen to individual cells and carbon dioxide away from individual cells
2. Anatomy (1 question on exam)

a. Pharynx serves as a passageway for both respiratory and digestive system.

For the purpose of this discussion, all structures located above the glottis are considered to be the upper airway, and all structures located below the glottis are considered to be the lower airway.

a. Upper airway structures

1) Nasopharynx (1 question on exam)
   a) The uppermost portion of the airway, just behind the nasal cavities
   b) The nasal septum separates the right and left nasal cavities
      (1) Warms and humidifies the nasal lining and inspired air
   c) The vestibule (lined with coarse hair) traps foreign substances in inspired air
   d) Olfactory membranes
      (1) Located in the roof of the nasal cavity
      (2) Contain receptors for sense of smell
   e) Connects to the middle ear cavities through the eustachian tubes

Teaching Tip

Eustachian tubes are much shorter and more horizontal in children, leading to an increased number of ear infections due to less efficient drainage. Discuss what methods can be used to decrease the number of ear infections in children who are often affected by them.

f) Sinuses
   (1) Frontal sinuses
   (2) Maxillary sinuses
   (3) Ethmoid sinuses
   (4) Sphenoid sinuses

2) Oropharynx
   a) Begins at the level of the uvula and extends down to the epiglottis
   b) Opens into the oral cavity
      (1) Lips
(2) Cheeks  
(3) Teeth  
(4) Tongue  
(5) Hard and soft palates  
(6) Palatine tonsils  

3) Laryngopharynx  
   a) Extends from the tip of the epiglottis to the glottis and esophagus  
   b) Lined with mucous membrane to protect internal surfaces  

4) Larynx (2 question on exam)  
   a) Three main functions  
      (1) Air passageway between the pharynx and lungs  
      (2) Prevents solids and liquids from entering the respiratory tree  
      “Trapdoor to the airway.”  
      (3) Involved in speech production  
   b) Consists of an outer casing of 9 cartilages (1 question on exam)  
      (1) The largest and most superior cartilage is the unpaired thyroid cartilage (Adam’s apple)  
      (2) The most inferior cartilage is the unpaired cricoid cartilage (the only complete cartilaginous ring in the larynx)  
      (3) The third unpaired cartilage is the epiglottis  
   c) The U-shaped hyoid bone lies beneath the mandible  
      (1) Only bone of the human body that does not articulate with another bone  
      (2) Helps suspend the airway by anchoring muscles to the jaw  
   d) The cricothyroid membrane joins the thyroid and cricoid cartilages  
   Have students palpate the cricothyroid membrane. Briefly describe the principle of obtaining an emergency airway using this structure.  
   e) Vestibular folds (false vocal cords)
(1) Not directly involved in speech production

(2) Formed by the superior pair of ligaments extending from the anterior surface of the largest inferior cartilages (arytenoids cartilages)

f) Vocal cords (true vocal cords)

(1) Participate directly in voice production

(2) Formed by the inferior pair of ligaments extending from the arytenoids cartilages

b. Lower airway structures (1 question on exam)

1) Trachea

   a) The air passage from the larynx to the lungs

   b) Composed of dense connective tissue reinforced with 1 to 20 C-shaped pieces of cartilage that form an incomplete ring

   (1) Protects the trachea

   (2) Maintains an open air passage

   c) Located anterior to the esophagus

   d) Extends from the larynx to the fifth thoracic vertebra (in adults)

   e) Lined with ciliated epithelium that contains goblet cells

These protective functions are decreased in smokers.

Discuss the effects of smoking and the benefits of stopping.

   (1) Cilia protect lower airway by sweeping mucus, bacteria, and foreign substances toward the larynx

2) Bronchial tree (1 question on exam)

   a) May be thought of as an inverted tree

      (1) Subdivides until termination at the alveoli

   b) Trachea divides into right and left primary bronchi at the carina

Point out the external landmark (sternal angle) that overlies the carina.

