Human Anatomy & Basic Physiology Rapid Learning Series

Master Content

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Chemistry : Biology : Physics : Math

Course Table of Content – Topical Summary

Core Unit #1 – From Molecules to Tissues

In this core unit, you will learn about anatomy and physiology. With these tutorials, you will form a strong foundation to understanding the workings of the human body.

Tutorial 01: Introduction to Human Physiology
Basic Physiology terms & concepts
Levels of organization of the human body
Systems of the human body
Homeostasis & Feedback systems
Basic anatomic terms, planes, & sections
Body fluid & cavities

Tutorial 02: Chemical Basis of Life
Atoms, elements, and molecules
Chemical bonds
Organic chemicals and macromolecules
Acids, bases, and buffers
Biochemical reactions

Tutorial 03: Cells: the Basic Units of Life
The definition of a cell
The nucleus of the cell
Cytoplasmic organelle structures and functions
How the cell membrane provides a stable internal cell environment
Transport across the cell membrane
Cell levels of organization

Tutorial 04: Tissues of the Human Body
The four types of tissue in the: Epithelial, Connective, Muscle and Nervous
Development of the tissues from the three germ cell layers
The five kinds of cell junctions

Core Unit #2 – Support and Movement of the Human Body

Tutorial 05: The Integumentary System
The two layers of the integument (skin): Epidermis and Dermis
The derivatives of the integument: Hair, Nails and Glands
Functions of the skin
Wound Healing

Tutorial 06: The Skeletal System 1: Bone, Bone Tissue and Joints
Bone types and structures
Calcium storage
Bone matrix
JOINTS: TYPES AND STRUCTURE

Tutorial 07: The Skeletal System 1: Axial Skeleton
Organization and function
Bones of the skull
Bones of the inner ear
Bones of the chest

Bones of the spine

Tutorial 08: The Skeletal System 1: Appendicular Skeleton
Organization and function
Bones of the shoulder
Bones of the upper extremity
Bones of the pelvis
Bones of the lower extremity

Tutorial 09: Muscle and Muscle Tissue
General function: support and mobility
The structure of three basic types of muscles
Contraction and Relaxation
Muscle Metabolism
Control of Muscle Contraction and Tension

Tutorial 10: The Muscular System
General function:
Support and mobility
Role in Vascular Resistance and Thermoregulation
Muscles of the Head, Neck and Chest
Muscles of the Upper and Lower Extremities

Core Unit #3 – Control of the Human Body

Tutorial 11: Control of the Human Body: The Nervous System
Cells of the nervous system
Information processing
Organization of the nervous system
Overview of the Central and Peripheral Nervous Systems

Tutorial 12: Control of the Human Body: The Central Nervous System
Cells
Organs
Information processing
Organization and integration

Tutorial 13: Control of the Human Body: The Peripheral Nervous System
Peripheral nervous system overview
Glial cells of the PNS
Proprioception
The five senses
Motor nervous system

Tutorial 14: Control of the Human Body: The Sensory Nervous System
Sensory organs
Information processing
Organization and integration

Tutorial 15: The Endocrine System
Hypothalamus, anterior and posterior pituitary
Other endocrine glands
Feedback control

Mechanisms of hormone action: major classes of hormones and hormone specificity

Core Unit #4 – Maintenance and Homeostasis of the Human Body

Tutorial 16: Cardiovascular System
The Circulatory system
The Heart: anatomy and conduction
Oxygen delivery to the tissues
Blood & blood vessels

Tutorial 17: The Lymphatic and Immune Systems
The Lymphatic system
The Immune system: Innate Immunity and Acquired Immunity

Tutorial 18: The Respiratory System
General function: gas exchange and protection against disease
Respiratory mechanics: differential pressures, lung elasticity and surface tension effects

Tutorial 19: The Digestive System
Ingestion
Structure of digestive organs
Absorption of food molecules and water
Muscular control

Tutorial 20: Metabolism and Nutrition
Absorption of macronutrients
Physiology of energy production
Carbohydrate, lipid and protein metabolism
Regulation of metabolism

Tutorial 21: The Urinary System
Homeostasis: Osmoregulation and acid-base equilibrium
Waste excretion and blood pressure regulation
The Urinary System: Kidneys, ureters, bladder, urethra
Kidney Structure and Function: Nephron and Urine formation

Tutorial 22: Fluid, Electrolyte and Acid-Base Balance
Body fluid compartments
Osmolarity and body fluid regulation
Acid-Base balance in the body
Kidney's role in body fluid, electrolyte regulation and acid buffering

Core Unit #5 – Continuity of Life

Tutorial 23: The Reproductive System
Reproductive anatomy: Male and female genitalia
Gametogenesis: gonads and meiosis
Ova and spermatozoa
Reproduction: fertilization, implantation, development, birth

Tutorial 24: Development and Inheritance
Chromosomes and ploidy
Genes and inheritance
Fertilization
Early embryogenesis
Fetal development and delivery

Tutorial Series Features

This tutorial series is a carefully selected collection of core concept topics in human physiology that covers the essential concepts in the course. It features three parts:

Human 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 in this tutorial and those previously introduced.
- Definition slides introduce terms, as they are needed.
- Visual representation of concepts.
- 3D visualization of graphs, equations, and other formulas.
- Conceptual explanation of important properties and problem solving techniques
- Animated examples—worked out step by step.
- A concise summary is given at the conclusion of the tutorial.

Problem Solving Drills

Each tutorial has an accompany Problem Set with 5 problems covering the material presented in the tutorial. Work out each problem and then check it with the provided answer and complete solution provided at the end.

Condensed Cheat Sheet

Each tutorial has a one-page cheat sheet that summarizes the key concepts and equations 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.

Chapter by Chapter Detailed Content Descriptions

01: Introduction to Human Physiology

Chapter Summary:

An introduction to human physiology is provided in this chapter. Including, the organization of the body organ systems, systems used to maintain homeostasis and an introduction to medical terminology.

A review of the organization of the human body is introduced here, beginning at the chemical level and including the tissues and organs in the various body systems. A definition and the role of specific body systems are provided along with information about the feedback loops the body uses to regulate a normal internal environment. Ideas are included on creating personal mnemonics to memorize key information.

Tutorial Features:

Specific Tutorial Features:

- Overview of the various body systems and organs including anatomically labeled pictures.

Series Features:

- Concept map showing inter-connections of concepts introduced.
- 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.

Key Concepts:

Definition of Physiology: Branches of Physiology
Levels of organization of the human body
    Chemical level
    Cell
    Tissue
    Organ
    System
    Organism
Systems of the human body (11)
    1. The Integumentary System
    2. The Skeletal System
    3. Muscular System
    4. Nervous System
    5. Endocrine System
    6. Cardiovascular System
    7. Lymphatic & Immune System
    8. Respiratory System
    9. Digestive System
    10. Urinary System
    11. Reproductive System
Homeostasis and feedback mechanisms
    Positive and negative feedback loops
Basic anatomic terms
    Body Positions
    Directional Terms
    Anatomical Planes & Sections

Body fluid and cavities
- Body Fluids
- The Dorsal Cavity
- The Ventral Cavity

Tips for studying physiology

Chapter Review:

Physiology: Physiology is the science of body functions; it is the study of mechanical, physical and biochemical properties of living organisms. Physiology incorporates a significant amount of anatomy; anatomy is the science of body structures and their inter-relationships.

Levels of organization of the human body:

Chemical - made up of atoms and molecules

Cell - are basic structural and functional units of an organism. There are many different types of cells in the body including: nerve cells, blood cells, muscle cells and fat cells.

