Human Anatomy and Physiology Comprehensive Series Course GuideBook

By Rapid Learning Center

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Chemistry : Biology : Physics : Math

Human Anatomy and Physiology Comprehensive Series

Tutorial Series Summary

Core Unit #1 – Levels of Organization

In this core unit, you will acquire the concepts of organization in the human body at the cellular, tissue and body organ system.

Tutorial 01: Introduction to Human Anatomy and Physiology

- What is anatomy?
- What is physiology?
- Integration between Anatomy and Physiology
- Levels of structural organization
- Homeostasis
- Body cavities
- Anatomical terms for the human body
- Sectional Anatomy – planes, quadrants and sections
- Anatomy and Physiology study tips

Tutorial 02: Chemical Level of Organization

- Atoms and Bonds
- Chemical Reactions in Physiology
- Enzymes and Energy
- Body pH Balance
- Cellular building blocks: carbohydrates, fats, lipids, proteins and nucleic acids

Tutorial 03: Cellular Level of Organization

- The Cell
- The Significance of Organelles
- Organelle Structures and Functions
- The Plasma Membrane, its Structure and Function
- DNA Transcription and Protein Synthesis
- Cell Cycle

Tutorial 04: Tissues of the Body

- Histology – Definition and Scope
- Animal Cell Structure
- Epithelial Tissue, Classification and Structure
- Connective Tissue, Cells and Organization
- The Structure and Function of Skeletal Muscle and Neural Tissue

Core Unit #2 – Support Systems

In this core unit, you will review the support systems of the body. The structure of the axial and appendicular skeleton will be covered. Also, you will also learn about the muscles of the body including the upper and lower extremities.

Tutorial 05: The Integumentary System

- The Integumentary System
- The Functions of the Integumentary System
- The Structures of the Skin and the Associated Appendages
- The Dermis
- The Epidermis

Tutorial 06: Osseous Tissue and the Structure of Bone
- The basic structure of bone
- Bone markings
- Classification of bones
- The process of endochondronal and intramembranous Ossification
- Stages of bone healing

Tutorial 07: The Skeletal System: Axial Skeleton
- The Structure of the Vertebral Column
- The General Characteristics of the Vertebrae
- Bones of the thorax
- Bones of the skull

Tutorial 08: Appendicular Skeleton and Articulations of the Body
- The Structure of the Pectoral and Pelvic Girdles
- Bones of the Upper Extremity
- Bones of the Lower Extremity
- Joint Formation and Classification
- Joints found in the Upper and Lower Extremity

Tutorial 09: The Muscular System
- The Structure of a Muscle Cell
- Muscle Fiber Arrangements
- Excitation-contraction Coupling
- The Contraction Cycle
- Muscle Energetics
- Cardiac Muscle Tissue

Tutorial 10: Axial and Appendicular Musculature
- Lever Action in the Body
- Muscles of the Head and Neck
- Muscles of the Trunk
- Muscles of the Upper and Lower Extremities

Core Unit #3 – Coordination Systems

In this core unit, you will learn about the control of the muscles and organ systems of the body through the central and peripheral nervous systems.

Tutorial 11: Neural Tissue and the Nervous System
- The Nervous System
- Neurons and Neuroglia
- The structure of the nervous system
- Synaptic transmission

Tutorial 12: The Spinal Cord and Spinal Nerves

- The spinal cord
- Spinal reflex
- Spinal pathways
- The spinal nerves

Tutorial 13: Brain and Cranial Nerves
The human brain: regions and hemispheres
Brain pathways to the spinal cord
Cranial nerves
Higher order functions: learning, memory and language

Tutorial 14: The Somatic Nervous System and the Special Senses
- The Structure of Sensory Receptors
- The Organ of Sight
- The Organ of Hearing
- The Organ of Taste
- The Organ of Smell

Tutorial 15: The Autonomic Nervous System
- An Overview of the Autonomic Nervous System
- The Parasympathetic Division
- The Sympathetic Division
- Higher Order Functions

Tutorial 16: The Endocrine System
- The Endocrine System and Hormone Signaling
- The Endocrine Organs
- Hormones and Aging

Core Unit #4 – Homeostatic Systems

In this core unit, you will learn about the anatomy and function of the different body organ systems.

Tutorial 17: Blood
- The Components of Whole Blood
- The Functions of Blood
- The Formation of Blood

Tutorial 18: The Cardiovascular System: Heart
- Anatomy of the Heart
- The Structure of the Heart and Surrounding Tissue
- The Structure of Cardiac Muscle
- The Electrical Conducting System of the Heart

Tutorial 19: The Cardiovascular System: Vessels and Circulation
- Anatomy of a Blood Vessel
- The Arteries and Veins of the Head and Neck
- The Arteries and Veins of the Trunk
- The Arteries and Veins of the Upper and Lower Extremities
- The Capillary Circulation

Tutorial 20: Immunity and the Lymphatic System

- The structure of the Lymph Vessels
- Lymphocytes
- Lymphatic Vessels and Organs of the Head, Neck and Thorax
- Lymphatic Vessels and Organs of the Abdominopelvic Region

Tutorial 21: The Respiratory System

- The Upper Respiratory System
- The Lower Respiratory System
- Respiration and the Mechanics of Breathing

Tutorial 22: The Digestive System, Metabolism and Nutrition

- The Digestive system
- Ingestion and swallowing
- The structure of digestive organs
- Accessory glandular digestive organs
- Metabolism

Tutorial 23: The Urinary System, Fluid, Electrolyte and Acid- Base Balance

- The Kidneys
- The Nephron
- The Ureters and Urinary Bladder
- Fluid Electrolyte Balance
- Acid-base Balance

Tutorial 24: The Reproductive System and Development

- Fertilization
- Embryology
- Gastrulation
- Human Development
- Continuity of Life

Tutorial Series Features

This tutorial series is a carefully selected collection of core concept topics in human anatomy and physiology that cover the essential concepts. It consists of three parts:
Human Anatomy and Physiology Concept Tutorials – 24 essential topics
Problem-Solving Drills – 24 practice sets
Super Condense Cheat Sheets – 24 super review sheets

Tutorials

- Self-contained tutorials…not an outline of information which would need to be supplemented by an instructor.
- Concept map showing inter-connections of new concepts.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Conceptual explanation of important properties and problem solving techniques.
- Animated examples of human anatomy and Physiology, and their integration.
- A concise summary is given at the conclusion of the tutorial.
- Clinical terms that are relevant to the material in the tutorial.

Problem Solving Drills

Each tutorial has an accompanying Problem Set with 10 problems covering the material presented in the tutorial. The problem set affords the opportunity to practice what has been learned.

Condensed Cheat Sheet

Each tutorial has a one-page cheat sheet that summarizes the key concepts and vocabularies and structures presented in the tutorial. Use the cheat sheet as a study guide after completing the tutorial to re-enforce concepts and again before an exam.

01: Introduction to Human Anatomy and Physiology

Chapter Summary:

This tutorial introduces the discipline of anatomy and physiology and their relationship with physiology.

Tutorial Features:

Specific Tutorial Features:

What is anatomy?
What is physiology?
Integration between Anatomy and Physiology
Levels of structural organization
Homeostasis
Body cavities
Anatomical terms for the human body
Sectional Anatomy – planes, quadrants and sections
Anatomy and Physiology study tips

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Anatomy is the study of structure and the relationship between structures. Physiology is the study of body function. Anatomical studies can include investigation at the molecular, cellular, tissue and organ level. Also, anatomy seeks to link and define structure and function.

Chapter Review:

- **Anatomy** is the study of structure and the relationship between structures.
- Gross anatomy is also known as macroscopic anatomy, and it is the study of large structures in the body that can be viewed with the naked eye.
- **Physiology** is the study of body function. It is the study of the biochemical, physical and mechanical functions of living organisms.
- At the chemical level, the human body is made up of some key elements as shown in the table. The 4 main elements (carbon, hydrogen, oxygen, nitrogen) account for approximately 99% of all atoms in the body.
- Multiple tissues come together to form the organ level of organization (heart). Organs are structures that are made of two or more different types of tissues.
- Systems come together to form an organism. An organism is the highest level of organization.
- The human body has a total of 11 organ systems that function both independently and together to maintain a stable environment, known as homeostasis.

- The **skin** is the largest organ of the body, covering the entire surface of the body. The skin provides a protective barrier for the human body, as well as playing a key role in body temperature regulation as part of homeostasis. The skin is divided into 2 layers: the epidermis and the dermis.
- The **skeletal system** provides the rigid, yet mobile, structure for the human body. It protects the underlying organs and prevents injury to them.
- The **muscular system**, along with the nerves that supply them, generate motion in arms and limbs.
- The **nervous system** controls movement and function through nerve impulses sent to and from the brain. The nervous system is divided into the Central Nervous system and the Peripheral Nervous system.
- The **Endocrine system** is a series of organs or glands spread throughout the body whose effects include the production and release of circulating hormones.
- The cardiovascular system, or circulatory system, is responsible for moving oxygen and carbon dioxide, as well as nutrients and waste products in and out of cells in the body.
- The **Lymphatic system** is a network through which lymph fluid circulates, providing a filter system for the body.
- The **Respiratory system's** function is gas exchange, including oxygen uptake and carbon dioxide release in the lungs.
- The **Digestive System** is responsible for breaking down, digesting and absorbing the food we eat and what we drink.
- The **urinary system** filters the blood and removes waste and excess water from the bloodstream which, in turn, removes waste and excess fluid from the tissues.
- The **Reproductive system**, in both males and females, is responsible for reproduction of humans.
- Limbs have their own directional terms. Proximal describes where the limb attaches to the body. Distal describes the furthest point from where the limb attaches to the body.

How to Study Anatomy and Physiology

- Anatomy can be a difficult subject to learn because of all the names and terms to learn. There are some common root words, suffixes and prefixes that will help as you learn and study anatomy.
- When studying the muscular system and learning the individual muscles, it can be helpful to learn the function of each muscle type. For example, flexor muscles decrease the angle between the components of a limb, resulting in flexion.
- Typically in science, keyword mnemonics are a great way to memorize what is needed for class. Here is a simple 3-step process to do so: Step 1: List the keywords in a logical order, Step 2: Write down the first letter of each keyword, Step 3: Create a word, phrase, or sentence from the first letters of these keywords.
- (1) Memorize basic information to save time later ,e.g., commonly used terms and concepts, the four tissues, eleven body systems, etc., (2) Learn vocabulary quickly for understanding when it's used later. Make cheat-sheet or flashcards if needed. (3) Brush up on your basic biology; don't try to remember every variation of each process, (4) Look for the commonalities between processes and functions; don't treat each one as different.

02: Chemical Level of Organization

Chapter Summary:

This tutorial reviews the chemical level of organization including chemical bonds and the chemical building blocks of cells. Enzymatic action and catalysis are also presented.

Tutorial Features:

Specific Tutorial Features:

- Atoms and Bonds
- Chemical Reactions in Physiology
- Enzymes and Energy
- Body pH Balance
- Cellular building blocks: carbohydrates, fats, lipids, proteins and nucleic acids

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Bonds
    Ionic
    Hydrogen
    Covalent
Enzymatic Action
Acid-base Buffering
Macromolecules
    Carbohydrates
    Proteins
    Lipids
Nucleic Acids

Chapter Review:

Organic Molecules

- **Atomic nuclei** contain protons and neutrons. Each type of atom, or element, has a different number of protons. For example, hydrogen has 1 proton, while carbon has 14.
- Chemical compounds are made up of two or more atoms joined together. Bonds hold the atoms together.
- **Covalent bonds** are formed when atoms share electrons. They are very strong bonds and are the major type in organic chemicals.
- **Ionic bonds** are bonds that form between 2 oppositely charged ions. Atoms become ions when they gain or lose electrons; ionic bonds are weaker than covalent bonds and tend to dissociate in water.
- **Hydrogen bonds** are weak intra- or inter-molecular attractions between molecules with a net dipole.
- **Hydrogen-bonded water network**, when a molecule is put into water, this network effects its orientation and associations.