   (1) Right primary bronchus is shorter, wider, and more vertical

   (2) Both are lined with ciliated epithelium and supported by C-shaped cartilage rings

   (3) Bronchi extend from the mediastinum to the lungs
The primary bronchi are sometimes referred to as “main-stem” bronchi.

c) Primary bronchi divide into secondary bronchi as they enter the right and left lungs
d) Secondary bronchi divide into the tertiary segmental bronchi
   (1) Extend to individual segments of each lobe (lobule)
   (2) Eventually become bronchioles
e) Bronchioles
   (1) Walls are devoid of cartilage
   (2) Muscles are sensitive to circulating hormones (e.g., epinephrine)
   (3) Contraction and relaxation of these muscles alter resistance to airflow
      (a) May constrict forcefully (as in asthma)
   (4) Divide to form terminal bronchioles, and finally respiratory bronchioles

Bronchiolar size can be increased by drugs such as epinephrine, albuterol, and aminophylline, which cause smooth muscle relaxation.

(5) Respiratory bronchioles form alveolar ducts, ending in grapelike clusters of alveoli

3) Alveoli
   a) Functional units of respiratory system
   b) Primary constituent of lung tissue
      (1) 300 million alveoli in the two lungs
   c) Alveolar walls
      (1) Consist of single layer of epithelial cells and elastic fibers
         (a) Permit stretching and contracting during breathing
      (2) Location of respiratory gas exchange
d) Each alveolus is surrounded by a network of blood capillaries
      (1) Air in the alveolus is separated from the blood contained in the alveolar capillaries by a thin respiratory membrane with a large surface area
      (2) Surface area may be decreased by respiratory diseases
         (a) Emphysema
(b) Lung cancer

(3) Decreased surface area restricts gas exchange

e) Pulmonary surfactant

(1) Thin film that coats alveoli

(2) Prevents alveoli from collapsing

4) Lungs

   a) Large, paired spongy organs whose principal function is respiration

   b) Attached to the heart by pulmonary arteries and veins

   c) Separated by the mediastinum and its contents

   d) An adult lung weighs less than 2 pounds

   e) The base of each lung rests on the diaphragm, with its apex extending 2.5 cm above each clavicle

   f) The left lung is slightly smaller than the right and is divided into two lobes (which in turn are divided into lobules)

      (1) 9 lobules in left lung

      (2) 10 lobules in right lung

   g) A separate pleural cavity surrounds each lung

   Ask students, “Why is the left lung smaller?” (To make room for the heart.)

      (1) The pleural cavity and lungs are attached to each other only at the point of entry of the bronchi, vessels, and nerves of each lung

      (2) Comprises two layers (visceral and parietal)

      (3) Layers are separated by pleural fluid

         (a) Serves as a lubricant to allow the pleural membranes to slide past each other during respiration

      (4) Pleural space (1 question on exam)

         (a) Potential space between the two pleurae

         (b) May become filled with air (pneumothorax) or blood (hemothorax) with significant chest wall injury or pulmonary pathological conditions

         (c) Other fluid may accumulate in the pleural space due to congestive heart failure, infections, etc.
(d) Visceral pleura covers the lung tissue and is smooth, moist epithelial layer of tissue.

Lesson Plan (5 of 5)

J. Digestive System (1 question on exam)

1. Function
   a. Provides the body with water, electrolytes, and other cell nutrients
   b. Specialized functions
      1) Ingests food
      2) Propels food through the GI tract
      3) Absorbs nutrients across the wall of the lumen of the GI tract
      4) The digestive organs are surrounded by a peritoneum membrane of connective tissue,

2. Anatomy
   a. Oral cavity

Classroom Activity

Have the students chew a small plain cracker or piece of bread, and ask them how the taste changes when they
chew it for a few minutes (it will get sweet). Discuss how salivary amylase has changed the food.

