Chapter 6, The Human Body

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1. Introduction to Human Body Systems

Term	Definition	Importance for Medical Professionals
Anatomy	Focuses on the physical structure of the body and its systems [5]	Understanding anatomy is important [4]
Physiology	Examines the normal functions, actions, and	Understanding the roles of structures and system

	activities of the body and its systems [6]	interactions in maintaining life support is important [3]
Pathophysiology	Studies the functional changes that accompany a particular disease or syndrome [7]	Discussing possible consequences of illness and injury on proper body functioning is important [4]

- Understanding the human body is important for medical professionals [2].
- This understanding includes body planes and topographic anatomy [2].
- Identifying basic structures and functions is also key [3].
- Describing each body system and its role is necessary [3].
- Understanding how systems interact to maintain life is vital [3].
- Discussing the impact of illness or injury on function is crucial [4].

2. Topographic Anatomy and Body Planes

- **topographic anatomy** applies to the body in the **anatomic position** [9].
- The anatomic position is when the body stands facing you [10].
- Arms are to the side, and palms face forward [10].
- **Body planes** are imaginary straight lines that divide the body [11].
- There are three main body planes [11].
- The **coronal** (frontal) plane divides the body's front and back [12].
- The **sagittal** (lateral) plane divides the body's left and right sides [13].
- A **mid-sagittal** (midline) plane is a special sagittal plane [14].
- It cuts the body in half, leaving equal left and right halves [15].
- A **transaxial** plane divides the body's top and bottom [15].

3. Cellular to Systemic Organization

Level	Composition	Forms
Cells	Foundation of the human body [18]	Tissue [18]
Tissue	Cells that share a common function [18]	Organs [18]

Organs	Groups of tissues that perform similar or interrelated jobs [18]	Body System [18]
Body System	Organs with similar functions working together [18]	Human Body

- The human body is organized in a hierarchical manner [17].
- **Cells** are the basic building blocks [18].
- Cells with similar functions group together to form **tissue** [18].
- Groups of tissues performing similar jobs form **organs** [18].
- Organs with similar functions work together to form a **body system** [18].
- Understanding this organization is key to understanding the body [19].

4. The Skeletal System: Structure and Function

Division	Description	Components
Axial Skeleton	Forms the longitudinal axis of the body [22]	Skull, facial bones, thoracic cage, vertebral column [22]
Appendicular Skeleton	Comprises the upper and lower extremities and their connections [23]	Upper extremity, pelvis, lower extremity [49]
Joints	Occur wherever bones come in contact [25]	Ligaments, cartilage, tendons, joint capsule, articular cartilage, synovial membrane [26]

- The skeletal system gives the body its form [20].
- It also protects vital internal organs [20].
- The adult skeletal system has 206 bones [21].
- It has two major divisions: axial and appendicular [21].
- The **axial skeleton** includes the skull down to the coccyx [22].
- The **appendicular skeleton** includes the extremities [23].
- The pelvis includes parts of both divisions [24].

- **Joints** are where bones meet [25].
- **ligaments** connect bone to bone and stabilize joints [26].
- **cartilage** cushions bone ends [27].
- **tendons** attach bone to muscle [28].
- **symphysis** joints allow slight movement [29].
- joint capsules hold bone ends together [30].
- Articular cartilage allows bones to glide easily [30].
- synovial membranes produce fluid for joint movement [31].
- Types of joints include ball and socket and hinge joints [32].
- The skull has 28 bones: cranium, facial, and ear bones [36].
- The cranium protects the brain and has four bones [37].
  - These include the occiput, temporal, parietal, and frontal bones [38].
- Facial bones include the maxilla, zygomas, mandible, orbits, and nasal bones [38].
- The spinal column has 33 vertebrae in five sections [39].
  - Sections are cervical (7), thoracic (12), lumbar (5), sacrum (5 fused), and coccyx (4 fused) [41].
- Vertebrae are connected by ligaments and discs [47].
- The thorax is formed by thoracic vertebrae and ribs [48].
- It protects the heart, lungs, esophagus, and great vessels [48].
- The sternum is in the midline of the chest [48].
- The upper extremities extend from the shoulder girdle to the fingertips [49].
- The shoulder girdle includes the clavicle, scapula, and humerus [51].
- The humerus is the arm's supporting bone [52].
- The forearm has the radius (thumb side) and ulna (little finger side) [53].
- The wrist is a modified ball and socket joint [56].
- The hand has metacarpals and phalanges [56].
- The pelvic girdle has hip bones, the sacrum, and the coccyx [56].
- Each hip bone has the ilium, ischium, and pubis [56].
- The pubic symphysis joins the pubic bones [57].
- The femur is the longest bone in the lower extremity [58].
- The femoral head connects to the pelvis [59].
- The knee is a hinge joint connecting the femur to the tibia and fibula [60].