Enzymes

- **Catalysts** are molecules or substances that effect the conversion of reactants to reaction products. By interacting with one or more of the reactants, catalysts provide an alternative reaction pathway.

- **Enzymes** lower the activation energy, as compared to the same reaction without one, which helps ensure the reaction will proceed.
- **Enzymes** are often named after their substrate, function and/or location within the body. For example, salivary amylase is found in the mouth and breaks down starch.

Macromolecules

- **Carbohydrates** are categorized into 3 main forms: monosaccharides, disaccharides and polysaccharides. The functions of carbohydrates include energy usage, energy storage, and building material (e.g., cellulose in plant cell walls); they can also modify other macromolecules (e.g., glycolipids, glycoproteins).
- **Lipids** are group of fat soluble molecules, such as free fatty acids and cholesterol. Lipid functions include: energy storage, cell membrane components, and steroid hormones. Lipids also serve as intermediate signaling molecules.
- **Proteins** are formed by amino acids being linked together and assuming their final conformation. The amino acids are linked together through peptide bonds.
- **Deoxyribonucleic acid (DNA)** is the blueprint of life; it is present in almost every cell in the body. A copy from a male donor and a copy from a female donor, through fertilization, can create a human being.

03: Cellular Level of Organization

Chapter Summary:

This tutorial reviews the cell structure including the plasma membrane and cell processes. DNA replication and the cell cycle are presented along with RNA transcription and proteins translation.

The cell is surrounded by a protective, functional plasma membrane. The plasma membrane protects the cell, separates it from the interstitial fluid and is involved in cell signaling. Cells must copy their DNA in order to replicate and divide into daughter cells.

Tutorial Features:

Specific Tutorial Features:

The Cell
The Significance of Organelles
Organelle Structures and Functions
The Plasma Membrane, its Structure and Function
DNA Transcription and Protein Synthesis
Cell Cycle

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Plasma Membrane and the Phospholipid Bilayer
Cellular Processes
    Cilia
    Flagella
Phagocytosis
RNA Transcription
Types of RNA
Protein Translation
Cell Cycle Divisions

Chapter Review:

Plasma Membrane

- **Microscopy** involves the passage of light or an electron beam through a thin section of a sample and then through one or more lenses to magnify the object.
- **Phospholipids** are a type of lipid that makes up the majority of mammalian cell membranes. The phospholipids are amphipathic because they have a hydrophobic tail and hydrophilic head group.
- **The plasma membrane** of mammalian cells is also known as the phospholipid bilayer. It is semi-permeable barrier around the outside of the cell and, within its interior, is the cytosol, organelles and nucleus of the cell.
- The plasma membrane's major functions include: Semi-permeable barrier, Anchor for the Cytoskeleton, and Signaling.
- **Cilia** are tail-like projections, which extend approximately 5-10 microns from the cell body. Motile cilia are usually found in large numbers, beating together in waves.
- **Phagocytosis** is a form of endocytosis where portions of the cell or an entire cell, such as a bacterium, are engulfed. Phagocytes, such as macrophages and neutrophils, perform this function regularly as part of an immune response.
- Exocytosis is a process used by cells to deliver materials to the extracellular fluid, as well as membrane proteins, to be incorporated into the plasma membrane.

Cellular Organelles

- The cell nucleus is usually near the center of the cell; it contains the majority of the genetic material in cells. Within the nucleus, the DNA is compacted and organized into chromosomes.
- **Microtubules** are made of subunits of the protein, tubulin. Microtubules are dynamic and assemble and disassemble regularly. These nonmembranous organelles are part of the cytoskeleton, move intracellular materials and organelles, and form the spindle apparatus during cell division.
- **Protein translation** is the process by where amino acids are assembled into a polypeptide chain or protein, based on the DNA code.
- The different types of membranous organelles within mammalian cells are: (1) nucleus, (2) mitochondria, (3) endoplasmic reticulum, (4) golgi apparatus, (5) lysosomes and (6) peroxisomes.

Cell Cycle Division

- DNA replication must take place in order for a cell to divide during mitosis. During DNA replication, the parental DNA is separated and each parent strand acts as a template for the formation of a new complementary strand.
- The cell cycle is a series of events that takes place before the cell divides, during mitosis (M phase). There are regulatory molecules, such as cyclins and cyclin-dependent kinases,

which determine a cell's progression through the cell cycle. The cell cycle is divided into 4 phases: G_1, S, G_2 and M.

- **Meiotic cell division** and Mitotic cell division have a lot in common, although there are some key differences between these two processes. One way that these two processes are different is in the amount of DNA in the offspring cells. At the end of mitosis, each daughter cell has a total of 46 chromosomes whereas, at the end of meiotic cell division, each gamete has a total of 23 chromosomes.

04: Tissues of the Body

Chapter Summary:

This tutorial reviews the cell structure including the four different primary tissue types.

Cells in the human body are organized into tissues and organ systems. The organ systems perform all the major functions of the body and each organ system has independent functions that also impact the body as a whole.

Tutorial Features:

Specific Tutorial Features:

- Histology – Definition and Scope
- Animal Cell Structure
- Epithelial Tissue, Classification and Structure
- Connective Tissue, Cells and Organization
- The Structure and Function of Skeletal Muscle and Neural Tissue

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Histology
Biological sample preparation
Connective tissue
Epithelial tissue
Neural tissue
Muscle tissue

Chapter Review:

Histology

- **Histology** is the study of tissue, and histopathology is the study of diseases in certain tissues.
- Biological tissues typically do not have the strength and rigidity to allow them to be cut and not disrupt the architecture. In order to facilitate sectioning the sample, it can be embedded in paraffin wax, for example, by placing it in a liquid wax and then allowing it to harden.

- Tissue samples can then be stained or treated with labeled antibodies for microscopy. Examples of stains commonly used include: (1) H&E, (2) Gram Staining for bacterial identification, and (3) DAPI fluorescent stain to label DNA.
- There are many different cell types in the human body, approximately 200 or more. Every one of the 11 body organ systems contains a variety of cells that function together to perform the functions of the system.

Tissue Types

- **Connective tissue** is the most abundant body tissue. It consists of cells and a matrix of ground substance and fibers. Connective tissue has abundant matrix with relatively few cells.
- **Epithelial tissue** is made of different cell types organized into a sheet with one or more layers. An epithelium consists mostly of cells with little extracellular material between adjacent plasma membranes. It is arranged in sheets and attached to a basement membrane.
- **Neural tissue** is composed of neurons (nerve cells) and neuroglia (protective and supporting cells). Neuroglia is found in the central and peripheral nervous systems. The neuroglia include: Astrocytes (the most abundant type of glial cell), which regulate the external environment around neurons; Oligodendrocytes (wrap around the axons of neurons, a process called myelination); Ependymal cells; and Microglia. Neurons are cells that convert stimuli into electrical impulses, and neuroglia are supportive cells.
- The **muscular system** is made of muscles, the central nervous system and the peripheral nerves that control them. The muscular system provides structural rigidity and support and is organized into 3 types: Skeletal, Cardiac and Smooth Muscle - controlled by the central nervous system via neuromuscular junctions.
- Mucous membranes are Flat sheets of flexible tissue that cover or line a part of the body is called a membrane. There are 4 major types of membranes in the body: (1) Mucous membrane, (2) serous membrane, (3) cutaneous membrane, and (4) synovial membrane.

Origin of Tissue

- All tissues of the body develop from the three primary germ cell layers that form the embryo: ectoderm, endoderm and the mesoderm.
- Tissue injury involves different phases of repair that bring new blood vessels to the site if needed, to deliver the necessary cells and factors. Tissue repair can be divided into the following phases: (1) Inflammatory phase, (2) proliferative phase, and (3) remodeling phase.
- As we age, the normal reparative processes in the different types of tissue become less active. Also, changes in key hormone levels and activity level contribute to the decline of the tissues in the body. There are changes in the cellular functions as well due to aging, secretions, hormone production, and the thinning of epithelia.

05: The Integumentary System

Chapter Summary:

This tutorial covers the components of the integumentary system – the skin, glands of the skin, hair and nails.

The integumentary system is involved in protection from the outside environment, protection from microorganisms, and temperature regulation.

Tutorial Features:

Specific Tutorial Features:

The Integumentary System
The Functions of the Integumentary System
The Structures of the Skin and the Associated Appendages
The Dermis
The Epidermis

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Integumentary systems
The epidermis
The dermis
Derivatives of the integumentary system
    Hair follicles
    Sebaceous glands
    Sweat glands
    Nails
Skin injury

Chapter Review:

Integumentary System

- **The integument** is considered an organ because it is made up of several different tissues. The integumentary system includes not only epithelial tissue but also connective tissue, sensory nerves, blood vessels, and muscle tissue.
- The **Epidermis** is made of differentiated squamous epithelium and is the first part of the skin barrier. There are a number of different cell types spread throughout the epidermis, the most predominant type being keratinocytes. The epidermis is divided into the following layers: stratum corneum, stratum lucidum, stratum granulosum, stratum spinosum and the stratum basale (basal layer).
- The epidermis is made of keratinized stratified epithelium. It has many layers of cells that are constantly dividing to replace skin as it sloughs off during everyday activities. The epidermis has four types of cells: Langerhans cells, melanocytes, keratinocytes, and Merkel cells.
- The skin covering the human body can be described as thick or thin. The majority of the skin covering the body is thin, specifically if it lacks the stratum lucidum layer in the epidermis. The skin on the palm of the hands, fingers and sole of the feet is thinker than elsewhere in the body.

The Dermal Layer of the Skin

- The **dermis** is the deep layer of the skin between the epidermis and the tissues under the skin (subcutaneous). The dermal layer is thicker than the epidermal layer and contains the blood vessels and innervation for both layers. The dermis is made up of two main components: the papillary layer and the reticular layer.
- The dermis delivers the blood supply to the skin. The blood vessels exist in the subcutaneous reticular dermis boundary, and they supply the subcutaneous layer and the skin itself.
- The subcutaneous tissue is also known as the hypodermis; this layer is the bottom layer of the integumentary system. This layer is between the dermis above and the underlying muscles and organs.
- There are a number of effects on the integumentary system that occur as we age: (1) decrease in melanocytes – this leads to pale skin that becomes more susceptible to UV radiation, (2) decrease in active hair follicles and, therefore, hair becomes more sparse, (3) reduction in sebum – skin becomes dry and cracked as less sebum is produced and secreted, (4) Thinning of skin layers, causing the skin to sag and wrinkle.

The Derivatives of the Integumentary System

- The skin has a number of derivatives or accessory structures: hair follicles, sebaceous glands, sweat glands, and nails.
- **Hair** is a nonliving structure made up of keratin produced from a hair follicle. Hair functions by protecting the scalp from the sun, insulating the body, filtering the air in the nasal cavities, and sensing foreign particles or insects on the skin.
- **Sebaceous oil glands** produce a lipid secretion, known as sebum. The gland produces the sebum and delivers it into the duct that is connected to the hair follicle. As the arrector pili muscles contract, this elevates the hair and squeezes the gland, forcing the sebum from the hair follicle onto the skin.
- **Sweat glands** can be divided into two categories: apocrine and merocrine. Sweat glands function by cooling the surface of the skin to contribute to body temperature regulation, water excretion and limiting the growth of bacteria.
- **Nails** are tightly packed, hard, keratinized epidermal cells. Nails offer protection to fingers and toes and enhance the grip and handling of small objects. The average growth rate of a nail is 1 millimeter per week.
- The following are some disorders of the skin: (1) Rash – a change in color and texture of the skin, typically caused by allergies or sun exposure, (2) Sunburn - UV radiation from the sun can increase melanin production but can also directly and indirectly damage DNA, and (3) Cold Sores - Herpes simplex virus 1 and 2 can lead to the development of watery blisters on the skin.