   1) Saliva secreted in response to the presence of food in the mouth
      a) Contains mucus that helps bind food together into a bolus
      b) Contains digestive enzyme (salivary amylase)
         (1) Begins chemical breakdown of carbohydrates (starch)
      c) Contains antibodies and enzymes that help prevent bacterial infection
   2) Ingested food is chewed by teeth for processing and is swallowed

Discuss why food poisoning takes 6 to 8 hours to develop.

   a) The tongue pushes the bolus of food into the pharynx
b) Food is pushed into the esophagus by the pharyngeal muscles
c) The epiglottis closes the entrance to the airway to prevent aspiration

3) Muscular contractions push food through the esophagus into the stomach

This is called peristalsis or peristaltic waves.

Relaxation of the cardiac sphincter allows food to enter the stomach.

b. Stomach

1) Connects the esophagus to the duodenum (first part of small intestine)
2) Storage area for food before release into the small intestine
3) Lined with mucous membranes (to protect stomach wall and duodenum) and gastric glands that secrete:

Teaching Tip

About 2 to 3 liters of gastric secretions are produced by the stomach each day.

a) Hydrochloric acid—kills bacteria and activates the protein-digesting enzyme pepsin
b) Intrinsic factor—assists in absorption of vitamin B12
c) Gastrin—stimulates flow of gastric juice
d) Pepsin—begins digestion of protein
e) Gastric lipase—aids digestion of triglycerides

4) Mechanically breaks down food by churning activity of stomach muscles
5) Mixes saliva, food, and gastric juice to form chyme

Relaxation of the pyloric sphincter allows chyme to enter the duodenum.

c. Small intestine

1) Mucosa produces secretions that contain mucus, electrolytes, and water
   a) Lubricates and protects the intestinal wall from acidic chyme and digestive enzymes
2) Primary mechanical functions of the small intestine

Teaching Tip

Chyme moves through the small intestine in 3 to 5 hours, but passage through the large intestine takes 18 to 24 hours.

a) Mixing and propulsion of chyme
b) Absorption of fluid and nutrients

3) Peristaltic contractions move chyme through the small intestine toward the ileocecal sphincter, where chyme enters the cecum

d. Liver (1 question on exam)

1) Largest internal organ, located just below the diaphragm in the upper abdominal cavity

2) Very vascular

   a) Receives blood supply from hepatic artery and portal vein

3) Major functions

   a) Maintaining normal blood glucose level

      (1) Breaks down glycogen to glucose (glycogenolysis) when blood glucose level is low

      (2) Can also convert certain amino acids and lactic acid to glucose (gluconeogenesis)

      (3) When blood sugar level is high, converts glucose to glycogen and triglycerides (lipogenesis) for storage

   b) Lipid and protein metabolism

   c) Removal of drugs and hormones

   d) Storage of vitamins A, B12, D, E, and K

   e) Storage of minerals (iron and copper)

4) Secretes bile

   a) Secretes 600 to 1,000 mL (about 1 quart) of bile each day

   b) Dilutes stomach acid and emulsifies fats

Emulsification breaks down fats into smaller units. This action increases the surface area available for contact with digestive enzymes leading to improved digestion.

e. Gallbladder

1) Stores bile secreted by the liver

   a) Dilutes stomach acids and emulsifies fat

2) Releases bile into the small intestine when stimulated by the hormones secreted by intestinal mucosa

f. Pancreas
1) Both an exocrine gland (secretes pancreatic juice) and an endocrine gland (secretes hormones, e.g., insulin)

a) Pancreatic juice is the most important enzyme

(1) Contains digestive enzymes, sodium bicarbonate, and alkaline substances that neutralize hydrochloric acid in the digestive juices entering the small intestine

(2) Also contains amylase, which continues digestion initiated in the oral cavity

g. Large intestine

Distention of the rectal wall by feces initiates the defecation reflex, causing weak contractions and relaxations of the internal anal sphincter. The external anal sphincter (under conscious cerebral control) prevents the movement of feces out of the rectum until it is relaxed. During defecation, pressure in the abdominal cavity increases and forces the contents of the colon through the anal canal and out of the anus.