- The lower leg bones are the tibia and fibula [60].
- The foot has tarsals, metatarsals, and phalanges [62].
- The ankle joint is formed by the tibia, fibula, and talus [63].
- The foot has seven tarsal bones [65].
- The talus and calcaneus are the largest tarsal bones [65].
- Five metatarsal bones form the foot's substance [66].
- The toes are formed by 14 phalanges [66].
- The skeletal system allows movement and stores calcium [67].
- It also helps create blood cells [67].
- The musculoskeletal system provides posture and protects organs [68].

5. The Muscular System: Types and Actions

- There are three types of muscles: skeletal, smooth, and cardiac [69].
- **Skeletal muscle** attaches to bones [70].
- It forms the major muscle mass and is voluntary [70].
- Voluntary muscle is under the brain's direct control [70].
- You can use skeletal muscle to pick things up [71].
- **Smooth muscle** and **cardiac muscle** are involuntary [72].
- They do not require constant thought to function [72].
- Smooth muscle is in blood vessels and intestines [72].
- Cardiac muscle is found in the heart [72].
- Contraction and relaxation of skeletal muscle allow movement [74].
- Skeletal muscle contraction also produces heat [75].
- Shivering is involuntary muscle action to produce heat [75].
- Muscles also protect underlying structures [75].

6. The Respiratory System: Anatomy and Physiology

Division	Components	Key Structures

Upper Respiratory System	Nose, mouth, tongue, jaw, larynx [77]	Pharynx, trachea, epiglottis [79]
Lower Respiratory System	Thyroid cartilage, cricoid cartilage, cricoid thyroid membrane [79]	Trachea, carina, main stem bronchi, lungs, alveoli [79]
Lungs	Held in place by trachea, arteries, veins, ligaments [80]	Lobes (right has 3, left has 2), bronchi, bronchioles, alveoli [80]

- The respiratory system is responsible for breathing [76].
- It exchanges oxygen and carbon dioxide in the lungs [76].
- The system is divided into upper and lower parts [77].
- The **upper respiratory system** includes the nose, mouth, tongue, jaw, and larynx [77].
- The larynx divides the upper and lower airways [78].
- The pharynx, trachea, and epiglottis are also in the upper airway [79].
- The **lower airway** includes the thyroid cartilage (Adam's apple) [79].
- The cricoid cartilage and cricoid thyroid membrane are also present [79].
- The trachea is below the cricoid cartilage [79].
- It ends at the carina, dividing into bronchi [79].
- Bronchi branch into smaller airways within the lungs [79].
- The lungs are held in place by the trachea and vessels [80].
- Each lung is divided into lobes [80].
- The right lung has three lobes, and the left has two [80].
- Within the lobes are bronchi and bronchioles [81].
- These end at the **alveoli**, where gas exchange occurs [81].
- **alveoli** exchange oxygen and carbon dioxide [81].
- **Pleura** are membranes that cover the lungs (visceral) and line the chest wall (parietal) [82].
- Fluid between the pleura facilitates lung movement [82].
- The **pleural space** is a potential space between the pleura [82].
- The **diaphragm** is the primary muscle of breathing [83].