06: Osseous Tissue and the Structure of Bone

Chapter Summary:

The skeletal system provides support for the body and protection of the underlying organs. The structure and formation of bone is covered in this tutorial.

Osseous tissue is a specialized connective tissue that is formed into bone. Osseous tissue forms the rigid portion of bone and, along with the bone marrow, blood vessels, epithelium and nerves, makes up the bones in the skeletal system.

Tutorial Features:

Specific Tutorial Features:

The basic structure of bone
Bone markings
Classification of bones
The process of endochondronal and intramembranous Ossification
Stages of bone healing

Series Features:

- Concept map showing inter-connections of concepts.
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- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Ossification of Tissue into Bone
Bone Matrix
Cells of the Bone
Bone Classification

Chapter Review:

Basic Structure of Bone

- Osseous tissue is a specialized connective tissue that is formed into bone. Osseous tissue forms the rigid portion of bone and, along with the bone marrow, blood vessels, epithelium and nerves, makes up the bones in the skeletal system.
- **Bone matrix** is made up of hydroxyapatite crystals. Hydroxyapatite crystals are made from the interaction between calcium phosphate and calcium hydroxide. Inorganic compounds, such as calcium salts, sodium and magnesium, are incorporated into these crystals to strengthen bones.
- **Compact bone** wraps around the spongy bone and is called compact because of the minimal free space as compared to spongy bone.
- **Spongy bone** makes up the ends of long bone, known as the epiphysis, as well as being located deep in the bone interior. Spongy bone can transmit forces that are placed on the bone from different angles, and the trabecular meshwork can transmit forces across the bone.
- Bone tissue contains cells that mineralize bone, such as osteocytes, and others that are involved in the resorption of bone, called osteoclasts. The different cells that are contained in mature bone include: Osteocytes, Osteoprogenitor cells, Osteoblasts and Osteoclasts.

Bone Markings

- Bones have unique surface markings and shapes, known as bone markings. These are functional additions to the bone that provide for attachment points for tendons and ligaments.
- The following is a general description of some common bone markings, including their general function: (1) Process and Ramus, (2) Trochanter, (3) Head, Neck or Condyle, (4) Fossa or Sulcus, and (5) Foramen or Fissure.

Bone Growth and Development

- **Ossification** is the process of laying down new bone by replacing other tissues in the process. The bones of the skeleton begin to develop early, within weeks of fertilization.
- In endochondronal ossification, hyaline cartilage (Hyaline Cartilage Model) is converted to bone in a series of steps.
- When an individual reaches bone maturity, approximately age 25, the epiphyseal cartilage eventually disappears.
- **Appositional bone** growth is the process by which a developing bone increases its diameter.
- **Intramembranous ossification** is different from endochondronal ossification for a number of reasons, the most important one being that there is no cartilage as a starting material.

Bone Maintencance and Healing

- There are a number of hormones and minerals involved in bone growth. The hormones required for normal bone growth include: (1) parathyroid hormone, which stimulates osteoclast and osteoblast activity; (2) growth hormone from the pituitary gland - stimulates bone growth, (3) thyroxine from the thyroid gland – stimulates bone growth.
- Normally, there is a balance between the bone produced by osteoblasts and the bone degraded by osteoclasts.
- Approximately 15 - 20% of the total skeletal system is turned over (degraded and replaced) each year. This turnover of bone requires tremendous control, including hormones and cellular activity**.**
- Different Bones are subject to damage, such as a fracture, if they are exposed to enough force or trauma. The healing process involves key events beginning almost immediately after the injury.

07: The Skeletal System: Axial Skeleton

Chapter Summary:

This tutorial covers the bones of the axial skeleton including the bones of the skull, vertebral column and the bones of the thorax.

The axial skeleton does more than protect major organs, such as the heart and lungs; it also is involved in mobility. The vertebral column turns and rotates the neck and head.

Tutorial Features:

Specific Tutorial Features:

The Structure of the Vertebral Column
The General Characteristics of the Vertebrae
Bones of the thorax
Bones of the skull

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Function of the Axial Skeleton
Divisions of the Vertebral Column
Bones of the Thoracic Cage
Bones of the Cranium

Chapter Review:

Vertebral Column

- The major functions of the axial skeleton include: (1) protecting the organs in the thorax, as well as the brain, (2) providing surfaces for the attachment of muscles in the region, (3) adjusting the position of the head and neck, and (4) playing a role in the breathing cycle.
- The human vertebral column is made up of a total of 24 vertebrae, a sacrum bone and a coccyx.
- The **vertebrae** in the spinal column share some common structural features. The vertebral body is in contact with the intervertebral discs and transfers the weight along the axis and length of the spinal column.
- The cervical region of the spinal column contains two unique vertebrae, the Atlas C_1 and the Axis C_2.
- There are 12 thoracic vertebrae named T1 through T12. The thoracic vertebrae support the weight of the head, as well as the neck and upper limbs.
- There are 5 lumbar vertebrae named L_1 through L_5. The lumbar have the largest vertebral body but the smallest vertebral foramen.

Bones of the Thorax

- The **ribcage**, or thoracic cage, is made up of the sternum, the thoracic vertebrae and the 12 pairs of ribs.
- The **sternum** is a 3-component bone that forms the anterior midline of the thoracic wall. The three components are the manubrium, body and xiphoid process.
- There are 12 pairs of ribs in the human ribcage. The first 7 pairs are known as true ribs; pairs 8 through 12 are known as false ribs because they do not attach directly to the sternum.

Bones of the Skull

- The **skull** is made up of 22 bones and is divided into two major divisions: bones of the cranium and the facial bones.
- The 5 major sutures of the skull are: (1) lambdoid suture, (2) sagittal suture, (3) coronal suture, (4) squamous suture, and the (5) frontonasal suture.
- The cranial vault, or fossa, houses the brain and changes in size as the skull grows.
- The **occipital bone** forms the back and the posterior portion of the floor of the skull.
- **The endocrine system** is a series of organs or glands spread throughout the body whose effects include the production and release of circulating hormones.
- The **frontal bone** makes up the forehead and the roof of the eye orbits. The vertical portion of the bone forms the forehead, and the orbital or horizontal portion of the bone forms the orbital roof.
- There are a total of 14 facial bones, 2 pairs each of: maxillae, palatine, nasal, inferior nasal conchae, zygomatic and lacrimal bones.

08: The Appendicular Skeleton and Articulations of the Body

Chapter Summary:

The bones of the appendicular skeleton including the pectoral girdle and pelvic girdle are presented.

The appendicular skeleton facilitates human movements, such as walking and sitting down.

Tutorial Features:

Specific Tutorial Features:

The Structure of the Pectoral and Pelvic Girdles
Bones of the Upper Extremity
Bones of the Lower Extremity
Joint Formation and Classification
Joints found in the Upper and Lower Extremity

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Bones of the Appendicular Skeleton
Bones of the Pectoral Girdle
Bones of the Pelvic Girdle
Bones of the Limbs
Joints of the Body

Chapter Review:

Appendicular Skeleton and the Bones of the Pectoral Girdle

- The **appendicular skeleton** facilitates human movements, such as walking and sitting down.
- The pectoral girdle is made up of the scapula and the clavicle. The pectoral girdle is the articulation point between the upper arm and the chest.
- The **clavicle bone** braces the shoulder and connects the pectoral girdle to the axial skeleton.

Bones of the Upper Extremity

- The bones of the upper extremity, or limb, are the humerus, radius, ulna, carpal bones (wrist), the metacarpal bones, and phalange bones of the hand.
- The **humerus** is made of a head, a shaft (body), and a condyle. The head of the humerus, which is the ball of the ball-and-socket shoulder joint, articulates with the glenoid cavity (socket).

- The **radius bone** extends from the lateral side of the elbow to the thumb side of the wrist, making it a lateral bone of the forearm.
- The **ulna** is the second bone of the forearm; it lies medial to the radius, on the little finger side of the forearm.
- The **carpus**, or wrist, is made up of a total of 8 bones. The bones form two rows, the four proximal bones and the four distal bones.

The Pelvic Girdle and the Bones of the Lower Extremity

- The **pelvic girdle** is made up of the two hip bones. Each hip bone is made up of three bones: ilium, ischium and the pubis.
- The **pelvis** is made up of the two hip bones and the sacrum and coccyx of the spinal column. The anterior portion of the pelvis is made up of the hip bones, and the posterior portion is made up of the sacrum and coccyx.
- The **femur**, or thigh bone, is the proximal leg bone. It contains the ball (head) of the ball-and-socket hip joint.
- The **tibia** bone is the medial bone of the lower leg. The tibia is expanded in its proximal end where it enters the knee joint and narrows in the shaft.
- The **fibula**, or calf bone, is on the lateral side of the tibia. The fibula bone articulates with the tibia bone at both ends.
- The **tarsus**, or ankle, is made up of the talus bone, calcaneus bone, cuboid bone, navicular bone and the three cuneiform bones.

Classification of Joints

- The **joints** (articulations) of the body are the movement points for bones that allow such movements as bending an arm or leg. The joints of the body can be categorized into three main groups based on function: (1) synarthrosis joint, (2) amphiarthrosis, and (3) diarthrosis.
- The joints of the body allow for a number of movements, which are referenced from the anatomical position. The movements are categorized into sliding movements, angular movements, rotations and special complex movements.
- The hip joint is a ball-and-socket diarthrosis joint. This joint permits flexion/extension and a limited amount of rotational movement.
- The knee joint is a complex articulation that functions as a hinge. The knee joint permits some degree of rotation, as well as flexion/extension.

09: The Muscular System

Chapter Summary:

This tutorial covers the structural components of muscle. Skeletal muscles produce movement by contracting and exerting force on tendons which, in turn, pull on bones.

Tutorial Features:

Specific Tutorial Features:

The Structure of a Muscle Cell
Muscle Fiber Arrangements
Excitation-contraction Coupling
The Contraction Cycle
Muscle Energetics
Cardiac Muscle Tissue

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Muscular System
Types of Skeletal Muscles
Muscular Contraction
Muscle Terminology

Chapter Review:

The Structure of Muscle Fibers and Cells

- Muscles are connected to bones or to other muscles through tendons, which are formed from the collagen fibers of the perimysium, epimysium and the endomysium.
- Within the sarcoplasm of the muscle fiber are **myofibrils**. The myofibrils are approximately 1 - 2 μm in diameter and extend the length of the muscle cell. These myofibrils are made up of thick and thin filaments that are responsible for the contraction of the muscle fibers.
- A **sarcomere** is made up of thick and thin filaments; these produce the banding patterns, known as striations.
- Skeletal muscles and fibers are classified into three groups based on the following: (1) Speed of contraction – some muscle fibers contract quickly for explosive force, and (2) Resistance to fatigue – explosive fibers typically have a low resistance to fatigue.
- Muscle fibers are arranged into bundles, called fascicles. The pattern of fascicles affects muscle strength and motion. Skeletal muscle fibers are arranged in 4 distinct patterns: (A) Parallel, (B) Circular, (C) Convergent and (D) Pennate.