1) Chyme remains in the large intestine for 18 to 24 hours, during which

a) Water and salts are absorbed

b) Mucus is secreted

c) Chyme is converted to feces

2) During movement through the large intestine, undigested material is acted on by bacteria

3) Additional nutrients may be released and absorbed

4) Vitamin K and B complex vitamins are absorbed from the large intestine and enter the blood

5) Defecation reflex occurs because of distention of the rectal wall

K. Urinary System

1. Functions

a. Works with other body systems to maintain

1) Homeostasis

2) Constant body fluid volume and composition

2. Kidneys

a. Located on either side of the vertebral column near lateral border of psoas muscles
b. Superior pole of each kidney is protected by the rib cage

1) Right kidney is slightly lower than the left due to the position of the liver

c. Divided into outer cortex and inner medulla

The medulla consists of a number of triangular divisions called the renal pyramids that extend into the cortex. The papilla is the innermost end of a pyramid. Several large urinary tubes (calyces) extend to the renal pelvis from the kidney tissue.

d. Nephron

1) Basic functional unit of the kidney, consisting of the following:
   a) Renal corpuscle
   b) Proximal convoluted tubule
   c) Loop of Henle
   d) Distal convoluted tubule

2) Terminal end forms Bowman’s capsule
   a) Wall is occupied by a network of blood capillaries (glomerulus)

3) Glomerulus and Bowman’s capsule form the renal corpuscle

3. Ureters, urinary bladder, and urethra

a. Ureters

1) Extend from the renal pelvis to the urinary bladder

b. Urinary bladder

1) Hollow, muscular organ

2) Located in the pelvic cavity just posterior to the symphysis pubis

3) Size of the bladder depends on the volume of urine

4) Internal and external urinary sphincters control the flow of urine through the urethra

c. Urethra

1) In females, opens into the vestibule anterior to the vaginal opening

2) In males, the urethra is much longer and extends to the end of the penis, where it opens to the outside
4. Urine production
   a. More than 2 million nephrons form urine in a three-step process:
      
      1) Filtration
         
         a) Glomerular blood pressure pushes water and other substances out of the glomeruli into Bowman’s capsule
         
         b) Glomerular filtration normally occurs at a rate of 125 mL/min (180 L/day)
         
         (1) 90% is reabsorbed
         
         c) Healthy people produce 1 to 2 L of urine each day
      
      2) Reabsorption
         
         a) Filtrate leaves the renal capsule and flows into the collecting duct
         
         b) During this process, many substances (including water and glucose) in the filtrate are reabsorbed by blood capillaries and reenter the general circulation
      
      3) Secretion
         
         a) Process by which substances move out of blood and into urine
         
         b) Secreted substances
         
         (1) Hydrogen ions
         
         (2) Potassium ions
         
         (3) Ammonia
         
         (4) Certain drugs

5. Urine regulation
   a. Normally controlled by
      
      1) Hormonal mechanisms
      
      2) Autoregulation
      
      3) Sympathetic nervous system stimulation
   
   b. Hormonal mechanisms
      
      1) Aldosterone
a) Steroid hormone secreted by the adrenal gland
b) Stimulates the tubules to reabsorb sodium salts and water

2) Antidiuretic hormone (ADH)
   a) Secreted by the posterior pituitary gland
   b) Makes distal and collecting tubules permeable to water
   c) Increases water reabsorption
   d) Decreases the amount of urine produced

3) Atrial natriuretic factor
   a) Secreted from the cells of the heart’s right atrium when pressure in the right atrium is increased
   b) Inhibits ADH secretion and reduces the ability of the kidney to concentrate urine
   c) Results in large volume of dilute urine

4) Prostaglandins and kinins
   a) Substances formed in the kidneys
   b) Believed to influence the rate of filtrate formation and sodium reabsorption
   c. Autoregulation
      1) Kidneys have the ability to regulate a stable filtration rate over a wide range of systemic blood pressures

The kidneys are the windows to assess adequate blood flow (perfusion). In-hospital urine output is monitored as an important assessment tool to determine how well the tissues are being perfused.