- It contains voluntary and involuntary muscle [83].
- Other muscles aiding breathing include cervical, intercostal, abdominal, and pectoral muscles [83].
- **Inhalation** is active; the diaphragm and intercostal muscles contract [85].
- This creates a larger space in the thoracic cavity, and lungs fill [85].
- It uses negative pressure ventilation [85].
- **Exhalation** is passive; muscles relax [87].
- The thoracic cavity returns to normal, and air flows out [87].
- The respiratory system provides oxygen and eliminates carbon dioxide [90].
- **Ventilation** is air movement between lungs and the environment [91].
- **Respiration** is gas exchange in alveoli and tissues [91].
- Oxygen and carbon dioxide move by **diffusion** [94].
- Diffusion is passive movement from higher to lower concentration [95].
- The brain stem controls breathing by monitoring carbon dioxide levels [95].
- High carbon dioxide causes pH to decrease, stimulating breathing [95].
- The medulla oblongata initiates ventilation via the phrenic nerve [96].
- The primary reason for breathing is to lower carbon dioxide [97].
- Patients with chronic lung disease may use a **hypoxic drive** [99].
- This is a backup system stimulated by low oxygen levels [100].
- The pons helps adjust breathing depth during stress [105].
- **tidal volume** is air moved in a single breath (about 500 mL in adults) [107].
- **inspiratory reserve volume** is the deepest breath after normal [107].
- **expiratory reserve volume** is maximum air forcefully exhaled [107].
- **residual volume** is gas remaining after exhalation [108].
- **dead space** has no alveoli and little gas exchange [108].
- **minute volume** assesses ventilation adequacy [110].
- minute volume = respiratory rate × tidal volume [111].
- Normal breathing has a regular rate and depth [112].
- It has a regular rhythm of inhalation and exhalation [112].
- Clear breath sounds should be heard on both sides of the chest [112].
- The chest should rise and fall regularly on both sides [113].
- Movement of the abdomen is also a sign [113].
- Inadequate breathing signs include labored breathing [114].

- Rates slower than 12 or faster than 20 are inadequate [114].
- Muscle retractions, pale or cyanotic skin, cool damp skin, or tripod position are signs [114].

7. The Circulatory System: Structure and Function

Component	Description	Function
Heart	Involuntary muscle made of myocardium [119]	Pumps blood throughout the body [123]
Arteries	High pressure vessels [129]	Carry oxygenated blood from the heart to tissues (except pulmonary artery) [129]
Arterioles	Smaller branches of arteries [135]	Connect arteries to capillaries [135]
Capillaries	Tiny blood vessels [138]	Connect arteries to venules; gas and nutrient exchange occurs here [138]
Venules	Small veins [138]	Connect capillaries to veins [138]
Veins	Oxygen depleted blood going back to heart [142]	Carry deoxygenated blood back to the heart (except pulmonary veins) [142]
Blood	Composed of plasma, red blood cells, white blood cells, platelets [150]	Transports oxygen, CO2, waste, nutrients; fights infection; coagulates [166]

- The circulatory system, or cardiovascular system, is a network of tubes [115].
- It includes arteries, arterioles, capillaries, venules, and veins [115].
- There are two circuits: systemic and pulmonary [116].
- **systemic circulation** carries oxygen-rich blood from the left ventricle to the body and back to the right atrium [116].
- **Pulmonary circulation** carries oxygen-poor blood from the right ventricle to the lungs and back to the left atrium [117].

- The heart is an involuntary muscle made of myocardium [119].
- It functions as two paired pumps [121].
- The left side is a high-pressure pump; the right side is low-pressure [121].
- The top chambers are atria; the bottom are ventricles [122].
- The heart receives blood from the aorta via coronary arteries [123].
- The right side gets deoxygenated blood from body veins [123].
- Oxygenated blood returns from the lungs to the left side via pulmonary veins [124].
- Valves guide blood flow through the heart [124].
- A normal heart rate is 60 to 100 beats per minute [126].
- **Stroke volume (SV)** is the blood moved by one beat [126].
- **Cardiac output (CO)** is the blood moved in one minute [126].
- CO = Heart Rate × SV [126].
- The heart has an electrical conduction system [127].
- Impulses start at the sinoatrial node and travel through the heart [127].
- This produces a coordinated pumping action [128].
- **Arteries** are high-pressure vessels carrying blood away from the heart [129].
- They carry oxygenated blood, except for the pulmonary artery [130].
- The aorta is the main artery leaving the left heart [131].
- Its branches supply vital organs [132].
- The pulmonary artery originates at the right ventricle and carries deoxygenated blood to the lungs [134].
- Arteries branch into arterioles, which connect to capillaries [135].
- The **pulse** is created by blood pumped into major arteries [137].
- It can be felt at the neck, wrist, and groin [137].
- **Capillaries** are tiny vessels connecting arteries to venules [138].
- Oxygen and nutrients pass through thin capillary walls to tissues [139].
- Capillaries allow blood flow one cell at a time [140].
- **Veins** carry oxygen-depleted blood back to the heart [142].
- They have thinner walls and are larger than arteries [142].
- Major veins include the superior and inferior vena cava [143].
- The spleen is a solid organ filtering worn-out blood cells and foreign substances [146].