The Mechanics of Muscular Contraction

- The contraction of a muscle leads to the shortening of the fibers. A single contraction-relaxation cycle is called a twitch. A single action potential invokes a twitch.
- The **sliding filament theory** includes the following: after the signal to contract comes from the central nervous system, an action potential spreads over the muscle fiber. Calcium is released and binds to troponin, which alters the conformation of tropomyosin, which in turn unblocks actin-binding sites. Myosin (bound with ATP) binds to actin, hydrolyzes ATP, and the released energy delivers a power stroke. This hydrolysis also causes the myosin head to turn and ratchet the Z lines closer together.
- The **motor neuron** and the muscle fibers it innervates are called the motor unit. Groups of motor units work together to contract a muscle.

Muscle Terminology and Naming

- Muscles are named, based on various characteristics: (A) Location, (B) Size, (C) Number of Origins.
- The **origin** of a muscle is the point where the muscle attaches to another muscle or bone and is not moved during the muscle contraction. The **insertion** is where the muscle is attached to another muscle of bone, usually through a tendon, that does move during muscular contraction.

- Muscle groups are usually arranged into antagonistic pairs, each one performing the opposite function: (a) flexors or extensors, (b) abductors or adductors**.**
- **Muscle tone** is defined as the continuous and passive partial contraction of a muscle.
- **Muscle hypertrophy** is defined as the increase in the size of a muscle, as opposed to an increase in the number of muscle cells.
- **Myopathy** is a disease of the muscle in which muscular weakness occurs due to a malfunction of the muscle fibers.

10: Axial and Appendicular Musculature

Chapter Summary:

The muscles of the head, neck, upper trunk and the extremities will be covered in this tutorial. The lever actions of bones and joints in the body will also be reviewed.

The appendicular musculature includes the muscles of the pectoral and pelvic girdles, as well as the muscles of the upper and lower extremities. The axial musculature includes the muscles of the head and neck, vertebral column, and the muscles of the perineum and pelvic region.

Tutorial Features:

Specific Tutorial Features:

Lever Action in the Body
Muscles of the Head and Neck
Muscles of the Trunk
Muscles of the Upper and Lower Extremities

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Lever and Pulley Action
Muscle Divisions
Muscles the Position the Pectoral Girdle
Muscles that move the Arm
Muscles the move the Thigh

Chapter Review:

Action Levers and Pulleys

- Skeletal muscles produce movement by contracting and exerting force on tendons which, in turn, pull on bones. When producing a body movement, the bones act as levers and the joints act as fulcrums.
- **First-class Lever**: the fulcrum is between the effort and resistance.

- **Second-class Lever**: the resistance or load is located between the fulcrum and the effort.
- **Third-class Lever**: the effort is between the fulcrum and the resistance. This is the most abundant type of lever in the human body.

Appendicular Musculature

- Head and neck muscles: the muscles of facial expression, pharynx, eye muscles.
- The functions of the appendicular musculature are to move and stabilize the upper and lower extremities and the pectoral and pelvic girdles.
- The muscles that position the pectoral girdle are: **(1) Trapezius, (2) Subclavius, (3) Serratus anterior, (4) Rhomboid minor, (5) Rhomboid major, (6) Pectoralis minor, and the (7) Levator scapulae.**
- The muscles that move the arm include, 3 muscles are attached to the scapula and are involved in medial rotation of the arm, as well as flexion and adduction of the arm: coracobrachialis muscle, subscapularis muscle, and the teres major muscle.

Muscles of the pelvic Girdle and Lower Extremity

- The muscles associated with the pelvic girdle and the lower extremity can be grouped into the following categories: (1) muscles that move the thigh, (2) muscles that move the leg and the (3) muscles that move the foot and toes. The musculature of the lower extremity is more powerful than that of the upper extremity.
- The gluteal muscles attach to the hip bone and extend to the femur. These muscles produce: extension, lateral and medial rotation, and abduction at the hip joint.
- **Flexion at the hip** is performed by the iliopsoas group of muscles (psoas major and iliacus), as well as other muscles in this region. The gracilis muscle performs adduction and medial rotation at the hip.
- The **sartorius**, **semimembranosus**, and the **biceps femoris** are muscles that have their action lines pass posterior to the axis of the knee joint – and are flexors of the knee.

Axial Musculature

- The axial musculature moves the head and the spinal column and can be grouped based on function and location into the following: (1) muscles of the head and neck, (2) muscles of the vertebral column, (3) rectus and oblique muscles and the (4) muscles of the pelvic diaphragm and perineum.
- There are many muscles involved in facial expression, including the **buccinator**, which compresses the cheeks; and the **orbicularis oris muscle**, which compresses and purses the lips.
- The eye is moves by 4 rectus muscles – inferior, medial, superior and lateral, and 2 oblique muscles – superior and inferior.
- To masticate, or chew your food, the mandible and temporomandibular joint must be moved. The muscles of mastication that perform these movements are the: masseter, temporalis, medial pterygoid, and the lateral pterygoid muscle.
- The pharynx has a number of constrictor muscles that constrict the pharynx to move the food bolus into the esophagus – superior, middle and the inferior constrictor muscles.
- The **diaphragm** is a large muscle that separates the abdominopelvic and thoracic cavities. The diaphragm is part of the rectus group of muscles and its origin is the xiphoid process, ribs 7-12 and their associated cartilages, and anterior surfaces of the lumbar vertebrae.
- The muscles of the perineum and the pelvic diaphragm function to (1) support the organs of the pelvic cavity, (2) control the movements of material through the urethra and the anus, and (3) flex the joints of the sacrum and coccyx.

11: Neural Tissue and the Nervous System

Chapter Summary:

This tutorial reviews the structure of the nervous system, including the structure and classes of neurons.

Neurons are unique, excitable cells that transmit impulses and direct target cell function. The brain and spinal cord process and transmit impulses to the peripheral nervous system for function.

Tutorial Features:

Specific Tutorial Features:

The Nervous System
Neurons and Neuroglia
The structure of the nervous system
Synaptic transmission

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Neural Tissue
Anatomy of a Neuron
Classification of neurons
Neuroglia

Chapter Review:

Nervous System

- The **nervous system** is composed of neurons (nerve cells) and neuroglia (protective and supporting cells). Neuroglia is found in the central and peripheral nervous system. The neuroglia includes: Astrocytes (the most abundant type of glial cell); Oligodendrocytes (wrap around the axons of neurons, a process called myelination); Ependymal cells; and Microglia.
- The **central nervous system** is made up of the brain and the spinal cord. This division of the nervous system integrates information from the periphery and organ systems of the body; it generates and sends out nerve impulses to control these systems.
- The **peripheral nervous system** includes all the nervous tissue outside of the brain and spinal cord. The afferent division delivers information to the central nervous system and the efferent carries the motor commands to the organ systems and muscles of the body.

Neuron

- The **nervous system** is made up of neurons (neuronal cells), which conduct signals from the brain to the rest of the system; it also consists of glial cells, which support neuronal function.
- The **soma**, or nerve cell body, is the center of the neuron and it contains a nucleus and other organelles. The soma nucleus is the site of the majority of protein synthesis.
- **Dendrites** exist in many branches and make up a dendritic tree around the neuron soma. This is in the afferent region of the neuron where the majority of information flows into the neuron cell body.
- The **axon** is the cable-like projection that travels between the soma of a neuron and the dendrites of the next neuron. Axons contain microfilaments and microtubules, which are involved in vesicle traffic along the axon.
- **Motor neurons** (efferent neurons) transmit nerve impulses from the central nervous system to the periphery. Motor neurons modify the activity of an organ or muscle in the periphery.
- **Interneurons** connect neurons with specific regions in the central nervous system.
- **Excitatory neurons** activate or excite their target. Examples include spinal neurons, which synapse onto muscle cells. These neurons can excite the muscle into action.
- **Glial** cells provide the environment required for neurons to perform their functions. Glial cells myelinate neurons regulate the nutrients and gases in the extracellular environment and participate in the repair process. The glial cells found in the central nervous system are: ependymal cells, astrocytes, oligodendrocytes, and microglia.

Organization of the Nervous System

- The neural information that travels through the neurons in the PNS, into the central nervous system, must be processed in order to be acted on. In order to facilitate this processing, the central nervous system contains pools of neurons that are interconnected and share similar functions.
- **Divergent processing** involves information passing from one neuron or neuron pool to multiples.
- **Serial processing** involves the passage of information in a step-wise manner from one pool of neurons to another.
- The **gray matter** of the brain makes up the higher brain centers for processing incoming neuronal information.
- An **action potential** is defined as a change in the membrane potential of an excitable cell, followed by a return to its resting membrane potential.
- **Synaptic transmission** is the transfer of information from pre- to post-synaptic sides. Electrical impulses travel down the axon and are converted to a chemical signal (neurotransmitter). The neurotransmitter is stored in vesicles in the axon terminal until it receives the electrical signal and crosses the synaptic cleft. This then leads to it being converted to an electrical signal on the postsynaptic side.

12: The Spinal Cord and Spinal Nerves

Chapter Summary:

This tutorial reviews the anatomy and structure of the spinal cord. The organization of the spinal cord including the spinal motor tracts will be covered.

The spinal cord is encased in the bony vertebral column and is attached to the brain stem. It is the major conduit of information from the skin, joints, muscles, and organs to the brain and vice versa.

Tutorial Features:

Specific Tutorial Features:

The spinal cord
Spinal reflex
Spinal pathways
The spinal nerves

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Spinal Compartments
Histology of the Spinal Cord
Neural Reflex Action
Spinal Level Processing

Chapter Review:

Spinal Cord

- The **spinal cord** communicates via the spinal nerves; the nerves exit the spinal cord through notches between vertebrae with each nerve splitting and attaching to the spinal cord through the dorsal and ventral root.
- The spinal cord is a neural tube divided into 30 spinal segments, each with its own pair of nerves (one on each side). Each segment receives fibers from sensory receptors of the part of the body adjacent to it and sends back fibers to the muscles of that part of the body.
- The **dorsal root ganglia** are present at each spinal segment. Each pair of dorsal root ganglia contains sensory neuron cell bodies.
- The spinal cord is covered by special **meninges**, made up of three layers: dura mater, arachnoid mater, and the pia mater.
- The spinal cord is made up of **gray matter**, which contains nerve cell bodies and blood supply, and the **white matter**. The spinal cord is composed of an inner core of gray matter surrounded by a thick covering of white matter tracts that are often called columns.
- The reflexes of the body can be categorized into different types based on a number of factors. The factors used for classification include: (1) Circuit complexity – monosynaptic (one synapse) or polysynaptic (two or more synapses).

Spinal Nerves

- The spinal cord has a total of 31 pairs of spinal nerves. These are divided into the following categories: 8 cervical spinal nerves, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal spinal nerve.
- The spinal nerve is composed of the **dorsal and ventral root** from the spinal cord. The spinal nerve itself then divides into two main pathways: the dorsal ramus and the ventral ramus.

- Each specific body region is monitored by a pair of spinal nerves. The segmental organization of spinal nerves and the sensory innervation of the skin are related. The area of skin innervated by the right and left spinal nerve of a single spinal segment is known as a **dermatome** (a one-to-one correspondence between dermatomes and spinal segments).
- In certain regions of the body, the ventral rami do not proceed directly to their targets they innervate. The innervation of the neck and limbs comes from a blending of the ventral rami and spinal nerves, known as a **nerve plexus**.
- **Peripheral neuropathies** are also known as peripheral nerve palsies. These conditions lead to the loss of motor and sensory function in the peripheral nervous system. Peripheral neuropathy can be classified based on the number of nerves that are affected: mononeuropathy for a single nerve or polyneuropathy when more than one nerve is involved.

13: Brain and Cranial Nerves

Chapter Summary:

This tutorial covers the regions and functional areas of the human brain. Higher order functions of the brain such as learning and memory are also presented.