Tissue - groups of cells & the surrounding environment that work together to produce a specific function. There are only four types of tissues in the body: epithelial tissue, connective tissue, muscle tissue and nervous tissue.

Organ – organs are structures that are made of two or more different types of tissues, they have specific functions & a defined shape. The heart is an example of an organ; it is made of muscle, connective, & nervous tissue. The tissues work in concert to move blood through the body.

System - consists of related organs that have a common function, there are eleven organ systems in the body:

The Integumentary System: includes the skin & derived structures, it protects internal organs & helps maintain body temperature.

The Skeletal System: includes the bones & joints, it provides support & protection to internal organs.

The Muscular System: includes skeletal muscle and it provides movement.

The Nervous System: includes the brain, spinal cord, and nerves. It provides regulation of body functions & sensory perception.

The Endocrine System: includes hormone-producing cells & glands. It regulates homeostasis, growth & development.

The Cardiovascular System: includes blood, heart, & blood vessels. It is responsible for delivery of oxygen & nutrients to the tissues.

The Lymphatics & Immune System: includes lymphatic vessels & fluid. It is involved in the defense against infection.

The Respiratory System: includes lungs & airways. It is involved in the absorption of oxygen & release of carbon dioxide.

The Digestive System: includes organs of the gastrointestinal tract. It is responsible for the absorption of nutrients.

The Urinary System: includes the kidneys, ureters, and bladder. It is responsible for electrolyte balance & waste removal.

The Reproductive System: includes the reproductive organs in males and females. It controls the biological process by which new individuals are produced.

Homeostasis: The process through which a nearly stable internal environment is maintained in the body so that cellular functions can proceed at maximum efficiency.

Anatomical planes and sections: Anatomical planes are imaginary flat surfaces that pass through the body. The coronal plane coronal plane separates the body into front and back halves. The sagittal plane separates the body into left and right halves. The transverse plane separates the body into superior and inferior halves.

Tips for studying physiology:

Take each system in steps
Identify the information "given" and "wanted"
Try to understand why processes happen & look for patterns
Connect each thing you learn with previous concepts
Keep up with the work
Physiology builds on prior knowledge
Ask for help when you need it
Don't be afraid to seek out help early…find a instructor, TA, tutor or friend that can help!

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.

02: The Chemical Basis of Life

Chapter Summary:
The Chemical basis of life is covered in this tutorial. Starting with atoms and elements the tutorial expands towards covalently bonded organic molecules and the biochemical reactions they are involved in.

Cells use organic molecules such as enzymes to maintain homeostasis; an example is the buffering of acid formed by chemical reactions inside the body. Examples of organic molecules include nucleic acids and amino acids.

Tutorial Features:
Specific Tutorial Features:
- The process through which covalently bonded atoms are formed together into organic molecules and eventually into carbohydrates, lipids, proteins and nucleic acids. The activity of enzymes is also discussed including the role of energy in these processes, and specific examples of reactions catalyzed by enzymes are given.

Series Features:
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms, as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:
Atoms to organisms: Protons, neutrons, and electrons form atoms. Atoms form elements. Elements form molecules. Organic and inorganic molecules form cells. Cells form living organisms.

Atoms and Elements:
Atomic nuclei contain protons and neutrons (each 1amu).
Each element has a different number of protons.
Ex.., Hydrogen has 1 proton while Carbon has 14.
The number of electrons (e^-) equals the number of protons in the nucleus.
Electrons "live" in energy shells.

Organic Molecules:
Covalently bonded carbon-based compounds.
Stereoisomers
Organic chemicals bonds:
Single bonds
Double bonds
Triple bonds

Biochemical Reactions:
Thermodynamic laws
Enzyme activity

Chapter Review:

Atoms and Elements:
Atoms form bonds by gaining, losing, or sharing electrons. Bonding occurs when it produces a more stable electron arrangement.
Covalent bonds are formed when atoms share electrons. They are very strong bonds, and are the major type in organic chemicals.

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. Unequal sharing of electrons between H and an electronegative atom, such as O or N, creates dipoles.

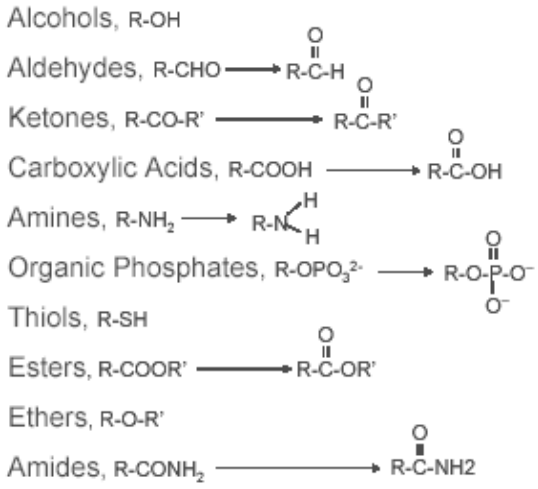
Organic Molecules:

Molecular formulas express the composition of a substance in the simplest whole-number terms. Structural formulas describe how atoms are arranged in a molecule.
Stereoisomers have the same atoms, same order, and different 3D arrangement.

enantiomers: non-superimposable mirror images
diastereomers: not mirror images

Organic chemicals bonds: 1) In single bonds, atoms share one pair of electrons. 2) In double bonds, atoms share two pairs of electrons. 3) In triple bonds, atoms share three pairs of electrons.

Common functional groups:



Important small organic molecules:

Monosaccharides contain C, H, and O (1:2:1). Provide energy via metabolism (Glycolysis, Krebs cycle).
Amino acids R-group specifies the identity (20 standard) as well as H_20 solubility. Amide bonding forms peptides and proteins (e.g., enzymes).
Fatty acids are hydrocarbon chain plus a carboxyl group. Forms ester bonds with glycerol to make glycerides .
Nucleotides are polymers which function as genetic material: DNA=phosphate(s), base (G,T,A,C), deoxyribose RNA=phosphate(s), base (G,U,A,C), ribose.

Buffer Solutions:
Buffers are solutions of weak acids or weak bases and their salts (i.e., the buffer pair).
Buffers resist changes in pH upon addition of small amounts of acid or base.
The buffer pair HCO_3^-/H_2CO_3 helps maintain the blood pH around 7.4.

Biochemical Reactions:

The first law: the total energy of the universe is always conserved; energy can be neither created nor destroyed.
The second law: the universe tends towards maximum disorder; all spontaneous processes occur in the direction that increases the entropy of the system plus its surroundings.

Entropy (S) describes the degree of disorder in a system. It increases with increasing disorder.

ΔG - Gibbs Free Energy
ΔG is the net change in free energy (products – reactants), given as kcal/mol or kJ/mol.
ΔG = ΔH - T ΔS
ΔH = enthalpy change, (>0=endo-, <0=exothermic)
ΔS = entropy change T = temperature (K)

Enzymes in Biochemical Reactions

Energy of activation (Ea) = the free energy necessary to start a reaction.
Enzymes act as catalysts to lower Ea, but they do not change ΔG.
Enzyme activity:

Some enzymes are made in an inactive zymogen form and must be activated.

Increase [substrate] and [enzyme] will increase the reaction rate until all the enzyme's active sites are filled (Vmax).

Increase T increases reaction rate to a point; excessive T denatures enzymes.
Enzymes function best at certain pHs; excessive changes inactivates them.
Allosteric effects and inhibitors regulate enzymatic activity.

03: Cells: The Basic Unit of Life

Chapter Summary:

The cell contains a nucleus, which contains the genetic material necessary for reproduction. Within the cytoplasm of the cell are the organelles the cell requires to reproduce, energy production, and removal of waste.