- The spleen is highly vascular and susceptible to injury [148].
- Blood is composed of plasma, red blood cells, white blood cells, and platelets [150].
- **Plasma** is the liquid portion with water, proteins, and nutrients [150].
- **Red blood cells (erythrocytes)** contain hemoglobin and carry oxygen [150].
- **White blood cells (leukocytes)** fight infection [151].
- **Platelets** help form blood clots [152].
- **Blood pressure** is the force against artery walls [153].
- **Systole** is when the left ventricle contracts and pumps blood [154].
- **Diastole** is when the ventricle relaxes and fills with blood [155].
- Blood pressure is measured with a cuff [156].
- It is expressed in millimeters of mercury [157].
- **Perfusion** is adequate blood circulation in organs and tissues [158].
- **Hypoperfusion**, or **shock**, is inadequate blood supply [159].
- The body can adjust to small blood loss by constricting vessels and increasing heart rate [161].
- Large blood loss can lead to shock [163].
- Mean arterial pressure can help detect shock [164].
- Mean arterial pressure = Cardiac Output × SVR [165].
- Blood functions include fighting infection, transporting oxygen/CO2, controlling pH, transporting waste/nutrients, and coagulation [166].

8. Nervous System Control of the Cardiovascular System

- The nervous system controls the cardiovascular system [168].
- This involves the sympathetic and parasympathetic nervous systems [169].
- The **sympathetic nervous system** controls the "fight or flight" response [169].
- It signals adrenal glands to secrete epi and norepi [169].
- These stimulate the heart and blood vessels [169].
- Alpha adrenergic receptors are in blood vessels and cause contraction when stimulated [170].
- Beta adrenergic receptors are in the heart and lungs [170].
- Beta-1 stimulation increases heart rate and contraction force [171].
- Beta-2 stimulation dilates lung bronchi [171].

- The **parasympathetic nervous system** causes heart rate to slow and beat more weakly [171].
- It is nearly the opposite of the sympathetic system [172].
- The sympathetic and parasympathetic systems usually balance each other [172].
- **Baroreceptors** detect pressure in blood vessels [173].
- They are found in the aorta and carotid bodies [173].
- Baroreceptor stimulation adjusts blood pressure via the nervous systems [173].

9. The Nervous System: Central and Peripheral Divisions

Division	Components	Function
Central Nervous System (CNS)	Brain, Spinal Cord [176]	Most complex system; controls voluntary and involuntary actions; transmits messages [174]
Peripheral Nervous System (PNS)	Nerves outside brain and spinal cord [176]	Connects CNS to rest of the body; divided into somatic and autonomic [177]
Somatic Nervous System (PNS subdivision)	Nerves transmitting signals to voluntary muscles [198]	Regulates voluntary control (walking, talking, writing) [177]
Autonomic Nervous System (PNS subdivision)	Involuntary nerves (sympathetic, parasympathetic) [199]	Controls automatic functions (smooth muscle, cardiac muscle, fight or flight, rest and digest) [178]

- The nervous system is perhaps the most complex system [174].
- It is divided into two main portions [175].
- The **central nervous system (CNS)** includes the brain and spinal cord [176].
- The **peripheral nervous system (PNS)** includes all nerves outside the brain and spinal cord [176].
- The PNS is divided into the somatic and autonomic nervous systems [177].