Tutorial Features:

Specific Tutorial Features:

The human brain: regions and hemispheres
Brain pathways to the spinal cord
Cranial nerves
Higher order functions: learning, memory and language

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Development of the Brain
Brain Regions
Visual Cortex
Sensory Cortex
Cranial Nerve Function

Chapter Review:

Brain Regions

- The **diencephalon** has three major divisions: (1) epithalamus – contains the pineal gland, (2) thalamus – are on both the left and right side, and they function as sensory processing areas, and (3) floor of the diencephalon – the hypothalamus and the pituitary gland.

- The **mesencephalon** is also known as the midbrain, which processes visual and auditory information.
- Within the brain are fluid-filled cavities, known as **ventricles**. There are four ventricles: one within each cerebral hemisphere, a third ventricle in the diencephalon and the fourth ventricle that is between the pons and the cerebellum.
- The human brain is protected by a number of coverings and brain-specific features: (1) bones of the skull, (2) cranial meninges, (3) cerebrospinal fluid and (4) blood-brain barrier. The meninges are made up of three layers: dura mater, arachnoid mater, and the pia mater. These layers offer protection, as well as being the passageway for blood vessels to the area.
- The spaces between the endothelial cells that line the capillaries throughout the body allow for drugs to pass between the cells to enter most organs. In the brain, the capillaries are lined with tightly-packed endothelial cells and a layer of glial cells; this is known as the **blood-brain barrier.**
- The **Cerebrum** is divided into two nearly symmetrical hemispheres, which are separated by a medial longitudinal fissure.
- The frontal lobe is located at the front of each cerebral hemisphere. Within the frontal lobe are the following primary regions: (1) Premotor cortex and the (2) Motor cortex
- The **limbic system** involves a number of structures and functions to produce emotion, behavior, and memory.

Cranial Nerves

- There are twelve pairs of cranial nerves, cranial nerves I – XII.
- The **oculomotor nerve** innervates 4 of 6 eye muscles; the trochlear nerve specifically innervates the superior oblique muscle.
- The **facial nerve** is responsible for deep sensations over the face and for controlling muscles in the scalp and face. The vestibulocochlear nerve has two branches, the vestibular branch and the cochlear branch.
- The ninth cranial nerve is the glossopharyngeal nerve, which is involved in swallowing and taste. The tenth cranial nerve is the vagus nerve, which provides motor function to the muscles of the pharynx, as well as respiratory, cardiovascular and digestive organs.
- The accessory nerve is made up of two branches: (1) the internal branch, which functions with the vagus nerve and (2) the external branch, which controls the sternocleidomastoid muscle and trapezius muscle. The hypoglossal nerve innervates the skeletal muscles of the tongue.

Brain Pathways

- The brain and spinal cord are connected through sensory and motor tracts, as well as the associated nuclei. The pathways are organized bilaterally in the spinal cord and according to the innervation target.
- The sensory neurons of the body monitor changes in the external environment around the body, as well as changes in the skin, etc. The majority of this sensory information is processed outside of the cerebral cortex – within the spinal cord, thalamus and brain stem.
- The primary somatic sensory pathways in the body are: (1) **Dorsal column**, (2) **spinothalamic pathway**, and (3) **spinocerebellar pathway**.
- The motor (descending) pathways are organized into: (1) **corticospinal pathway** – corticobulbar tract, lateral corticospinal, and the anterior corticospinal tract, (2) **medial pathway** – vestibulospinal, tectospinal, and the reticulospinal tract, and (3) **lateral pathway** – rubrospinal tract.
- Somatotopic maps have been established by systematic electrical stimulation of area M1 (motor cortex) and area S1 (somatosensory cortex), creating the diagram known as the **Homunculus.**

- The **cerebral cortex** performs a number of higher-order functions; these require the action and communication of certain specialized regions in the brain. The specialized centers and regions that perform these are the: (1) general interpretive area, (2) visual cortex, (3) auditory cortex, (4) speech center, (5) primary motor cortex, (6) premotor cortex, and (7) primary sensory cortex.
- **Higher-order functions** in the brain can be localized to one of the cerebral hemispheres; an example is the lateralization of speech. It has been estimated that approximately 70% of individuals have speech lateralized to the left hemisphere. The left hemisphere contains both Broca's and Wernicke's area, both of which are involved in speech. Evidence for this has come from anatomical and functional imaging studies.

14: The Somatic Nervous System and the Special Senses

Chapter Summary:

This tutorial reviews the major senses, and presents the mechanisms from the sensory receptor to the brain for decision making and interpretation.

Each of our senses has a wide variety of stimuli to trigger a response, which affords us a tremendous variety to our sense of sight, smell and taste.

Tutorial Features:

Specific Tutorial Features:

The Structure of Sensory Receptors
The Organ of Sight
The Organ of Hearing
The Organ of Taste
The Organ of Smell

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Sensory Receptive Fields
Mechanoreceptors
The Visual System
Hearing
The Sense of Taste
The Sense of Smell

Chapter Review:

Sense Receptors

- **Sensory receptors** are the initial component of our sensory systems, such as touch and vision. They respond to a stimulus and perform sensory transduction. They are specialized transducers of energy and information from our environment.
- The **receptive field** of a sensory neuron is the physical region of space where a stimulus must occur to trigger that neuron to fire.
- The **receptor generator potential** is defined as: the response a sensory nerve cell has to stimulation at the receptor, whose change in membrane potential is proportional to the strength of the stimulus.
- **Central adaptation** refers to adaptation to a stimulus that takes place in the central nervous system. The conscious awareness of the stimulus, such as a smell, almost completely disappears. The process involves the inhibition of nuclei along the particular sensory pathway, which leads to a reduction in sensory input to the cerebral cortex of the brain.
- The general sensory receptors are spread over the body in the skin and other locations. These receptors can sense stimuli, such as pain and changes in temperature. Based on the type of stimuli that excites the receptor, there are four groups: (1) nociceptors, (2) thermoreceptors, (3) mechanoreceptors, and (4) chemoreceptors.

Vision

- The **human eye** is made up of the following key structures: (A) Cornea – this is the transparent part of the eye that covers the iris and pupil. It reflects light and helps to focus the eye, (B) Iris – is the colored portion of the eye; this muscular structure constricts and dilates the pupil, (C) Pupil – is the sphere in the center of the iris through which the light enters the eye.
- The human eye detects light and transmits nerve impulses along the optic nerve to the visual area of the brain in the occipital lobe. The eye detects light in the visible spectrum, wavelengths between 400-750nm.
- The **retina** of the human eye converts light into chemical energy. It is made up of a number of layers that give rise to the optic nerve. In the center of the macula is the fovea, which is the most sensitive region of the eye to light.
- The visual information from the temporal visual field is projected from the retinal ganglion neurons through the optic nerve to the brain.

Hearing

- The **human ear** captures sound and it helps to balance the head and neck. The ear is divided into three regions: outer ear, middle ear and the inner ear. The outer ear includes the pinna, external auditory meatus, and the auditory canal. The auditory canal contains glands that secrete cerumen (ear wax), a protective substance. The auditory canal transmits sound waves to the inner ear.
- The middle ear is separated from the outer ear and the outside world by the tympanic membrane (eardrum). The middle ear contains air and the tympanic membrane is connected to the round window of the inner ear through the **malleus, incus and stapes.**

Taste and Smell

- The human taste, **or gustatory system**, is a system based on chemoreception. This system detects the flavors of food and drinks. There are four basic tastes we can detect, and taste is connected to our sense of smell. The four basic tastes are: sour, salty, bitter and sweet.
- **Gustatory (taste) receptors** are clustered together in taste buds, which are present on a raised surface on the tongue, called papilla.

- The **olfactory system** is part of the chemosensory system (along with taste) that detects chemical compounds. The human sense of olfaction (smell) is based on olfactory receptors detecting odorants, which are dissolved in the overlying mucous membrane.
- Once the specific odor-binding protein in the nasal cavity binds to a specific receptor on the cilia, this leads to activation of olfactory nerve filaments**.**

15: The Autonomic Nervous System

Chapter Summary:

The hormones of the endocrine system, the glands that produce them and their targets re presented.

Hormones exert their function by binding to or entering the target cell and inducing intracellular signaling. Signaling inside cells involves second messengers and intracellular signaling cascades.

Tutorial Features:

Specific Tutorial Features:

An Overview of the Autonomic Nervous System
The Parasympathetic Division
The Sympathetic Division
Higher Order Functions

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Primary and Secondary Lymphoid Organs
The Pituitary Gland
Classes of Hormones
    Amino Acid Derivatives
    Peptide Hormones
    Steroid Hormones
    Eicosanoids

Chapter Review:

Autonomic Nervous System

- The physiological actions of the human body, such as heart rate, blood pressure and digestion, occur with little or no conscious thought. These involuntary actions that maintain homeostasis within the body are performed by the autonomic nervous system.
- Sympathetic and Parasympathetic Branches differ in their location of origin in the body. The sympathetic division is primarily located in the thoracolumbar region of the spinal cord. The parasympathetic division is primarily located in the craniosacral region of the spinal cord.

- The **parasympathetic division** of the autonomic nervous system is active during periods of rest and digestion. The parasympathetic division innervation involves the cranial nerves, such as the facial nerve.
- The **parasympathetic nervous system** is known as the "Wine and Dine" or "Rest and Digest" system. It functions by decreasing the heart rate, increasing glandular activity, and increasing intestinal activity for digestion and absorption. Overall, the functions of the parasympathetic division lead to relaxation, food digestion and absorption that leads to increased blood nutrients.
- The **sympathetic division** of the autonomic nervous system is active during times of physical or mental stress on the body. As the system`s activity increases, skeletal muscles and heart rate are prepared for a fight-or-flight response.
- The sympathetic division uses the neurotransmitter, norepinephrine, and it is released through cholinergic synapses. The stimulation of ganglionic neurons leads to the release of norepinephrine at the neuroeffector junctions. Acetylcholine release at preganglionic fibers stimulates the ganglionic neurons, which eventually leads to norepinephrine release.
- Sensory information enters the central nervous system for organs under the regulation of the autonomic nervous system. The sensory information is delivered into the central nervous system through primary sensory neurons. These neurons project onto second-order neurons in the brain stem region.

Autonomic Nervous System Integration

- The sympathetic and parasympathetic divisions oppose each other but in a complementary fashion. Most of the major organs of the body receive projections from the sympathetic and parasympathetic divisions, known as dual innervation. Each system is "on" or active when needed and, at the same time, will inhibit or shut down the opposing system.
- Within the abdominopelvic cavities, both the parasympathetic and sympathetic fibers mix in special **plexuses**: cardiac, pulmonary, esophagus, celiac, inferior mesenteric and the hypogastric plexus.
- The visceral **reflexes** of the body allow for fast, automatic responses, which can be modified by signals from the brain. A visceral reflex arc is made up of the sensory neuron that delivers the sensory information from the peripheral receptor to the central nervous system.
- Centers in the brain stem control the parasympathetic and sympathetic nerve fibers. Within the brain stem are processing centers for the autonomic nervous system. The processing centers in the brain stem are in communication with the control center in the hypothalamus.
- The **cerebral cortex** performs a number of higher-order functions; these require the action and communication of certain specialized regions in the brain. The specialized centers and regions that perform these are the: (1) general interpretive area, (2) visual cortex, (3) auditory cortex, (4) speech center, (5) primary motor cortex, (6) premotor cortex, and (7) primary sensory cortex.
- **Higher-order functions** in the brain can be localized to one of the cerebral hemispheres; an example is the lateralization of speech. It has been estimated that approximately 70% of individuals have speech lateralized to the left hemisphere. The left hemisphere contains both Broca's and Wernicke's area, both of which are involved in speech. Evidence for this has come from anatomical and functional imaging studies.