Key concepts about how cells obtain and import the necessary nutrients for survival along with the energy requirements of these processes will be presented.

Tutorial Features:

Specific Tutorial Features:
- Detailed description of the function of each organelle within cells is discussed.
- The role of the nucleus as a command center will be covered along with the location of the cellular DNA within chromosomes.

Series Features:
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts.
- Examples given throughout to illustrate how the concepts apply.
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Key Concepts:
The definition of a cell: The smallest unit of an organism that can live independently.

The nucleus of the cell:
- Nucleus
- Nucleolus
- Nuclear envelope
- Chromsomes

Cytoplasmic Organelles:
- Golgi apparatus
- Lysosome
- Smooth endoplasmic reticulum
- Mitochondria
- Nucleus
- Ribosomes
- Rough endoplasmic reticulum

Cell membrane:
- Provides a stable internal cell
- Transport across the cell

Different Cell Types:
Prokaryotic vs. Eukaryotic
Cell Levels of Organization.

Chapter Review:
Cell Theory: All known living things are made up of cells. All cells come from preexisting cells by division. The cell is structural and functional unit of all living things.

Cell Structural Overview: The major parts of a cell are the nucleus, cytoplasm, and cell membrane.

Nucleus:
The nucleus contains a nucleolus and is separated from the cytoplasm by the nuclear envelope.
The nucleus contains the cell's DNA, a type of nucleic acid.
The nucleolus is like a "tiny nucleus" inside the actual nucleus. It contains RNA, a type of nucleic acid.
The nucleus communicates through holes in the envelope called nuclear pores.
The nucleus decides what the cell needs and uses DNA to print out instructions for the rest of the cell to produce that need.

Chromosomes:
Hold the cell's DNA in the nucleus.
The nucleus contains genetic information in the form of DNA (the universal genetic code).
The DNA does not hang around loosely in the nucleus. The DNA is packaged with proteins and wound up.
Recall that the role of nucleic acids is to carry genetic information, which is inherited by an organism's offspring.
These wound up DNAprotein structures are called chromosomes.

Cytoplasmic Organelles: Are compartmentalized structures that perform a specialized function within a cell.

Golgi apparatus: ships packages around the cell.
The golgi is made up of flattened, folded sacs.
Packages (e.g. containing proteins) are carried to the golgi in vesicles.
The golgi receives an incoming vesicle, tags the package, and sends the vesicle to its final destination.

Lysosome: destroy waste to clean up the cell.
Lysosomes contain an environment made to destroy waste.
Vesicles carry the waste (bacteria, old organelles, etc.) into the lysosome.
Once inside, the waste is destroyed and its parts recycled.

Smooth endoplasmic reticulum: The two types of ER make different building blocks for the cell.
Smooth ER is NOT attached to the nucleus and DOES NOT have attached ribosomes (thus smooth).
Smooth ER synthesizes carbohydrates (sugars) and lipids (fats).

Mitochondria: produce energy to power the cell.
The mitochondria convert carbohydrates (sugar) taken from food into ATP.
The mitochondria are unique in that it has two protective shells.

Ribosomes: make proteins for the cell.
The ribosome reads the DNA strand instructions to make proteins for the cell to use in its normal activities.
The units clasp around a strand of nucleic acid instructions from the nucleus.
Each ribosome is made of two protein subunits.

Rough endoplasmic reticulum: The two types of ER make different building blocks for the cell.

Rough ER is found attached to the outside of the nucleus. It appears rough because of the ribosomes on its surface.
Rough ER helps the attached ribosomes in finishing protein synthesis.

Cell membrane: A selectively permeable structure that envelops the cell and protects the cell's internal environment.
Plasma Membrane, the cell's membrane is made of phospholipids, which have carbohydrate heads and lipid tails.
Embedded proteins are anchored to the cell membrane.
Exterior of the plasma membrane touches water; polar heads touch water on the inside of the cell and water on the outside of the cell.
Interior Blocks Passage However, water and other molecules cannot pass through to either side because of the nonpolar tails.
Provides a stabilized environment, which protects and maintains the cell's internal environment, separate from the environment outside.
Proteins embedded into the membrane send and receive signals to communicate with other cells.

Transport across the cell membrane: The cell exchanges materials through the cell membrane using passive and active transport.

Three types of passive transport are osmosis, diffusion, and facilitated diffusion. Osmosis is the natural movement of water from a high concentration of water to a lower concentration of water. Diffusion is the natural movement of molecules from a higher concentration to a lower concentration. Facilitated Diffusion is the natural movement of molecules from a higher concentration to a lower concentration with the help of a transporter protein embedded on the cell membrane.

Active transport requires energy to occur. Active transport is "forced" movement of molecules from a lower concentration to a higher concentration. The most common type of active transport is a pump. Pumps are proteins embedded in the cell membrane, which use ATP energy to work.

Different Cell Types: Prokaryote and Eukaryote.
Prokaryotic: Bacteria and other microscopic organisms are made up of prokaryotic cells. Prokaryotic cells do not have any complex organelles (not even a nucleus). However, prokaryotes do have ribosomes.
Eukaryotic: Two types of eukaryotic cells are plant and animal cells.

04: Tissues of the Human Body

Chapter Summary:

This tutorial covers the four main types of tissue in the human body. It also includes a description of the anatomical location of those tissues within the body.

All 4 types of tissue originate from 3 primary layers in the developing human embryo. There are a number of cell junctions used by the various tissue types for contact with surrounding cells and the basement membrane, communication and for structural integrity.

Tutorial Features:

Specific Tutorial Features:
- A detailed description of the epithelial tissue in the body is presented including a histological description, subtype classification and location within organs and glands and the function.

Series Features:
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:
The four types of tissue in the human body: A tissue is a group of cells that is from similar embryological origin and is specialized for a particular function. Four types: epithelial, connective, muscle and nervous.

Epithelial
Connective
Muscle
Nervous

Development

Cell Junctions

Epithelial Tissue
General Aspects
Two Sub-types

Glandular Epithelium

Connective Tissue and Cartilage:
Connective tissue
Hyaline cartilage
Elastic cartilage
Fibrous cartilage

Tissues of the Human Body:
Muscle Tissue
Skeletal muscle
Cardiac muscle
Smooth muscle

Chapter Review:

Tissue in the human body:
(1) Epithelial: Is made of cells arranged in a continuous sheet with one or more layers, has apical & basal surfaces.
A basement membrane is the attachment between the basal surface of the cell & the underlying connective tissue.
Two types of epithelial tissues: (1) Covering & lining epithelia and (2) Glandular Epithelium.
The number of cell layers & the shape of the cells in the top layer can classify epithelium.

Simple Epithelium - one cell layer
Stratified epithelium - two or more cell layers
Pseudostratified Columnar Epithelium - When cells of an epithelial tissue are all anchored to the basement
Membrane but not all cells reach the apical surface.
Glandular Epithelium – (1) Endocrine: Release hormones directly into the blood stream and (2) Exocrine - Secrete into ducts.

(2) Connective: contains many different cell types including: fibroblasts, macrophages, mast cells, and adipocytes.
Connective Tissue Matrix is made of two materials: ground substance - proteins and polysaccharides, fiber – reticular, collagen and elastic.
Classification of Connective Tissue:

Loose Connective - fibers & many cell types in gelatinous matrix, found in skin, & surrounding blood vessels, nerves, and organs.

Dense Connective - Bundles of parallel collagen fibers& fibroblasts, found in tendons& ligaments.