- The **somatic nervous system** regulates voluntary control [177].
- The **autonomic nervous system** controls automatic functions [178].
- The brain has three parts: cerebrum, cerebellum, and brain stem [180].
- The **cerebrum** is the largest part [180].
- It is responsible for higher brain function [180].
- It has two hemispheres, each with four lobes [181].
- These lobes are frontal, parietal, occipital, and temporal [182].
- The frontal lobe handles personality and judgment [183].
- The parietal lobe deals with recognition [184].
- The occipital lobe deals with vision [184].
- The temporal lobe handles taste, hearing, and understanding words [184].
- The **cerebellum** controls balance, coordination, and posture [185].
- The **brain stem** controls life-sustaining functions [187].
- These include cardiac and respiratory functions and consciousness regulation [187].
- The brain stem is comprised of the midbrain, pons, and medulla oblongata [188].
- The reticular activating system regulates consciousness [188].
- **Cerebral spinal fluid (CSF)** filters impurities and cushions the brain/spinal cord [190].
- Oxygenated blood is supplied to the head by carotid arteries [192].
- Deoxygenated blood drains via jugular veins [192].
- The **spinal cord** is an extension of the brain stem [194].
- It leaves the skull through the foramen magnum [195].
- It is encased in the vertebral column [195].
- Its main function is to transmit messages between the brain and the body [196].
- The **peripheral nervous system** has two parts: voluntary and involuntary [197].
- The **somatic nervous system** transmits signals to voluntary muscles [198].
- It allows activities like walking and writing [198].
- The **autonomic nervous system** is involuntary [199].
- It includes the sympathetic and parasympathetic divisions [199].
- The PNS has sensory and motor nerves [200].

- **Sensory nerves** carry information from the body to the CNS [200].
- **Motor nerves** carry information from the brain to muscles [200].

10. The Integumentary System: Layers and Functions

- The integumentary system is the skin [201].
- It has two main layers: the epidermis and the dermis [201].
- The **epidermis** is the superficial, watertight layer [201].
- It is like a protective covering [201].
- The epidermis is composed of layers, including the stratum corneum [202].
- Skin cells in the epidermis are constantly replaced [202].
- The **dermis** is the deeper layer [203].
- It contains special structures of the skin [203].
- These include sweat glands, sebaceous glands, and hair follicles [203].
- Blood vessels and mucous membranes are also in the dermis [203].
- Below the skin is the **subcutaneous tissue** [204].
- This is a layer of fat [204].
- Subcutaneous tissue serves as an insulator and energy reservoir [204].
- The skin is the largest single organ [205].
- It has three major functions [206].
- It protects the body from the environment [206].
- It regulates body temperature [206].
- It transmits information from the environment to the brain [206].

11. The Digestive System: Organs and Processes

Organ	Quadrant Location(s)	Primary Function
Liver	Upper right, extends into upper left [210]	Filters harmful substances; forms clotting factors; stores sugar/starch; produces bile [227]
Gallbladder	Upper right [210]	Stores bile from the liver [228]

Stomach	Upper left [211]	Receives and stores food; produces movement into the bowel [222]
Spleen	Upper left [211]	Filters blood (part of lymphatic/circulatory) [147]
Large Intestines (Colon)	Portions in upper right, upper left, right lower, lower left [210]	Absorbs final 5-10% of digested food/water; forms solid stool [229]
Small Intestines	More than one quadrant [214]	Produce enzymes and mucus to aid digestion [229]
Pancreas	Behind the abdominal cavity (Retroperitoneal) [215]	Secretes pancreatic juice (exocrine); produces insulin and glucagon (endocrine) [224]
Kidneys	Behind the abdominal cavity (Retroperitoneal) [215]	Filter blood waste; control water/salt balance [248]
Urinary Bladder	Behind pubic symphysis in pelvic cavity [214]	Stores urine [254]
Appendix	Right lower abdomen [230]	Opens into the first part of the intestines; can become inflamed (appendicitis) [230]
Rectum	Not specified by quadrant, but large hollow organ holding feces [232]	Holds feces until expelled [232]

- The digestive system is also called the gastrointestinal system [208].
- Its components include the abdomen, organs, and vascular structures [208].
- The abdomen contains major organs of digestion and excretion [208].
- The abdomen is divided into four **quadrants** [208].
  - Upper right: liver, gallbladder, portion of colon [210].
  - Upper left: stomach, spleen, portion of colon [211].