   2) Large increases in arterial pressure increase the rate of urine production
   3) Decreases in arterial pressure decrease urine production

d. Sympathetic nervous system stimulation
   1) Sympathetic neurons innervate blood vessels of the kidney
   2) Causes of decreased renal blood flow
      a) Severe stress
      b) Intense exercise
      c) Circulatory shock
L. Reproductive System

1. Male reproductive system
   a. Components
      1) Testes
      2) Epididymis
      3) Ductus deferens
      4) Urethra
      5) Seminal vesicles
      6) Prostate gland
      7) Bulbourethral glands
      8) Scrotum
      9) Penis
   b. Purpose
      1) To produce and transfer spermatozoa to the female
   c. Testes
      1) Develop as retroperitoneal organs in the abdominopelvic cavity
         a) Move into scrotum by way of inguinal canal
      2) Interstitial cells secrete testosterone (male hormone)
         a) Causes spermatozoa production to begin (ages 1214)
      3) Contribute approximately 5% of seminal fluid
   d. Epididymis
      1) Site of final maturation of spermatozoa
      2) Located on the posterior side of the testes
      3) Infection or injury to epididymis may result in infection and/or infertility
e. Ductus deferens (vas deferens)
   1) Emerges from the tail of the epididymis and ascends to the seminal vesicles
   2) Associates with blood vessels and nerves that supply the testes
   3) Constitutes the spermatic cord
   4) Surrounded by smooth muscle that propels sperm through the prostate gland

f. Urethra
   1) Passageway for urine and reproductive fluids
   2) Divided into three portions
      a) Prostatic portion
      b) Membranous portion
      c) Spongy portion

g. Seminal vesicle
   1) Sac-shaped gland that lies adjacent to each ductus deferens
   2) Joins the ejaculatory duct
      a) Projects into the prostate and opens into the urethra

h. Prostate gland
   1) Approximately the size of a walnut
   2) Located at the base of the bladder
   3) Secretes prostatic fluid into the prostatic urethra
   4) Contributes approximately 30% of the seminal fluid

i. Bulbourethral glands
   1) Located near the membranous portion of the urethra
   2) Enter the spongy urethra at the base of the penis
   3) Contributes approximately 5% of seminal fluid

j. Scrotum
   1) Divided into two internal compartments
   2) Dartos muscle and abdominal muscles help control temperature regulation of the testes
a) Pull testes near the body in cold temperatures

b) Allow the testes to descend away from the body in warm temperatures

k. Penis

1) Consists of three columns of erectile tissue
2) Engorgement of tissues with blood produces an erection
3) Organ of copulation
4) Transfers spermatozoa from male to female

2. Female reproductive system

Discuss a woman’s need for an annual gynecological examination. What does this examination entail? What is a Pap smear?

a. Components

1) Ovaries
2) Uterine (fallopian) tubes
3) Uterus
4) Vagina
5) External genital organs
6) Mammary glands

b. Purposes

1) To produce oocyte
2) To receive and utilize spermatozoa for fertilization that may lead to conception, gestation, and birth
3) Ovaries

1) The two small ovaries are attached to the posterior of the broad ligament (mesovarium)
2) Other ligaments associated with the ovary are the suspensory ligament and the ovarian ligament
3) Ovarian arteries, veins, and nerves traverse the suspensory ligament and enter the ovary through the mesovarium
4) Each consists of a dense outer portion (cortex) and a looser inner portion (medulla)
5) Ovarian follicles (each of which contains an oocyte) are distributed throughout the cortex
d. Uterine tubes
   1) Ducts for the ovaries
   2) Open directly into the peritoneal cavity to receive the oocyte
e. Uterus
   1) Size and shape of a medium-sized pear
   2) The fundus is directed superiorly and the cervix inferiorly
   3) The main portion of the uterus is positioned between the fundus and the cervix
   4) Ligaments that hold the uterus in place are
      a) Broad ligaments
      b) Round ligaments
      c) Uterosacral ligaments
f. Vagina
   1) Functions to encompass the penis during intercourse
   2) Passageway for menstrual flow and childbirth
   3) Vaginal orifice is covered by a thin mucous membrane (hymen) until first intercourse
g. External genitalia (vulva)
   1) Consists of the vestibule and surrounding structures
   2) Bordered by a pair of skin folds (labia minora)
   3) Clitoris
      a) Erectile structure
      b) Located in the anterior margin of the vestibule
      c) The two labia minora unite over the clitoris to form a fold of skin (prepuce)
   4) Labia majora
      a) Two prominent folds of skin lateral to the labia minora
      b) United anteriorly over the pubic symphysis to form the mons pubis
   5) Perineum
a) Divided into triangles by perineal muscles