Cartilage - Cartilage is made of collagen & elastin fibers embedded in a matrix glycoprotein & cells called chondrocytes found in small spaces. Cartilage has three subtypes: (A) Hyaline cartilage – Weakest, most abundant type, Found at end of long bones, & structures like the ear and nose, (B) Elastic cartilage- maintains shape, branching elastic fibers distinguish it from hyaline and (C) Fibrous Cartilage - Strongest type, has dense collagen & little matrix, found in pelvis, skull & vertebral discs.

(3) Muscle: is divided into 3 categories, skeletal, cardiac and smooth.

Skeletal Muscle – voluntary, striated, striations perpendicular to the muscle fibers and it is mainly found attached to bones.
Cardiac Muscle – involuntary, striated, branched and has intercalated discs.
Smooth Muscle – involuntary, nonstriated, spindle shaped and is found in blood vessels & the GI tract.

(4) Nervous: Consists of only two cell types in the central nervous system (CNS) & peripheral nervous system (PNS):
Neurons - Cells that convert stimuli into electrical impulses to the brain, and Neuroglia – supportive cells.

Neurons – are made up of cell body, axon and dendrites. There are 3 types of neurons: (A) Motor Neuron – carry impulses from CNS to muscles & glands, (B) Interneuron - interpret input from sensory neurons & end responses to motor neurons and (C) Sensory Neuron – receive information from environment & transmit to CNS.
Neuroglia – is made up of astrocytes, oligodendrocytes, ependymal cells and microglia in the CNS, and schwann cells and satellite cells in the PNS.

Development: All tissues of the body develop from the three primary germ cell layers that form the embryo:
Mesoderm – develops into epithelial tissue, connective tissue and muscle tissue.
Ectoderm - develops into nervous tissue and epithelial tissue.
Endoderm – develops into epithelial tissue.

Cell Junctions:
Tight Junctions - Form a seal between cells, define apical and basal sides of an epithelial cell
Gap Junctions - An open junction between two cells, which allows ions, & small molecules to pass freely between the cells.
Adherens Junctions - Link actin cytoskeletal elements in two cells.
Desmosomes - Link keratin filaments in adjoining cells and resist shearing forces.
Hemidesmosomes - Anchor keratin fibers in epithelial cells to the basement membrane through integrin anchors.

05: The Integumentary System

Chapter Summary:

This tutorial describes the integumentary system including the skin, hair, nails and glands. The two layers of the skin and their functions are also discussed.

The integument is an organ that is involved in protection and barrier function. The integument is also involved in regulating body heat and blood pressure.

Tutorial Features:

Specific Tutorial Features:

- Step by step description of the various layers of the epidermis and the dermis.
- The relationship between the various layers of skin and the hair, nails and glands are discussed.
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Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

The integument as an organ:
The two layers of the integument (skin)
The derivatives of the integument
Hair
Nails
Glands

Functions of the skin:
Thermoregulation
Cutaneous sensation
Vitamin D production
Protection
Absorption & secretion
Wound healing

The Two Layers of Skin:
Epidermis – cells and layers.
Dermis – cells and layers.

Chapter Review:

The integument as an organ: The integument as an organ, and is an alternative name for skin. The integumentary system includes the skin and the skin derivatives hair, nails, and glands. The integument is the body's largest organ and accounts for 15% of body weight.

The derivatives of the integument:
Hair: functions include protection & sensing light touch.
Hair is composed of columns of dead, keratinized cells bound together by extracellular proteins. Hair has two main sections: The shaft- superficial portion that extends out of the skin and the root- portion that penetrates into the dermis. Surrounding the root of the hair is the hair follicle. At the base of the hair follicle is an onion-shaped structure called the bulb Papilla of the hair and the matrix within the bulb produce new hair.

Nails: participate in the grasp & handling of small things.
Nails are plates of tightly packed, hard, keratinized epidermal cells.
The nail consists of: (A) a nail root: -the portion of the nail under the skin, (B) nail body: -the visible pink portion of the nail, the white crescent at the base of the nail is the lunula, the hyponychium secures the nail to the finger, the cuticle or eponychium is a narrow band around the proximal edge of the nail and (C) free edge: -the white end that may extend past the finger.

Glands: participate in regulating body temperature.
There are three main types of glands associated with the integument:
Sebaceous - Oil glands. Located in the dermis, and secrete sebum.
Sudoriferous - Sweat glands. Divided into two main types: (A) Eccrine - Most common, main function is regulation of body temperature by evaporation, and (B) Apocrine - Responsible for "cold sweat" associated with stress.
Ceruminous – Lie in subcutaneous tissue below the dermis, secrete cerumen (ear wax) into ear canal or sebaceous glands.

Functions of the skin:
Thermoregulation - Evaporation of sweat & Regulation of blood flow to the dermis.
Cutaneous sensation - Sensations like touch, pressure, vibration, pain, warmth or coolness.
Vitamin D production - UV sunlight & precursor molecule in skin make vitamin D.
Protection – The sin acts as a physical barrier.
Absorption & secretion – The skin is involved in the absorption of water-soluble molecules and excretion of water and sweat.
Wound healing - When a minor burn or abrasion occurs basal cells of the epidermis break away from the basement membrane and migrate across the wound. They migrate as a sheet, when the sides meet the growth stops and this is called 'contact inhibition'. In deep wound healing - A clot forms in the wound, blood flow increases and many cells move to the wound. The clot becomes a scab; granulation tissue fills the wound and intense growth of epithelial cells beneath the scab. The scab falls off and the skin returns to normal thickness.

The Two Layers of Skin:
Epidermis – The Epidermis is the thinner more superficial layer of the skin.
The epidermis is made up of 4 cell types: (A) Keratinocytes – Produce keratin protein a fibrous protein that helps protect the epidermis, (B) Melanocytes - produces the brown pigment melanin (C) Langerhan Cells – participate in immune response and (D) Merkel cells - participates in the sense of touch.

There are five distinct sub-layers of the Epidermis:
Stratum corneum: the outermost layer, made of 25-30 layers of dead flat keratinocytes. Lamellar granules provide water repellent action and are continuously shed & replaced.
Stratum lucidum: Only found in the fingertips, palms of hands, & soles of feet. This layer is made up of 3-5 layers of flat dead keratinocytes.
Stratum granulosum: made up of 3-5 layers of keratinocytes, site of keratin formation, keratohyalin gives the granular appearance.

Stratum spinosum: appears covered in thornlike spikes, provide strength & flexibility to the skin.
Stratum basale: The deepest layer, made up of a single layer of cuboidal or columnar cells. Cells produced here are constantly divide & move up to apical surface.

Dermis: is the deeper, thicker layer composed of connective tissue, blood vessels, nerves, glands and hair follicles.
The epidermis contains 3 cell types: (A) Adipocytes, (B) Macrophages and (C) Fibroblasts.
There are two main divisions of the dermal layer:
Papillary region - The superficial layer of the dermis, made up of loose areolar connective tissue with elastic fibers.
Dermal papillae - Fingerlike structures invade the epidermis, contain capillaries or Meissner corpuscles which respond to touch.
Reticular region of the Dermis – Made up of dense irregular connective & adipose tissue, contains sweat lands, sebaceous (oil) glands, & blood vessels.

06: Skeletal System 1: Bone, Bone Tissue and Joints

Chapter Summary:
This tutorial describes the many roles of bone in the human body. Bones provide storage for calcium, are the formation site for red and white blood cells, as well as providing structural support and protection for the body's internal organs.

Tutorial Features:

Specific Tutorial Features:
- Sketches of bone functions with visual aids are shown in the tutorial to aid in understanding the many roles and function of bones in the body.