    - Right lower: portion of large intestines [212].
    - Lower left: descending and sigmoid colon [213].
- Some organs are in more than one quadrant [214].
- The kidneys and pancreas are **retroperitoneal**, behind the abdominal cavity [215].
- Digestion begins in the mouth [218].
- The mouth includes cheeks, lips, gums, teeth, tongue, and palates [218].
- Salivary glands produce saliva [218].
- The oral pharynx is a tube from the mouth back to the esophagus/trachea [219].
- The esophagus is a tube from the pharynx to the stomach [220].
- Muscles propel food down the esophagus [221].
- The stomach is a hollow organ in the left upper quadrant [222].
- It receives, stores, and moves food into the bowel [222].
- The pancreas is retroperitoneal, below and behind the liver/stomach [223].
- Its exocrine portion secretes pancreatic juice [224].
- Its endocrine portion produces insulin and glucagon [224].
- Insulin is produced in the pancreas [292].
- The liver is a large, solid organ in the right upper quadrant [225].
- It filters substances, forms clotting factors, and stores sugar [227].
- Bile ducts connect the liver to the intestine and gallbladder [228].
- The small intestines produce enzymes and mucus for digestion [229].
- The large intestine includes the cecum, colon, and rectum [229].
- Its main function is absorbing water and forming stool [229].
- The appendix is a tube in the right lower abdomen [230].
- It can become inflamed, causing appendicitis [231].
- The rectum holds feces until expelled through the anus [232].
- Sphincters control the escape of contents from the digestive tract [233].
- Digestion is completed by chemical processes using enzymes [235].
- Enzymes break food into sugars, fatty acids, and amino acids [237].
- Digested products are absorbed into the bloodstream and circulated [238].

12. The Lymphatic System: Components and Role

- The lymphatic system is important but not talked about much [240].
- Its elements include the spleen, lymph nodes, lymph vessels, and thymus gland [241].
- It supports the circulatory and immune systems [241].
- **Lymph** is a thin fluid that carries oxygen, nutrients, and hormones to cells [241].
- It also carries waste products away from cells [241].
- Lymph vessels form a network throughout the body [241].
- This network serves as an auxiliary to the circulatory system [241].
- **Lymph nodes** are tiny structures that filter lymph [242].
- They help rid the body of toxins and harmful materials [242].

13. The Endocrine System: Hormones and Regulation

- The endocrine system is a complex message and control system [244].
- It integrates many body functions [244].
- **Endocrine glands** release hormones directly into the bloodstream [245].
- Each gland produces one or more hormones [245].
- Each hormone has a specific effect on an organ, tissue, or process [245].
- The brain controls the release of hormones [246].
- The system uses feedback loops to maintain body balance [246].
- Excessive or deficient hormone levels can cause diseases like diabetes [247].

14. The Urinary System: Function and Organs

- The urinary system controls the discharge of waste filtered from blood [248].
- Its main functions are controlling fluid balance and eliminating waste [249].
- It also helps control the body's pH [249].
- The **kidneys** are two solid organs in the retroperitoneal space [250].
- They rid blood of toxic waste and control water/salt balance [252].
- The **ureters** pass from each kidney to the urinary bladder [253].
- The **urinary bladder** is located behind the pubic symphysis [254].
- The **urethra** controls urine flow from the bladder out of the body [255].

15. The Genital System: Reproductive Processes

- The genital system controls the reproductive processes [256].
- The **male reproductive system** includes testes, epididymis, vas deferens, prostate gland, seminal vesicles, and penis [257].
- It lies mostly outside the pelvic cavity [257].
- The **female reproductive system** includes ovaries, fallopian tubes, uterus, cervix, and vagina [258].
- It is contained entirely within the pelvic cavity [259].