16: The Endocrine System

Chapter Summary:

The hormones of the endocrine system, the glands that produce them and their targets re presented.

Hormones exert their function by binding to or entering the target cell and inducing intracellular signaling. Signaling inside cells involves second messengers and intracellular signaling cascades.

Tutorial Features:

Specific Tutorial Features:
The Endocrine System and Hormone Signaling
The Endocrine Organs
Hormones and Aging
Series Features:
- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Primary and Secondary Lymphoid Organs
The Pituitary Gland
Classes of Hormones
    Amino Acid Derivatives
    Peptide Hormones
    Steroid Hormones
    Eicosanoids

Chapter Review:

Endocrine System
- The **endocrine system** allows the various organ systems within the body to communicate with each other and to coordinate their activities. This is accomplished by means of endocrine organs, or glands, that secrete hormones.
- Hormones are chemicals that are produced in one cell type and then travel some distance and affect their target cells. Hormones can be broken down into 4 major categories: **(A) amino acid derivatives, (B) Peptide hormones, and (C) steroid hormones, and (D) eicosanoids.**
- The **Hypothalamus-Pituitary system** is the master control center of endocrine physiology. Hormones and signals from the hypothalamus drive pituitary hormone secretion.
- The **pituitary gland** is housed in a bony window (sella turcica) at the base of the brain. The pituitary gland is divided anatomically into an anterior and posterior lobe. Each of these lobes produces and secretes different hormones. The hypothalamus and pituitary gland are connected through the infundibulum.
- The **thyroid gland** is the largest endocrine gland in the body, and it is located in the neck on the anterior surface of the larynx. The thyroid's activity is controlled by the pituitary secretion of Thyroid-Stimulating Hormone.

- On the posterior surface of the thyroid gland, there are 4 or more small glands known as the **parathyroid glands**. The parathyroid glands produce Parathyroid Hormone (PTH). PTH is involved in calcium homeostasis.
- The **suprarenal (adrenal) glands** are located on top of the kidneys; they receive their own blood supply and are divided into 2 regions. The gland is divided into the adrenal medulla and the adrenal cortex. Both of these regions receive nerve impulses from the sympathetic nervous system.
- The **pancreas** is a gland contained within the digestive system. It is physically attached and communicates with the small intestine. The endocrine function of the pancreas is to regulate blood sugar levels. Insulin and glucagon are produced in cell clusters, known as the Islets of Langerhans.

Hormone Signaling

- Hormone signaling involves the transduction of the extracellular hormone signal into an intracellular signal. A single hormone stimulus to a target cell can be amplified through the activation of signaling cascades.
- Cells contain **second messenger systems**. These involve signal protein phosphorylation and dephosphorylation, ion transfer into and out of cells, and a change in the function/activation state of the target cell. Cyclic adenosine monophosphate (cAMP) is involved in signal transduction for blood sugar regulation and lipid metabolism.
- **Calcium** can function as a second messenger in intracellular signaling cascades, triggered by hormones. Normally, intracellular calcium levels are low, with calcium being sequestered in the smooth ER and mitochondria.
- In **autocrine signaling**, the hormone is secreted, binds to receptors on and affects the same cell.
- In **paracrine signaling**, the hormone is released from a cell, and the target for that hormone is near. An example of paracrine signaling is the release of histamine from mast cells. The mast cell near a blood vessel releases histamine, and this leads to vasodilation of the blood vessel in that region.
- Hormones can travel free in the plasma. Examples include peptide hormones and those from the amine class. Hormones can also travel bound to carrier proteins, such as serum albumin. Some hormones have specific carrier proteins, such as thyroxin being bound to thyroxin-binding globulin.

17: Blood

Chapter Summary:

This tutorial reviews the components and functions of blood. The cellular and non-cellular components of whole blood are also covered.

The primary function of the cardiovascular system is to transport materials throughout the body. Some of the materials transported include: gases (oxygen and carbon dioxide), nutrients, and water from the external environment through the respiratory and digestive systems, as well as waste material released by cells.

Tutorial Features:

Specific Tutorial Features:
The Components of Whole Blood
The Functions of Blood
The Formation of Blood
Series Features:
- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Transport Functions of Blood
Functions of the Blood
The Cellular Components of Blood
The Role of the Bone Marrow in the Formation of Blood

Chapter Review:

The Components of Whole Blood

- **Whole blood** is composed of two main elements, plasma and the formed elements - leukocytes and platelets, and erythrocytes. Whole blood is made of plasma, which represents 55% of blood, and formed elements make up the remaining 45%.
- **Plasma** is the fluid part of the blood. It is composed of 92% water. There are 1% of dissolved molecules like amino acids, glucose, lipids, nitrogenous wastes, ions like sodium, potassium and dissolved gases, like oxygen and carbon dioxide. The remaining 7% is made of proteins. The proteins make the blood different from the interstitial fluid. There are three types of proteins and they are albumin, globulin and fibrinogen.
- There are three major classes of proteins dissolved in the plasma: albumin, globulins, and fibrinogen. The major plasma protein is albumin.
- The two major groups of formed elements or cells in the blood are **erythrocytes** (red blood cells) and **leukocytes** (white blood cells).
- **Erythrocytes**, or red blood cells, transport O_2 and CO_2. They are biconcave, anucleate cells that contain hemoglobin for the transport of oxygen. Their biconcave shape is maintained by protein, called spectrin.
- **Hemoglobin** is a metalloprotein, made up of 4 globin polypeptide chains with 4 imbedded oxygen-binding heme molecules. The oxygen saturation of hemoglobin is pressure dependent.
- The presence of specific proteins in the plasma membrane of red blood cells, called antigens, determines an individual **blood type**. The surface antigens that are particularly important are A, B, and D (Rh). The main blood groups in humans are A, B, AB and O.
- **Platelets** are small cytoplasmic fragments of large cells, called megakaryocytes. Platelets play a fundamental role in the control of bleeding.

Hemopoiesis

- **Hemopoiesis** is the synthesis of new blood cells; it occurs in the bone marrow of all bones until the age of 5. Then, in adults, it occurs primarily in the pelvis, vertebrae and sternum. The process begins with a pluripotent hemopoietic stem cell that leads to the formation of erythrocytes, leukocytes and platelets.
- **Bone marrow** is a special form of connective tissue that is located in certain bones of the body. In a long bone, for example, it only accounts for approximately 4% of the total

mass of the bone. Red marrow contains the hemopoietic stem cells where the red blood cells, white blood cells and platelets are formed. As we age, red marrow can be converted into yellow marrow, which consists mainly of fat cells.

- **Leukopoiesis** is the formation of white blood cells. The granulocyte line of white blood cells is fully matured in the bone marrow, whereas the monocyte-macrophage line of white blood cells completes their maturation in the tissues.
- **Thrombocyte formation**, or platelet formation, stems from the precursor cells, megakaryocytes. Platelets are very important in normal blood clotting from an injured blood vessel.

18: The Cardiovascular System: Heart

Chapter Summary:

The function of the heart is to beat and generate the pressure that drives blood through the cardiovascular system. The anatomy and function of the heart is presented in this tutorial

Tutorial Features:

Specific Tutorial Features:

Anatomy of the Heart
The Structure of the Heart and Surrounding Tissue
The Structure of Cardiac Muscle
The Electrical Conducting System of the Heart

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Heart Muscle Structure
Electrical Conduction and Heart Muscle Contraction
The valves of the Heart
Blood Flow Circuits

Chapter Review:

Anatomy of the Heart

- The **heart** is within the thoracic cavity between the two lungs. The left and right atrium is separated by the interatrial septum. The left and right ventricles are separated by the interventricular septum.
- The **pericardium** itself is made up of serous and fibrous layers, and the wall of the pericardium is divided into the visceral pericardium and the parietal pericardium.

- The heart wall is made up of three layers: **the epicardium, myocardium and endocardium.**
- Deoxygenated blood returns to the heart and passes through the superior and inferior vena cava into the right atrium. Deoxygenated blood is pumped from the right atrium through the tricuspid valve into the right ventricle. The left atrium receives oxygenated blood from the lungs through the pulmonary veins. There are two on the left side and two on the right. The left ventricle is the most powerful pumping chamber of the heart; its muscular wall is the thickest. The left ventricle is responsible for pumping the blood throughout the systemic circuit, as opposed to the right ventricle which pumps the blood to the lungs.
- The heart valves separate the atria from the ventricles and the arteries and veins connected to the heart, such as the pulmonary arteries and the pulmonary veins.
- The **coronary circulation** provides the blood supply to the muscle tissue of the heart itself. The coronary circulation is made up of the two main arteries: right coronary and the left coronary.
- One special feature of myocardium is that it **has intercalated discs** that play an important role in functionality of heart muscle. Intercalated discs are interlocking membranes linked by cell junctions, called desmosomes that connect adjacent cells.

The Electrical Conducting System of the Heart

- The electrical conduction through the heart begins in the **sinoatrial node**, spreads to the atrioventricular node and eventually through the Purkinje fibers into the myocardium of the heart.
- The nervous system directly can increase or decrease the heart rate, depending on the neurotransmitters released. Catecholamines increase the flow of Na+ and Ca2+ by activating the B1 receptors. The more the influx of ions, the faster depolarization and the faster the action potential, and eventually this increases the heart rate.
- The ECG is a recording of the electrical activity of the heart. It sums up all of the electrical potential of all cells at any time. The electrical waves of the ECG correspond to the depolarization and repolarization of the atria or ventricles.
- As we age, there are a number of changes that occur in the cardiovascular system – including the heart. The heart enlarges slightly as we age, and the capacity to meet the increased cardiac demands of exercise is reduced. Also, the elastic recoil of the arteries decreases and the blood vessels become more rigid. This increases the demand on the heart to maintain blood pressure at rest and can lead to an increase in blood pressure.

19: The Cardiovascular System: Vessels and Circulation

Chapter Summary:

This tutorial reviews blood vessels of the body that supply blood to the tissues, and removes carbon dioxide from the tissues.

The arterial and venous blood vessels are separated by capillary beds, which are the site of exchange between the blood and the tissues.

Tutorial Features:

Specific Tutorial Features:
Anatomy of a Blood Vessel

The Arteries and Veins of the Head and Neck
The Arteries and Veins of the Trunk
The Arteries and Veins of the Upper and Lower Extremities
The Capillary Circulation

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

The Histology of the Blood Vessel Wall
Exchange at the Capillary
Hydrostatic and Osmotic Pressure
Veins of the Body
Arteries of the Body

Chapter Review:

Anatomy of a Blood Vessel

- There are three types of blood vessels: **(1) Arteries**, which carry oxygenated blood away from the heart (pulmonary arteries are the exception); (2) **Veins** carry deoxygenated blood to the heart (again, pulmonary veins are the exception); and (3) **Capillaries** are found in the tissues.
- Blood vessels are made of layers of smooth muscles, elastic connective tissue, and fibrous connective tissues. The inner lining is known as the intima or tunica intima.
- The **media layer** of a blood vessel is the middle layer and it contains concentric rings of smooth muscle.
- The **adventitia** is the outer most layer of a blood vessel and is made up of layers of connective tissue. The chief component of this layer is the collagen fibers, and these fibers are interconnected with the surrounding tissue and secure the blood vessel in place.
- **Arteries** carry blood away from heart. They have thick layers of smooth muscle, as well as elastic and fibrous tissue.
- The **capillaries** are the smallest blood vessels, and they receive blood from arterioles. The capillary bed is the site of exchange between the blood and interstitial fluid. They lack smooth muscle and connective tissue and have a flat layer of endothelium supported by a basement membrane.
- **Veins** function by carrying blood returning to the heart from the body, and they exist in the body in three sizes. The smallest veins are called venules and they receive blood from capillaries.