Series Features:
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Types of Bones and Bone Structures
- Long bones
- Short bones
- Flat bones
- Irregular bones

Bones: Calcium Storage
- Calcium Release into the Bloodstream
- Calcium Deposition in Bone

- Bone Structure
- Bone Matrix
- Bone Marrow

Joint Structure and Cartilage
- Types of joints
- Types of cartilage
- Ligaments and tendons

Chapter Review:

Types of Bones and Bone Structures
Muscles are attached to bones and use the bones as an anchor from which to exert forces that result in limb movement. Bones provide for functional structure in the respiratory system such as: (a) bones in the face providing a nasal cavity passageway and (b) bones of the thorax are shaped to allow expansion of the chest cavity during inspiration.

Long bones: longer than they are wide, act as levers. Examples in the upper extremity include the humerus, radius and ulna.

Short bones: are short cubed shaped bones, found in the wrist and ankle. In the wrist there are 8 total in two rows.

They articulate with each other, as well as provide attachment points for ligaments.

Flat bones: have broad surfaces for the protection of organs and attachment of muscles. In the skull, there are 8 bones that protect the brain and brain stem.

Irregular bones: have a unique shape and provide both protection and multiple attachment points for muscles. Examples include the vertebra, which protects the spinal cord.

Bones: Calcium Storage: Calcium is stored primarily in bones and is released into the blood in response to hormones. Calcium is needed for bone development, blood clotting, normal muscle and nerve activity.

Calcium Release into the Bloodstream
Calcium is stored in bone as a mineral salt with phosphate. Calcium is released from the bone in response to parathyroid hormone (PTH).

Calcium Deposition in Bone
Calcium is stored in the bone as a mineral salt, along with phosphate, in response to decreased PTH levels and increased calcitonin (CT) release from the thyroid gland.

Bone Structure: bone is a complex array of osteocytes, canals and blood vessels. Bone is relatively hard and lightweight and is primarily made of calcium phosphate. Bone can either be: (a) spongy - has an open meshwork which contains bone marrow or (b) compact – is dense; it forms the surface of bones and makes up approximately 80% of the bone mass.

Bone Matrix
Bone matrix is made up of Osteons, which are long narrow cylinders containing both Haversian and Volkmann canals. Haversian canals surround blood vessels and nerves inside the bone. Volkmann's canals connect the individual osteons to each other and to the periosteum. The periosteum provides the blood supply and houses the osteoclasts for bone resorption.

Bone Marrow
The bone marrow is the site of red blood cells, white blood cell and platelet production. B-Cells and T-Cells are produced in the bone marrow and then circulate to other lymphoid organs to be stimulated by antigens.

Joint Structure and Cartilage: Joints facilitate movement between bones by providing a meeting point between the bones and providing lubrication.

Types of joints: Joints are separated into two categories: (a) fibrous – no synovial cavity containing synovial fluid, i.e.- sutures between bones of the skull and (b) synovial – in which there is a space between the articulating bones and the space is filled with synovial fluid which lubricates the joint, i.e.- knee joint.

Types of cartilage: Cartilage is a type of dense connective tissue composed of cells called chondrocytes, which produce and maintain the cartilage. Cartilage contains no blood vessels; nutrients diffuse through the cartilage matrix. Cartilage is found between bones, in the nose, throat and in the spinal column.
Hyaline cartilage: such as articular cartilage, line bones in joints and also provide a site for bone growth
(growth plate).
Elastic cartilage: such as in the walls of the larynx (voice box), keeps tubes permanently open. It is made with elastin bundles to provide elasticity and yet be stiff.

Fibrocartilage: such as between intervertebral disks, is located in sites that require great tensile strength. It is also found at sites connecting tendons and ligaments to bone.

Ligaments and tendons: connect muscle to bone or bones together.
Ligaments are short bands of tough fibrous tissue, composed mainly of collagen fibers. Ligaments connect bones to other bones to form a joint, i.e.- ilio-femoral ligament of the hip joint.

Tendons are a tough band of fibrous tissue that connects muscle to bone or muscle to muscle, i.e. – Achilles tendon. Tendons are designed to withstand tension and stretch. The origin of a tendon is where it joins to a muscle and collagen fibers from the muscle itself extend directly into the tendon.

07: Skeletal System 2: Axial Skeleton

Chapter Summary:

This tutorial shows the bones that make up the skull, inner ear, chest and spine. Detailed pictures help localizing the bones within the region of the body.

The functions of the major bones are discussed and their interactions (articulations) with other bones and their attachment points for muscles.

Tutorial Features:

Specific Tutorial Features:

- Problem-solving techniques are used to work out and illustrate the example problems, step by step.
- Easy explanation for sometimes confusing physics formulas.
- Animation showing conservation of energy by a skydiver.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

The bones of the axial skeleton include the skull, chest, and spine.

Bones of the Skull

Bones of the Face

Bones of the Inner Ear

Malleus (hammer)
Incus (anvil)
Stapes (stirrup)

Bones of the Chest

The Vertebral Column: The vertebral column is divided into three regions: (A) Cervical, (B) Thoracic and (C) Lumbar.

Chapter Review

The axial skeleton provides: (a) structural support for the body, (b) attachment points for ligaments and muscles, and (c) protects the brain, spinal cord and major organs of the chest. The axial skeleton includes bones of the skull, inner ear, chest and spinal column.

Bones of the Skull: Can be categorized into two groups: (A) Neurocranium and (B) Splanchnocranium. With the exception of the mandible, all the bones of the skull are joined together by sutures. The Neurocranium includes the following 8 bones: Frontal bone: makes up the forehead and part of the eye orbits and part of the nasal cavities. Parietal bones: here are 2 parietal bones, which articulate together and form the roof of the cranium. Temporal bones: one on either side of the skull, contain the inner ear. These bones also provide a foramen (canal) for the major blood supply to the brain, the carotid artery and jugular vein. Occipital bone: makes up the back and floor of the cranium. The brainstem passes through this bone and then continues as the spinal cord. Ethmoid bone: forms the front part of the cranial floor, part of the eye orbits, and contains the ethmoid sinuses. Sphenoid bone: contains the sphenoidal sinus cavity. Has a unique depression called the sella turcica, which houses the pituitary gland. Palatine Bone: these bones are at the back of the roof of the mouth. They form the wall of the nasal cavities and the floor of the eye orbit.

Bones of the Face: The bones of the face (Splanchnocranium) are 14 in total. They are: 2 nasal, 2 maxilla, 2 zygomatic, 2 lacrimal, mandible, 2 palatine, 2 inferior nasal conchae and vomer.

Lacrimal Bone: is the smallest bone of the face, from part of the inside wall of the eye orbit. Nasal Bone: the two nasal bones meet in the middle and this forms the bridge of the nose. Inferior Nasal Conchae: these bones form the lateral wall of the nasal cavity and cause the inhaled air to swirl and be filtered.

Vomer Bone: is a triangular shaped bone that forms part of the nasal septum. Zygomatic Bone: it is a paired bone, which makes up the lower eye orbit and is frequently referred to as the cheekbone.

Maxilla Bone: the largest bones of the face; they form together to make the whole upper jaw. These bones hold the upper teeth.

Mandible Bone: the strongest bone of the face; it forms the lower jaw and holds the lower teeth. It is the only bone of the skull that moves.

The hyoid bone is a bone in the neck, which does not articulate with any other bone. Muscles of the neck support it and it provides support for the root of the tongue; it is involved in the production of speech.

Bones of the Inner Ear: The bones of the inner ear are called the (a) Malleus (hammer), (b) Incus (anvil) and (c) Stapes (stirrup). These bones function together to transmit sound waves from the external environment to the fluid filled cochlea.

Malleus (hammer): The malleus, or hammer, is a hammershaped bone that is attached to the incus. It is attached to the inner surface of the eardrum and, therefore, it moves as the eardrum vibrates in response to incoming sound.