16. The Life Support Chain and Metabolism

- Cells are the body's foundation and require oxygen, nutrients, and waste removal [260].
- The respiratory and circulatory systems deliver these supplies [260].
- Interference with these systems can damage and kill cells [260].
- Cells use oxygen and nutrients to create chemical energy through **metabolism** [261].
- **Aerobic metabolism** uses oxygen to create energy (ATP) [262].
- When oxygen is limited, cells switch to **anaerobic metabolism** [262].
- Anaerobic metabolism produces **lactic acid** as a waste product [263].
- Accumulation of lactic acid and waste makes the area toxic [263].
- This can eventually lead to cell death [263].
- Movement of oxygen, waste, and nutrients occurs by **diffusion** [264].
- **pH** is critical to diffusion [264].
- The body uses significant energy to maintain normal pH [264].

17. Pathophysiology: Respiratory Compromise and Shock

Condition	Definition	Causes	Effects
Respiratory Compromise	Inability of the body to move gas effectively [265]	Blocked airway, damaged breathing muscles, obstructive airway (asthma, overdose, trauma,	Hypoxia (decreased oxygen), hypercarbia (elevated carbon dioxide), increased

		allergic reaction), change in atmosphere, impaired gas movement, ventilation/perfusion mismatch [267]	respiratory rate (attempt to compensate), blood becomes acidotic, decreased blood oxygen, shift to anaerobic metabolism, cell damage/death [266]
Shock (Hypoperfusion)	Inadequate blood flow and oxygen to organs and tissues [159]	Large blood loss (systemic adjustment fails), impaired oxygen delivery [163]	Cellular hypoxia, anaerobic metabolism, lactic acid production, organ dysfunction, decreased blood pressure, increased heart rate, forceful heartbeats, blood vessel contraction, interstitial fluid moves into capillaries [275]

- **Pathophysiology** studies functional changes in disease [265].
- **Respiratory compromise** is the inability to effectively move gas [265].
- It can lead to **hypoxia** (low oxygen) or **hypercarbia** (high carbon dioxide) [266].
- Causes include blocked or obstructed airways [267].
- Damaged breathing muscles can also cause it [267].
- Trauma, allergic reactions, and high altitudes are causes [267].
- Impaired gas movement across membranes is a cause [267].
- A **ventilation/perfusion mismatch** occurs when gas movement or blood flow is abnormal [268].
- Pulmonary emboli or fluid in alveoli cause mismatches [269].
- Respiratory compromise causes oxygen levels to fall and carbon dioxide to rise [270].
- The brain increases the respiratory rate to compensate [270].

- If ineffective, blood becomes more acidotic [271].
- Decreased oxygen forces cells into anaerobic metabolism [273].
- This leads to **shock**, inadequate blood flow and oxygen [274].
- Impaired oxygen delivery causes cellular hypoxia [275].
- Hypoxia leads to anaerobic metabolism and lactic acid production [275].
- This results in organ dysfunction [275].
- The effects of shock are similar to respiratory compromise [278].
- Oxygen supplied to tissues fails [278].
- Cells switch to anaerobic metabolism and produce lactic acid [278].
- Baroreceptors detect decreased blood pressure [279].
- They initiate the release of epi and norepi [279].
- This increases heart rate and contraction force [280].
- Blood vessels contract, and fluid moves into capillaries [280].
- Anaerobic metabolism requires more energy than aerobic [282].
- It can result in metabolic acidosis [281].
- There is decreased ability of blood to carry oxygen [283].
- Brain cells cannot use alternative fuels [284].
- Decreased glucose can damage and kill brain cells [284].
- Cellular injury can be repairable if perfusion is restored [285].
- Irreversible injury means no treatment will help [285].

18. Review of Key Concepts

- Which is found in the retroperitoneal space? The kidneys [287].
- The cartilaginous tip of the sternum is called the xiphoid process [290].
- A person with bilateral femur fractures has both femurs fractured [291].
- The most prominent landmark on the anterior neck surface is the Adam's apple, also called the thyroid cartilage [291].
- Insulin is produced in the pancreas [292].
- tendons connect muscle to bone [293].
- ligaments connect bone to bone [293].
- The normal resting heart rate in an adult is 60 to 100 beats per minute [294].
- Bradycardia is below 60; tachycardia is above 100 [295].
- The left atrium receives oxygenated blood from the lungs [296].

- The largest part of the brain is the cerebrum [297].
- White blood cells, not red blood cells, help fight infection [299].