Arteries and Veins of the Body

- The major arteries of the neck region on the right side of the body are the brachiocephalic trunk, right common carotid artery and the right subclavian artery. On the left side, the left common carotid artery and the left subclavian.
- The **anterior cerebral artery** (ACA) supplies blood to the medial portion of the frontal lobes and the superior medial parietal lobes. The **middle cerebral artery** (MCA) supplies blood to the majority of the cerebrum, and the **posterior cerebral artery** (PCA) supplies blood to the occipital lobe of the brain.

- The formation of urine involves: (a) the filtration of plasma by the glomerulus, (b) reabsorption of water and solutes and (c) the secretion of certain solutes into the tubular fluid which ultimately becomes urine.
- The venous drainage of the brain includes the superficial cerebral veins, the superior and inferior sagittal sinuses, the sigmoid sinus and the internal jugular vein.
- The superficial veins of the head and neck region include: **(1) temporal, (2) facial, and (3) maxillary.**
- The diaphragm separates the descending **aorta** into the thoracic aorta, above the diaphragm itself, and the abdominal aorta below the diaphragm.
- The abdominal aorta divides into the **left and right common iliac** arteries at the level of the 4th lumbar vertebra. These arteries deliver blood to the pelvis and the lower limbs.
- The venous blood from the organs and structures below the level of the diaphragm is delivered into the right atrium of the heart through the inferior vena cava.
- The **hepatic portal system** transports blood from the capillary beds supplied by the celiac, superior mesenteric and inferior mesenteric arteries.
- The major veins of the lower limb include the **anterior and posterior tibial veins**, the **popliteal vein**, and the **femoral vein**, which becomes the external iliac vein in the pelvic cavity.

20: Immunity and the Lymphatic System

Chapter Summary:

The lymphatic system transports lymph fluid and cells throughout the body and provides protection along with the immune system against microorganisms.

Tutorial Features:

Specific Tutorial Features:

The structure of the Lymph Vessels
Lymphocytes
Lymphatic Vessels and Organs of the Head, Neck and Thorax
Lymphatic Vessels and Organs of the Abdominopelvic Region

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Anatomy of the Lymph Capillaries
Anatomy of the Lymph Node
Function of the Lymph Node
Formation of White Blood Cells
Antigen Processing
Immune Cell Activation

Chapter Review:

Lymphatic System

- The **lymphatic system**, along with the immune system, delivers lymphocytes to the different regions of the body to protect against invading microorganisms.
- The **lymph capillaries** are closely associated with the tissue (blood) capillaries, at the junction of the arterioles and venules. The lymph capillaries are larger and are structured to allow the collection of lymph fluid.
- There are three primary functions of the lymphatic system: (1) production and distribution of lymphocytes, (2) maintenance of blood volume, and (3) provision of an alternate route for the transport of hormones and nutrients.
- **Lymph fluid** is made up of: (1) fluid from the intestines containing proteins and fats, (2) a few red blood cells, and (3) many lymphocytes. Lymph fluid can also contain bacteria, which can lead to the activation of the immune system, through presentation to lymphocytes by antigen-presenting cells.
- **Lymphocytes** are responsible for responding to the presence of foreign protein, antigens, bacteria, viruses and altered self-cells. Lymphocytes include B-Cells, T-Cells, and Natural Killer (NK) cells.
- **B-cells** develop in the bone marrow and become antibody-producing plasma cells. These cells of the immune system are involved in humoral immunity and can lead to long-term immunity.
- **T-cells** develop in the thymus; they differentiate into T-helper cells or T-cytotoxic cells. These cells of the immune system are central to cell-mediated immunity.

Lymphoid Organs

- **Lymph nodes** are small, oval lymphoid organs that range in size from a diameter of 1 – 25 mm. Lymph nodes are distributed throughout the body and exist in high density in certain regions, such as the neck and axilla.
- **Tonsils** are specialized lymphoepithelial tissues located in the oropharynx and nasopharynx. Within the tonsils are lymphocytes that gather and remove microorganisms that enter through the respiratory tract or the gastrointestinal tract.
- The **thymus gland** is made up of 2 lateral lobes, which are enclosed in a capsule. Inside the thymus, lymphocyte precursors mature into T-Cells. To be released into the circulation, the T-Cells must undergo both positive and negative selection.
- The **spleen** is made up of masses of lymphoid tissue, which are located around terminal branches of the circulation. The spleen contains 2 functional areas: (1) Red Pulp: made up of blood-filled sinuses and is responsible for removing worn-out or damaged red blood cells from the circulation and (2) White Pulp: made up of follicles rich in B-Cells and periarteriolar lymphoid sheaths (PALS), which are rich in T-Cells. Lymphocytes in the white pulp help fight infection.
- Along the length of the digestive tract, as well as other regions in the body, are lymphoid nodules, known as **mucosal-associated lymphoid tissue (MALT).**
- The immune system is involved in the recognition and infiltration of tumors in the body. These responses of the immune system towards tumors may slow their development and or eliminate the tumor.

21: The Respiratory System

Chapter Summary:

The organs of the digestive system and their function are presented. The fundamentals of nutrition and nutrient utilization are also included.

The digestive tract is responsible for processing, digesting and absorbing the nutrients we eat and drink.

Tutorial Features:

Specific Tutorial Features:
The Upper Respiratory System
The Lower Respiratory System
Respiration and the Mechanics of Breathing
Series Features:
- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Anatomy of the Lungs
  Upper Respiratory Tract
  Lower Respiratory Tract
  Thorax
Functions of the Respiratory System
Respiratory mechanics
Gas Exchange and Oxygen Transport

Chapter Review:

The Respiratory System
- The respiratory system's function is gas exchange, including oxygen uptake and carbon dioxide release in the lungs. The respiratory cycle of breathing brings gas into the lungs during inspiration; oxygen and carbon dioxide are exchanged and then the carbon dioxide is blown off during expiration.
- The **upper respiratory tract** is primarily a conducting passageway for air to reach the lungs.
- The **lower respiratory tract** is made up of the following structures: (1) larynx (voice box), which is the site of voice production, (2) trachea or windpipe, (3) bronchi, which deliver air to the lungs, and (4) lungs - the lungs contain alveoli, which are tiny sac-like structures in which gas exchange occurs.
- The **pharynx** is a tube that connects the nose, mouth and throat, and it is divided into three regions: nasopharynx, oropharynx, and the laryngopharynx.
- The **larynx**, which is also known as the voice box, is the site of voice production. The larynx extends from the C_4 or C_5 vertebral level to the level of C_7 and is held in position in the anterior neck with a variety of muscles and ligaments.
- The **vocal folds** of the larynx are flexible due to the elastic nature of the vocal ligament. Voice production occurs primarily in the larynx, or voice box. Within the voice box is a set of cartilages located at the front of the throat, which contains the vocal folds.
- The **trachea**, or windpipe, is a flexible tube that extends from the level of the C_6 to the mediastinum at the level of T_5. This is a flexible tube approximately 11cm long, and 2.5 cm in diameter.

The Lungs

- On the medial (mediastinal) surface of the lung is the hilum and grooves that mark the position of the great vessels and the heart. There is also a groove for the association to the esophagus. The left lung has a cardiac impression for the heart, and the left lung has a concavity in its medial margin in the anterior view.
- The **primary bronchi** inside the lungs are known as the intrapulmonary bronchi. Together, the primary bronchi and their branches are known as the bronchial tree.
- Gas exchange in the lungs occurs in the alveoli. The alveoli are surrounded by capillaries, and the distance between the capillaries and alveoli is very small. The diffusion of gases, based on partial pressures, occurs between the alveoli and the capillaries.
- **Surfactant** adsorbed into the liquid layer on the alveoli decreases surface tension. This increases lung compliance and makes the lungs easier to inflate, as well as preventing the lungs from collapsing at the end of expiration.
- **Basal Metabolic Rate (BMR)** is defined as the lowest level of caloric intake necessary to sustain life. The BMR accounts for approximately 70% of energy output daily.
- Another aspect of metabolism that affects our basal metabolic rate is the work done and heat generated during the digestion of food, a process known as the **thermal effect of food.**
- Metabolism is the sum of two basic processes, catabolism and anabolism.

Respiration and the Respiratory Muscles

- The **diaphragm** is a large muscle that separates the abdominopelvic and thoracic cavities. The diaphragm is part of the rectus group of muscles and its origin is the xiphoid process, ribs 7-12 and their associated cartilages, and anterior surfaces of the lumbar vertebrae.
- The volume of the chest cavity (and subsequent pressure) is changed by contraction of the diaphragm.
- During **inspiration (inhalation)**, the volume of the chest cavity is increased; this is caused by the diaphragm contracting. During inspiration, the pressure within the alveoli is reduced below atmospheric pressure, and this change in pressure causes air to flow into the lungs.
- During **expiration (exhalation)**, the diaphragm relaxes (and becomes dome-shaped). During deeper breathing, the internal intercostal muscles contract. These changes lead to a decrease in the lung volume and an increase in the pressure within the alveoli, relative to atmospheric pressure. This causes air to flow from the alveoli into the atmosphere.
- The **respiratory center** is located in the medulla oblongata. Neurons in the medullary respiratory center establish basic, rhythmic inspiration and expiration. They function by signaling the diaphragm to contract and relax; this provides the control of the breathing cycle. Carbon dioxide is the primary chemical monitored by the respiratory system.

22: The Digestive System, Metabolism and Nutrition

Chapter Summary:

The organs of the digestive system and their function are presented. The fundamentals of nutrition and nutrient utilization are also included.

The digestive tract is responsible for processing, digesting and absorbing the nutrients we eat and drink.

Tutorial Features:

Specific Tutorial Features:

The Digestive system
Ingestion and swallowing
The structure of digestive organs
Accessory glandular digestive organs
Metabolism

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Anatomy of the Digestive Organs
Anatomy and function of the Accessory Organs
Nutrient Absorption
Nutrition and Health
  Vitamins
  Minerals

Chapter Review:

Digestive System

- The **digestive system**, or alimentary canal, is responsible for the breakdown of materials, absorption of nutrients and water. As well as, the temporary storage and elimination of wastes from the body.
- The wall of the digestive tract can be divided into 4 main concentric layers: **mucosa, submucosa, muscularis externa, serosa.**
- Food is moved through the digestive tract by **peristalsis**. This process involves a contraction behind the food bolus from the circular muscles
- The oral cavity is responsible for mechanically processing the food bolus, early carbohydrate digestion, lubrication, and delivering it to the stomach for digestion.
- **Swallowing** is a complex event that is coordinated by the swallowing center in the lower portion of the brainstem. During this process, food passes from the mouth to the pharynx and into the esophagus, this occurs in three phases – (a) oral phase (b) pharyngeal phase and (c) esophageal phase.
- The **stomach** is a J-shaped organ, directly under the diaphragm. The superior portion is a continuation of the esophagus. The inferior portion (pylorus) empties the stomach contents into the first segment of the small intestine. With breathing, the stomach moves downward during inspiration and upward during expiration.
- The main component of gastric juices released during digestion is gastric acid. Gastric acid is hydrochloric acid produced by the parietal cells, and it makes the lumen of the stomach very acidic with a pH of 2-3. This increased acidity contributes both to the conversion of pepsinogen to pepsin and to the breakdown of foods.
- The **small intestine** is approximately 6 m or 20 ft in length. It is called the small intestine because its width is less than the large intestine by approximately 4cm.