Incus (anvil): is an anvil-shaped bone in between the malleus and the stapes. It is the bridge that connects the incoming sound waves to the inner ear.
Stapes (stirrup): The stapes, or stirrup, transmits the sound vibrations from the Incus to the oval window. The oval window connects the inner ear bones with the cochlea.

Bones of the Chest

Clavicles (or collar bones) are long bones, which support the ribcage and shoulder joints. The clavicles provide an attachment for the scapula and rotate when the arm is moved forward. There are twelve ribs in the rib cage, 10 pairs that are joined to the sternum and spine and 2 floating pairs. The ribs protect the underlying organs and assist in respiration. Scapula: also known as the shoulder blade; it is a pair of broad flat bones that connect the arm bone with the clavicle. Sternum: also known as the breastbone; it is a long flat bone in the center of the chest. It connects to the ribs via cartilage and completes the rib cage. It has three portions, from the top downward: (A) Manubrium, (B) Body and (C) Xiphoid Process.

The Vertebral Column:

Cervical: The cervical region is the first portion of the spinal column and is made up of 7 vertebras. The first and second vertebrae are unique, and they are called the atlas and the axis.

Thoracic: The thoracic region of the vertebral column is located in the chest. It contains 12 vertebrae and is connected to the lumbar region of the spine.
Lumbar: The lumbar region of the vertebral column is the last main portion of the vertebral column and is located in the lower back. It contains 5 vertebrae and is connected to the pelvis, through the sacrum and coccyx.

Sacrum: The sacrum is a triangular shaped bone that is made up of 5 fused sacral vertebrae. It articulates with and provides a strong foundation for the pelvis.

Coccyx: The coccyx is also a triangular shaped bone that is made of 4 fused coccygeal vertebrae, and is also known as the tailbone. It is attached to the sacrum by cartilage, and this allows some movement between them and shock absorbance.

08: Skeletal System 3: Appendicular Skeleton

Chapter Summary:

This tutorial describes the bones of the appendicular skeleton, including: shoulder region, bones of the upper and lower extremities and the pelvis.

The appendicular skeleton is connected to the axial skeleton, but has its own function and role in the human body. The appendicular skeleton protects the organs of digestion, excretion and reproduction.

Tutorial Features:
Specific Tutorial Features:

- Detailed pictures of the major bones of the shoulder region, upper and lower extremities, and pelvis provide the necessary learning of their anatomical location in the human body and function.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Organization and function

Bones of the shoulder
Clavicle
Scapula
Humerus

Bones of the upper extremity
Humerus
Radius
Ulna
The wrist, or carpal bones, is made up of 8 small bones held together by ligaments. The carpal bones articulate with the radius and ulna and the 5 metacarpal bones of the hand.

Bones of the pelvis
Ilium
Ischium
Pubis

Bones of the lower extremity
Femur
Tibia
Fibula
The Tarsal bones are a group of bones that make up the ankle, and the foot is made up of meta-tarsal ones and phalange bones.

Chapter Review:

Bones of the shoulder: The shoulder joint provides a connection between the chest and the arm.

Clavicle: The clavicle, or collar bone, is a long bone that articulates with the sternum in the chest and the scapula in the shoulder. It provides a rigid support from which the scapula and arm are suspended and transfers stress, due to physical impact to the axial skeleton.

Scapula: The scapula, or shoulder blade, is a triangular shaped flat bone that connects the humerus with the clavicle. It has a large oblong process, called the acromium.

Humerus: The humerus bone makes up the upper arm between the elbow and the shoulder. It has a large process called the head, which articulates with the scapula in the gleonhumeral joint. At the opposite end, is a medial and lateral epicondyle, where it forms the elbow joint with the bones of the forearm.

Bones of the upper extremity

Elbow joint: The bones of the elbow include the humerus, radius and ulna. This joint is a pivot point for the forearm and plays a major role in hand movement and function.

Humerus: The humerus has a depression called the olecranon fossa. This depression receives the olecranon of the ulna, while the forearm is extended. The olecranon forms the prominence of the elbow.

Radius: The radius is the lateral bone of the forearm (located on the thumb side). The radial head articulates with the humerus and the radia notch of the ulna.

Ulna: The ulna is the medial bone of the forearm (located on the little finger side), which articulates with the humerus in the elbow joint and the carpals in the wrist.

The wrist: or carpal bones, is made up of 8 small bones held together by ligaments. The carpal bones articulate with the radius and ulna and include the: The scaphoid, lunate, triquetrium, pisiform, hamate, trapezium, trapezoid and the capitate.

The hand is made up of: The hand is made up of the metacarpal bones and phalange bones. There are 5 metacarpal bones, which make up the palm. There are a total of 14 phalanges, which make up the fingers.

Bones of the pelvis: The pelvis is located at the base of the spine and contains two sockets for articulation with the lower extremities.

Ilium: The ilium bone articulates with the sacrum at the sacroiliac joint. This joint, along with its ligaments, connects the lower extremities with the torso.

Ischium: The ischium bone forms the lower and back part of the pelvis. The ischium bone also makes up part of the acetabulum and contains the obturator foramen.

Pubis: The pubis bone is between the ilium and the ishium, and it forms part of the acetabulum.

Bones of the lower extremity: the leg bones are the largest bones of the body and, along with the ankle and feet, provide support for standing and walking.

Femur: The femur, or thighbone, is the largest and strongest bone of the human body. It articulates with the hip at the hip joint and the bones of the lower leg at the knee joint.

Tibia: The tibia is the larger of the two shinbones. It articulates with the fibula and femur at the knee joint and the tarsal bones of the ankle.

Fibula: The fibula is the smaller shinbone; it is more posterior than the tibia. It forms the lateral portion of the ankle joint.
The Tarsal bones are a group of bones that make up the ankle, and the foot is made up of meta-tarsal ones and phalange bones.

09: Muscles and Muscle Tissue

Chapter Summary:

Muscles are key to providing strength and movement to the body, as well as providing organ function and the ability to modulate systemic blood pressure. Muscles are controlled by the nervous system and the signals to contract are transmitted through the neuromuscular junction.

Tutorial Features:

Specific Tutorial Features:

- Step by step details are shown to describe how the individual sarcomere and eventually the entire muscle contract.
- The various types of muscles and their unique function in the body are presented.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Muscles are organized into three basic types:
Striated
Cardiac
Smooth

Skeletal muscle fiber
Anatomy
Sarcomere
Sliding filament model

Physiology of contraction
Excitation-Contraction coupling
Length-Tension Relationship

Muscle metabolism
- Breakdown of ATP
- Anaerobic Glycolysis
- Aerobic Glycolysis
- Lipolysis

Types of Skeletal Muscle Fibers

Control of muscles
- Neuromuscular junction

Voluntary muscles

Involuntary muscles

Chapter Review:

Muscles are organized into three basic types:
Striated: Skeletal muscle facilitates movement by applying forces to bones and joints through its contraction. They are generally under voluntary control. Muscles have an origin; a thick portion of the muscle between the insertion and origin is called the muscle belly or gaster and a tendon.

Cardiac: Cardiac muscle is an involuntary striated muscle found exclusively in the heart. Cardiac muscle has unique properties; it stimulates its own contraction without the required electrical impulse from the central nervous system via special pacemaker cells in the sinoatrial node.

Smooth: Smooth muscle is an involuntary non-striated muscle found in the walls of hollow organs such as the bladder, and in blood vessels. Smooth muscle can be directly stimulated by the CNS or can react to hormones secreted locally, such as vasodilators and vasoconstrictors.