b) Urogenital triangle—contains external genitalia

c) Posterior anal triangle—contains anal opening

d) Clinical perineum—region between the vagina and anus (sometimes tears during childbirth)

h. Mammary glands

Discuss current breast cancer statistics and the need for regular mammograms.

1) Organs of milk production located within breasts (mammae)

2) Breasts of females and males have a raised nipple surrounded by a circular pigmented areola
   a) Nipples are sensitive to tactile stimulation
   b) May become erect in response to sexual arousal

3) Female breasts enlarge during puberty under the influence of estrogen and progesterone

4) Each adult female mammary gland consists of 15 to 20 glandular lobes covered by adipose tissue
   a) Each lobe possesses a single lactiferous duct that divides to form smaller ducts, each of which supplies a lobule
   b) These ducts expand at their ends to form secretory sacs called alveoli, which secrete milk during nursing

V. SPECIAL SENSES

A. Provide the Brain with Information about the Outside World

B. Components
   1. Smell
   2. Taste
   3. Sight
   4. Hearing and balance
C. Olfactory Sense Organs

1. Receptors for the fibers for the olfactory nerve (cranial nerve I) lie in the mucosa of the upper part of the nasal cavity.

2. Stimulation by airborne molecules results in nerve impulses that travel through the olfactory nerves in the olfactory bulb and olfactory tract.

Most of the nasal cavity is involved with respiration, and only a small portion is devoted to olfaction.

   a. There they enter the thalamic and olfactory centers of the brain.
   
   b. Nerve impulses are then interpreted by the brain as specific odors.

3. Olfactory receptors are extremely sensitive and fatigue easily.

The exact mechanism of olfactory stimulation is not clearly understood. It generally is believed that the variety of detectable smells are actually combinations of seven primary odors: (1) camphoraceous, (2) musky, (3) floral, (4) pepperminty, (5) ethereal, (6) pungent, and (7) putrid.

4. System quickly adapts to continued stimulation.

   a. A particular odor may cease to be noticed within a short time.

D. Taste

1. Taste buds—sensory structures that detect taste stimuli.

Discuss which conditions can cause a loss of the senses of taste and smell.

2. Receptors for taste nerve fibers are in the seventh and ninth cranial nerves.

3. Taste buds

   a. Associated with specialized portions of the tongue.
   
   b. Also located on palate, lips, and throat.
   
   c. Divided into four basic types:

      1) Bitter
      2) Sour
      3) Salty
      4) Sweet
E. Visual System

The tip of the tongue reacts more strongly to sweet and salty tastes, the back of the tongue to bitter taste, and the sides of the tongue to sour taste. All the other taste sensations result from a combination of taste bud and olfactory receptor stimulation.

1. Components
   a. Eyes
   b. Accessory structures (eyelids, eyebrows, eyelashes, tear glands)
   c. Optic nerve, tract, and pathways

2. Optic nerve (cranial nerve II) conducts impulses from the eye to the brain to produce vision

3. Oculomotor nerve (cranial nerve III) conducts impulses from the brain to the muscles of the eye, resulting in eye movement

4. Anatomy of the eye
   a. Composed of three layers
      1) Fibrous tunic, consisting of sclera and cornea
      2) Vascular tunic, consisting of the choroids, ciliary body, and iris
      3) Nervous tunic, consisting of the retina
   b. Sclera

Discuss what normal vision changes occur with aging and at what age they begin.