- The **large intestine** runs from the ileum of the small intestine to the anus. Also called the large bowel, it is approximately 1.5 m (5 ft) long and 7.5 cm wide

Accessory Glandular Organs

- The **liver** is the largest visceral organ in the body. It has many functions and can adapt readily to the changing needs of the body. The functions of the liver include: (1) Metabolic Regulation, and (2) Hematological Regulation.
- The **gallbladder** is a pear-shaped organ underneath the liver that stores and concentrates bile until it's needed for digestion.
- The **pancreas** is an elongated organ, adjacent to the stomach and in close association with the first segment of the small intestine, the duodenum. The pancreas has both an endocrine and exocrine function. The endocrine function includes the formation and release of insulin and glucagon. The exocrine function includes the production and release of enzymes for digestion.
- The digestive system is innervated and controlled by the **enteric nervous system.** While the central nervous system inputs control on the enteric nervous system, the enteric nervous system can operate independently.
- The two layers of the enteric nervous system are interconnected and operate together. The primary role of the myenteric plexus is to transmit sensory signals and deliver motor impulses for muscular contraction. The submucosal plexus is responsible for regulating the glandular activities in the digestive organs (hormone secretion).

Metabolism

- **Metabolism** is the catalytic breakdown of the products of digestion to provide nutrients for the cells of the body. The metabolic pathways and cycles create end-products, which are used as substrates in the next phase of metabolism.
- **Glycolysis** is a series of 10 steps with reactions that convert glucose into pyruvate. During the process of these reactions, ATP is produced and the coenzyme NADH is produced.
- Under normal circumstances, when sufficient oxygen is available, aerobic respiration takes place. Glycolysis, which takes place in the cytoplasm of cells, produces pyruvate from glucose. Next, pyruvate is converted to Acetyl-CoA for use as a substrate in the Krebs cycle. This conversion is performed by the pyruvate dehydrogenase enzyme complex (PDHC). PDHC performs this conversion inside the mitochondria where the Krebs cycle takes place.

23: The Urinary System, Fluid, Electrolyte and Acid- Base Balance

Chapter Summary:

The function of the kidney and the many nephrons within it are presented, the role of the kidneys in blood volume and urine volume output is reviewed.

The kidneys filter the blood in the circulation constantly. This produces filtrate, of which the majority is reabsorbed.

Tutorial Features:

Specific Tutorial Features:

The Kidneys
The Nephron
The Ureters and Urinary Bladder

Fluid Electrolyte Balance
Acid-base Balance

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.
Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

The Kidney and the Nephron
The function of the Nephron
Filtration, Reabsorption, Secretion and Excretion
The regulation of Urine Volume
Urine Elimination

Chapter Review:

The Kidney and the Nehpron

- The renal system is comprised of the kidneys, ureters, bladder, and urethra. The kidneys are located retroperotineal – or behind the abdominal cavity, near the lower ribs in the back.
- The kidneys are covered by a protective fibrous tissue layer, overlying a fat layer. Situated on top of each kidney are the adrenal glands.
- The internal anatomy of the kidney is quite complex. The **cortex** is the outer area of the kidney, whereas the medulla is the inner compartment. The **medulla** contains the renal pyramids which contain nephrons. The nephrons drain into the minor calyx, then the major calyx, the renal pelvis, and finally the ureter.
- Ureters are hollow, muscular tubes that lead from each kidney to the bladder. Fluid drains from the kidneys to the bladder. The bladder serves as collection and storage area of urine. The urethra is a hollow tube leading from the bladder to the body surface. This is external opening for the elimination of urine.

The Function of the Nephron

- The **nephrons** are tubular structures, which are the functional unit of the kidneys. There are over 1 million in each kidney. All the nephrons drain towards the center of the kidney into the collecting duct system. The nephron perfoms almost all of the kidneys functions, including reabsorption and secretion of certain solutes and ions. Nephrons are classified into two groups :(1) The Juxtamedullary apparatus extends into the medulla, and (2) Cortical, which do not extend into medulla.
- The **renal corpuscle** is made up of Bowman's capsule and the glomerulus. The renal corpuscle connects the nephron to the glomerulus, which is a specialized capillary.

Filtration, Reabsorption, Secretion and Excretion

- **Filtration** in the kidney refers to the movement of substances from the glomerular capillary into the nephron. This is due to the pressure exerted by the blood entering Bowman's Capsule, which forces water and dissolved components through the glomerulus to form filtrate.
- **Reabsorption** is the process whereby the filtrate produced in the glomerulus is reabsorbed through the renal tubule. Approximately 99% of all the filtrate is reabsorbed

and this includes: water, sodium, glucose, magnesium, etc. The reabsorption process is specific to the changing needs of the body.
- **Tubular secretion** performs the opposite function of reabsorption. Specifically, it adds materials to the filtrate from the bloodstream. These materials are usually unwanted substances, such as H+ and toxins, as well as urea.
- **Excretion** is the elimination of urine from the body. Urine formation actually begins with filtrate formation in the glomerulus; a total of 180 L/day is filtered. Next, approximately 99% of the filtrate is reabsorbed.

The regulation of Urine Volume

- When there are no hormones released for reabsorption, a large volume of dilute urine is produced. This occurs by the nephron containing dilute fluid, after the ascending limb, which then proceeds out of the kidney for excretion.
- During times of low water intake, the kidneys can conserve water by increasing the volume of reabsorbed fluid. This is accomplished by the **Countercurrent Mechanism**. The countercurrent mechanism establishes an osmolarity gradient in which the osmolarity increases from the cortex towards the medulla.
- **Antidiuretic hormone**, or vasopressin, is a hormone released from the posterior pituitary gland to act on the kidneys. When water must be conserved, ADH is released and causes water channels to be inserted.
- **Aldosterone** is released from the adrenal glands (which are attached to the kidneys), specifically from the adrenal cortex. Aldosterone causes the kidneys to increase sodium and water reabsorption, which leads to an increase in blood volume and blood pressure.
- The **Atrial natriuretic hormone** serves as a signal from the heart to the kidneys. It is released from the atria when blood pressure is high, and it reduces water reabsorption in the kidneys.

24: The Reproductive System and Development

Chapter Summary:

This tutorial reviews the development of the different body organ systems. The different stages from fertilization, gastrulation and prenatal development are also presented.

Tutorial Features:

Specific Tutorial Features:

Fertilization
Embryology
Gastrulation
Human Development
Continuity of Life

Series Features:

- Concept map showing inter-connections of concepts.
- Definition slides introduce terms as they are needed.
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Challenge questions based on the material in the tutorial.

Clinical terms are presented relevant to the material covered in the tutorial.

Key Concepts:

Gamete Formation
Prenatal Development
Gastrulation

Chapter Review:

Embryology and Prenatal Development

- **Gestation** is the period of prenatal development; this time period is divided into three 3-month blocks, known as trimesters.
- The steps that take place during embryonic development: **cleavage, gastrulation and organ formation**. During cleavage, cells divide rapidly and form a ball-like structure, called a blastula; each individual cell is known as a blastomere. The divisions occur rapidly, the first one being within 30 hours of fertilization.
- The **blastocyst** is made up of the blastocele and the inner cell mass; these are surrounded by the trophoblast. The interior (blastocele) of the blastocyst is a fluid-filled cavity; that later is involved in the processes of gastrulation.
- **Implantation** of the trophoblast must occur during a specific window. The blastocyst is made up of approximately 70-100 cells. This is surrounded by the trophoblast, which later becomes the placenta.
- **Gastrulation** is a developmental stage for embryos, it generates three layers of cells, which can further differentiate into organs.
- During embryogenesis, four different extraembryonic membranes develop: **(1) yolk sac, (2) the amnion, (3) the allantois, and (4) the Chorion.**
- Active labor is usually characterized by regular contractions, which begin to dilate the cervix. However, some women progress to the delivery phase quickly without going through regular, rhythmic contractions. The onset of labor is due to a variety of factors, including: (1) Oxytocin release from the posterior pituitary, (2) Decrease in progesterone.

Embryology Summary

- The gestational age is the time that has passed since the onset of the last menstrual period. Embryonic age is the actual age of the embryo beginning at fertilization; therefore, the first week of embryonic age is the third week of gestational age.
- In the second month of development, the superficial ectoderm is made up of a simple epithelium and an organized mesenchyme. In the third month, basal or germinative cell division leads to the formation of a stratified epithelium (early skin).
- The skull develops from a series of cartilages that surround the brain and are formed by the 5^{th} week of development. By the 8^{th} week of development, the combination of the cartilage and skull, known as the **chondrocranium**, houses the brain and the sense organs.
- The development of the **appendicular skeleton** begins early in the 4^{th} week. The mesoderm gradually accumulates at the end of each ridge in the region of the limb buds.
- The **muscular system** begins to develop by 4 weeks of embryonic development. By 4 weeks, the somites have developed from the mesoderm on either side of the notochord.
- The **nervous system** begins to develop in the first 4 weeks of embryonic development. By the end of the second week, the neural groove and folds are in place, as preparation for the closing of the neural tube.
- Prior to the closure of the neural tube, the initial cephalic expansions occur, during brain development. By 4 weeks of development (28 days), the distinct brain vesicles, through subdividing, lead to the formation of the: Telencephalon, Diencephalon, Mesencephalon,

Metencephalon, and the Myelencephalon. By 8 weeks of development, the meninges are developing and the blood vessels begin to form the choroid plexus.

- The development of the **endocrine system** is linked to the formation of the pharyngeal arches, after 4-5 weeks of development. The thyroid gland develops from the floor of the primitive pharynx as the thyroid diverticulum forms and extends down into the neck, leaving the thyroglossal duct as a remnant connecting the tongue and thyroid gland.
- In the first two weeks of development, the **heart** is formed as thin-walled tubes of muscle. After three weeks of development, the heart is now pumping blood and contains a single, central chamber. At this time, a single large artery, the truncus arteriosus, delivers the blood to the general circulation.
- The **lymphatic system** is derived from the mesoderm during embryogenesis. Lymph vessel formation is connected to and develops with blood vessels. By the 7^{th} week of development, there are lymph sacs that become connected to the venous system. The thymus gland and spleen are formed by the 8^{th} week of development.
- The **lungs** develop from the endoderm germinal layer. By the 3^{rd} week of development, a shallow pulmonary groove appears in the midventral floor of the pharynx. By the 4^{th} week of development, the groove gives rise to a tube, which will form the trachea, and at the end of the tube are the lung buds.
- In the 3^{rd} week of development, two pockets of endoderm form, known as the foregut and the hindgut. The foregut develops into the GI tract, extending from the pharynx to the duodenum. The hindgut develops into the GI tract, extending from the distal transverse colon to the rectum. The midgut develops into the GI tract, extending from the duodenum to the transverse colon.
- The **kidneys** develop along the urogenital ridge and begin with the formation of the pronephros, by 3.5 weeks of development. By the 6^{th} week of development, the uteric bud is formed and the allantois gives rise to the urinary bladder by the 8^{th} week. The uteric bud eventually branches and forms the calyces and collecting systems.
- The development of both males and females involve the presence or absence of the Wolffian duct. **Female development** is the default development with disappearance of the mesonephric duct or Wolffian duct and development of the paramesenteric or Mullerian duct, which progresses to form the fallopian tubes, uterus and a portion of the vagina.
- **Male development** is dependent on the SRY gene of the Y chromosome, which is responsible for testis-determining factor. The developing testes secrete a paramesenteric or Mullerian duct inhibiting factor and androgens, which promote development of the Mesonephric or Wolffian duct. The mesonephric duct progresses to form the Seminal vesicles, Epididymis, Ejaculatory duct and Ductus deferens – SEED.