Skeletal muscle fiber
Anatomy: Skeletal Muscle Fibers are made up of many myofibrils surrounded by sarcoplasmic reticulum. The sarcolemma is on the outside of the muscle fiber and contains many nuclei.

Sarcomere: The dark striations of skeletal muscle are made up of a lattice of thick and thin filaments, which are formed into a functional unit of contraction known as the sarcomere. Sarcomeres are the basic unit of muscle, made up of actin and myosin.

Sliding filament model: Sliding filament model: after the signal to contract comes from the central nervous system, an action potential spreads over the muscle fiber.

Physiology of contraction
Excitation-Contraction coupling: Excitation-Contraction coupling is the process by which an action potential causes calcium (Ca2+) release and cross bridge cycling. An incoming action potential, transmitted through the neuromuscular junction, causes the depolarization of the skeletal muscle cell.

Length-Tension Relationship: The amount of tension (force of contraction) a skeletal muscle creates is dependent, in part, on the length of the muscle itself. The optimal length for a muscle is when the maximum number of myosin cross bridges make contact with thin filaments.

Muscle metabolism

Breakdown of ATP: when a muscle is stimulated to contract, the initial ATP (stored as phosphocreatine) is the initial energy source, lasting seconds.

Anaerobic Glycolysis: when the phosphocreatine source is depleted, muscle converts glucose into pyruvic acid and ATP.

Aerobic Glycolysis: if sufficient oxygen is available muscle tissue will convert glucose into CO2, H2O and ATP to use as energy.

Lipolysis: during long periods of exercise, muscle can use the byproducts of fat breakdown, which are free fatty acids (FFA). FFA are converted into ATP.

Types of Skeletal Muscle Fibers: There are 3 main types of skeletal muscle: (A) Slow Oxidative Fibers, (B) Fast Oxidative-Glycolytic Fibers and (C) Fast Glycolytic Fibers. Most skeletal muscles are a mixture of all 3 types.

Control of muscles

Neuromuscular junction: Motor neurons axons connect with muscle fibers via a neuromuscular junction. The axon ends at the neuromuscular junction and is separated from the muscle fiber itself by a synaptic cleft. Neutortansmitters such as acetylcholine, cross the synaptic cleft and transmit the chemically converted electrical impulse to the muscle causing it to contract.

Voluntary muscles: broadly only skeletal muscles are under voluntary control. Meaning we can contract the muscles at will.

Involuntary muscles: Involuntary muscles are rhythmic, automatically controlled muscles. The muscles of breathing are under both voluntary and involuntary control. Cardiac (heart) muscle is under involuntary control. The pacemaker cells in the sinoatrial node set the rate and the autonomic nervous system can modulate that rate. Smooth muscles in the walls of organs and blood vessels are primarily under involuntary control.

10: The Muscular System

Chapter Summary:

The muscular system includes all the skeletal muscles of the head and neck, upper and lower extremities and the torso. These muscles are arranged in antagonistic pairs and work to move the limb or body part they control. Muscle use lever actions in the body to increase efficient, the joints are the fulcrums.

Tutorial Features:

Specific Tutorial Features:

- Examples to illustrate the groups of muscles around in the different regions of the body.
- Detailed anatomical pictures of the different muscles and the levers they control in the human body are presented.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Muscle Naming System
Location
Size
Number of insertions

Muscle lever action
First-class
Second-class
Third-class

Muscle Fascicles
Parallel
Circular
Convergent
Pennate
Role of Muscles in Blood Pressure and Thermoregulation

Muscles of the Human Body

Muscles of the head and neck
Muscles of the Neck and Shoulder
Muscles of the Chest and Back
Muscles of the Upper Extremity
Muscles of the Lower Extremity

Chapter Review:

Muscle Naming System: Muscles are named, based on various characteristics.
Location: muscles are named based on location, such as the tibialis anterior muscle, which is located near the front of the tibia bone.

Size: muscles are named based on their size; maximus means larger and minimus means smaller. Examples include the pectoralis major and minor muscles of the chest.

Number of insertions: muscles are named based on the number of origins, such as the quadriceps femoris, which has 4.

Muscle lever action: 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: the fulcrum is between the effort and resistance. There are only a few examples of this type in the human body.

Second-class: the resistance is between the fulcrum and the effort.
Third-class: the effort is between the fulcrum and the resistance.

Muscle Fascicles: Muscle fibers are arranged into bundles called fascicles. The pattern of fascicles effects muscle strength and motion.

Parallel: In this arrangement, the fascicles are parallel with the longitudinal axis of the muscle, such as the stylohyoid muscle of the neck.

Circular: In this arrangement, the fascicles are arranged in a circular pattern and enclose an orifice.

Convergent: In this arrangement, the fascicles have a broad origin and converge to a narrow insertion.

Pennate: In this arrangement, the fascicles are short in relation to the entire length of the muscle, and the tendons extend almost the entire length of the muscle.

Role of Muscles in Blood Pressure and Thermoregulation: Smooth muscle in the walls of precapillary arterioles contract and cause the peripheral vascular resistance to be increased, thereby increasing systemic blood pressure.

Muscles of the Human Body

Muscles of the head and neck: The muscles of the face and head can be divided into 3 main categories: (A) muscles of expression – orbicularis, buccinator, frontalis, occipitalis (B) muscles of chewing – masseter, temporalis and (C) muscles of the neck – sternocleidomastoid.

Muscles of the Neck and Shoulder: Sternocleidomastoid, Trapezius, Deltoid, Rotator Cuff: is a group of 4 muscles which hold the head of the arm bone in the shoulder joint and attach the arm to the chest.

Muscles of the Chest and Back: muscle of the chest includes - Pectoralis Major, Pectoralis Minor and Intercostal Muscles. The muscles of the back include – Trapezius, Latissimus Dorsi and Serratus Posterior.

Muscles of the Upper Extremity: the muscles of the upper arm include – Coracobrachialis, Biceps, Brachialis and the Triceps muscle. The muscles of the forearm include - Pronator Teres, Extensor Digitorum Communis and the Flexor Carpi Radialis. Muscles of the hand include - Palmaris Brevis, Abductor Digiti Quinti, Abductor Pollicis Brevis and the Flexor Pollicis Brevis muscle.

Muscles of the Lower Extremity: the muscles of the thigh and shin region include - Quadriceps Muscles, Hamstring Muscles, Tibialis Anterior, Calf Muscles and yhe Extensor Digitorum Longus muscle. The muscles of the foot include - Plantar Aponeurosis, Abductor Hallucis, Flexor Digitorum Brevis and the Abductor Digiti Quinti.

11: Control of the Human Body: The Nervous System

Chapter Summary:

This tutorial covers the organization of he nervous system and what tissues the brain uses to transmit information from the brain to the muscles and glands of the body. The different components of the central and peripheral nervous system will be discussed.

Tutorial Features:

Specific Tutorial Features:
- Example will be given of the pathway information travels from the brain into the spinal cord and information to and from the muscles of the body.

Series Features:
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Organization of the nervous system
- Neurons and Glia
- Receiving
- Transmitting
- Sending

The Action Potential
- Resting Potential
- Action Potential
- Synapse

Central Nervous System
- Overview
- Brain
- Spinal Cord

Peripheral Nervous System
- Overview
- Sensory Nervous System
- Motor Nervous System

Chapter Review:

Organization of the nervous system: The body is innervated by neurons that send information to the brain and carry out commands sent by the brain.
Neurons and Glia: The neuron is a cell that is specially designed for receiving, propagating, and transmitting signals. Glial Cells provide the environment required for neurons to do their job. In the Central Nervous System: glial cells include - ependymal cells,

astrocytes, oligodendrocytes and microglia. In the peripheral nervous system glial cells include - schwann cells and satellite cells.