1) Firm, opaque, white outer layer of the eye
   a) Functions
      (1) Helps to maintain the shape of the eye
      (2) Protects the internal structures of the eye
      (3) Provides an attachment point for the muscles that move the eye
   c. Cornea
1) Continuous with the sclera

2) Avascular and transparent structure

3) Functions
   a) Permits light to enter the eye
   b) Bends and refracts entering light

d. Vascular tunic
   1) Contains most of the blood vessels of the eyeball
   2) Choroid layer associated with the sclera
   3) Anteriorly, consists of the ciliary body and iris
      a) Ciliary body
         (1) Consists of ciliary muscles that can change the shape of the lens
         (2) Complex capillaries involved in producing aqueous humor
      b) Iris
         (1) Colored part of the eye
         (2) Consists mainly of smooth muscle that surrounds pupil
         (3) Light enters through the pupil
         (4) Iris regulates amount of light by controlling the size of the pupil

e. Retina (1 question on exam)
   1) Consists of an outer pigmented retina and an inner sensory layer that responds to light
   2) Sensory retina contains photoreceptor cells (rods and cones) and numerous relay neurons

Discuss macular degeneration.

   a) Rods are the receptors for night vision
   b) Cones are the receptors for daytime and color vision
   c) Retina is layered nervous tissue membrane that is continuous with the optic nerve

5. Compartments of the eye
a. Two compartments are separated by a lens that is suspended by ligaments

1) Anterior chamber
   a) Filled with aqueous humor, which helps maintain intraocular pressure (pressure within the eye that keeps the eye inflated)
   b) Refracts light
   c) Provides nutrition for the anterior chamber

2) Posterior chamber
   a) Almost completely surrounded by the retina
   b) Filled with a transparent, jellylike substance called vitreous humor
      (1) Vitreous humor helps maintain intraocular pressure
      (2) Also helps to hold the retina in place
      (3) Functions in the refraction of light

6. Accessory structures
   a. Protect, lubricate, move, and aid in the function of the eye
   b. Eyebrows—provide shade from direct sunlight and prevent perspiration from running into the eyes
   c. Eyelids
      1) Protect eyes from foreign objects
      2) Blinking helps lubricate the eyes by spreading tears over their surfaces
      3) Help regulate amount of light entering the eyes
   d. Conjunctiva
      1) Thin, transparent mucous membrane
      2) Covers inner surface of eyelids and outer surface of sclera
   e. Lacrimal gland
      1) Produces lacrimal fluid (tears), which
         a) Moisten the surface of the eye and lubricate the eyelids
         b) Wash away foreign objects
c) Contain lysosomes that destroy some forms of bacteria

F. Hearing and Balance

1. Organs of hearing can be divided into three portions
   a. External ear
   b. Middle ear
   c. Inner ear

2. The external and middle ears are involved in hearing only

3. The inner ear functions in both hearing and balance

4. The senses of hearing and balance are transmitted by the vestibulocochlear nerve (cranial nerve VIII)

5. The external ear
   a. Includes the auricle, pinna, and external auditory meatus
   b. Auricle collects sound waves and directs them to the external auditory meatus
   c. Opens into the external auditory canal
      1) Lined by hairs and glands that produce cerumen
   d. Terminates at the eardrum or tympanic membrane
      1) Sound waves cause the membrane to vibrate

6. Middle ear
   a. Air-filled space within the temporal bone
   b. Contains the auditory ossicles
Describe ways to communicate with the hearing-impaired patient.

1) Transmit vibrations from the tympanic membrane

c. Connected to the inner ear by two membrane-covered openings (round and oval windows)

d. Two other openings not covered with membranes provide passage for air from the middle ear

1) The first opens into the mastoid air cells

2) The second (eustachian tube) opens into the pharynx and permits equalization of pressure between the outside and middle ear cavity

7. Inner ear

a. Contains sensory organs for hearing and balance

b. The bony labyrinth is divided into three regions

1) Vestibule

2) Cochlea

3) Semicircular canals

c. The vestibule and semicircular canals are involved primarily with balance

d. The cochlea is involved with hearing

1) Contains the hearing sense organ (organ of Corti)

This is the end of this outline!!!