Receiving: A neuron communicates with other neurons at synapses, small spaces between terminal branches of one neuron and dendrites of another.

Transmitting: Nodes of Ranvier: the electrical signal jumps from one of these gaps in myelin to the next.

Myelin Sheath: the axon is wrapped in fatty membranes called myelin that increase electrical conductivity, allowing the signal to travel long distances (mm).

Sending: Synapse: the empty space between one neuron's terminal branches and the next neurons dendrites. Neurotransmitters: molecules released from the terminal branches when the impulse arrives from the axon.

The Action Potential

Resting Potential: Before the neuron is excited, the inside of the cell has a negative charge and the outside is positively charged.

Action Potential: When another neuron sends a sufficiently strong signal to the next neuron, the neuron excites to a threshold potential.

Central Nervous System: the CNS includes the brain and spinal cord.

Brain: the brain is made up of the following regions – Cerebrum, Cerebellum, Hypothalamus and the Brainstem.

Spinal Cord: Receiving: the PNS receives data (such as sights, sounds) and sends it to the CNS for processing. Sending: the CNS sends commands to the PNS in response to inputs, and the PNS carries them out (e.g. move arm). The spinal cord is the information highway connecting the brain and the rest of the body.

Peripheral Nervous System
Overview: the peripheral nervous system (PNS) includes the nerves, which receive input and directly control the body.

Sensory Nervous System: The sensory nervous system includes sensory organs, which receive information from the environment, and sends it to the CNS. Each sense organ has unique receptors, which register the signals from the environment.

Motor Nervous System: The somatic system directly controls voluntary movement. The autonomic system directly controls automatic body functions (involuntary movements).

12: The Central Nervous System

Chapter Summary:

This tutorial describes the central nervous system organs in detail, including the brain and spinal cord. The method of information transmission used by the brain, namely electrical impulses transmitted by nerves, is discussed.

Tutorial Features:

Specific Tutorial Features:
- Detailed anatomical pictures of the brain and the spinal cord. The sensory and motor pathways are also presented.

Series Features:
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Central Nervous System organization and cell types
- Neurons
- Bipolar neurons
- Grey and white matter

Glial Cells
- CNS Glial Cell Types
- Functions

The Brain
- Overview
- Anatomy
- Functions

The Spinal Cord
- Overview
- Anatomy
- Functions

Chapter Review:

Central Nervous System organization and cell types
Neurons: there are several types of neurons - anaxonic neurons: small neurons where the dendrites and axons are indistinguishable. Bipolar neurons: small neurons with two distinct processes; a dendritic process and an axon extending from the cell body. Unipolar neurons: large neurons with the cell body lying to one side of the continuous dendritic process and axon. Multipolar neurons: large neurons with several dendrites and a single axon extending from the cell body.

Bipolar neurons: Biopolar neurons are CNS neurons specific for transmitting information from specialized sensory systems: sight, smell and hearing.

Grey and white matter: Grey matter consisting of unmyelinated neurons is the processing area of the CNS. White matter – located in the inner cortex and surrounding grey matter in the spinal cord - provide pathways of communication between grey matter.

Glial Cells

CNS Glial Cell Types: there are 4 types of glial cells – (A) astrocytes - Regulates the chemical microenvironment surrounding neurons, (B) Oligodendrocytes - Myelinate central nervous system axons, (C) Microglia - Migrating phagocytic cells resembling immune cells that remove waste, debris, and pathogens and (D) Ependymal cells - Columnar cells that line the ventricals of the brain and the spinal canal in the spinal cord.

The Brain

Overview: The brain is the control center of the body.
Anatomy: the brain is divided into the following regions: (A) The Cerebrum - controls voluntary movements and coordinates mental activity, (B) The Cerebellum - coordinates voluntary movements, balance and posture, (C) The Limbic System - control center for the autonomic nervous system, emotion and memory and (D) The Brainstem - life support systems (e.g. breathing, swallowing).

Ventricles are the spaces in the brain and the spinal cord where cerebrospinal fluid is produced and circulated.

The Spinal Cord

The spinal cord is the portal connecting the brain to the rest of the body.
Overview: The spinal cord, in an adult, is approximately 45 cm long and 1.5 cm wide and extends only to L1 or L2. Spinal nerves are named according to the vertebra they are adjacent to.

Anatomy: The spinal cord is well protected inside vertebrae. The dura (hard) mater is the outermost layer protecting the spinal cord. The pia (delicate) mater is the innermost layer protecting the spinal cord.

Functions: The spinal cord has a butterfly-like pattern, which consists of the grey matter - mostly unmyelinated interneurons. Afferent signals from the periphery synapse on interneurons in the grey matter of the spinal cord. Signals are then sent via myelinated neurons for processing by the appropriate centers in the brain.

13: The Peripheral Nervous System

Chapter Summary:

This tutorial is all about the peripheral nervous system and its functions. Specific details about the signal transmission through the peripheral nervous system are discussed. The cell types unique to the peripheral nervous system will be presented and their function discussed.

The afferent and efferent neurons that transmit the initial information to the spinal cord and then transmit the information from the brain will also be presented.

Tutorial Features:

Specific Tutorial Features:
- Animated diagrams showing the five sensory organs and their mode of actions.

Series Features:
- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Peripheral nervous system overview
- Organization and function
- PNS specific neurons
- Signal transmission
- Action potential

Glial cells of the PNS
- Satellite Cells
- Schwann Cells

Proprioception
The five senses:
- Skin
- Nose
- Tongue
- Ears
- Eyes

Motor nervous system
- Spinal Nerve Anatomy
- Reflexes
- Autonomic nervous system

Chapter Review:

Peripheral nervous system overview: The PNS is the communication network between the CNS and the rest of the body.
Organization and function: The peripheral nervous system (PNS) includes all neural tissue excluding the brain and the spinal cord.

PNS specific neurons: Unipolar Sensory Neurons: large myelinated neurons with the cell body off to one side of the single dendritic-axon process. Multipolar Motor Neurons: large myelinated neurons that have many dendrites off the cell body and an axon that may branch to effect many effectors.

Signal transmission: electrical signals are transmitted in 3 steps: (1) Neurotransmitters released from one neuron bind to and activate the dendrites of the next neuron. (2) If the signal is strong enough, an action potential is propagated down the axon. (3) Which causes the release of neurotransmitters from that neuron.

Action potential: When another neuron sends a sufficiently strong signal to the next neuron, the neuron excites to a threshold potential. Transporters on the cell membrane let positive ions into the cell, causing a change in potential, which spreads down the axon. This electrical propagation is called the action potential.

Glial cells of the PNS
Satellite Cells: The cell bodies of several sensory neurons form structures called Ganglia. Satellite cells are the glial cells that surround each ganglion.

Schwann Cells: Like Oligodendrocytes in the CNS, Schwann cells wrap themselves around neurons in the PNS to form the myelin sheath. Unlike Oligodendrocytes, which myelinate several neurons, a single Schwann cell forms a segment of myelin sheath.

Proprioception: involve sensors that keep track of where the body is in space.
The five senses: The sensory nervous system includes sensory organs, which receive information from the environment, and sends it to the CNS.

Skin: detects temperature, touch, and painful stimuli. Three separate kinds of nerves detect sensation on the skin
1. Mechanoreceptors: Detect pressure and tension on the skin 2. Thermoreceptors: Detect the temperature of the
stimulus 3. Nociceptors: Detect painful stimuli.

Nose: detects aromatic molecules. Thousands of chemicals can be detected by our olfactory and taste receptors and sorted into "pleasant, toxic, etc."

Tongue: taste buds detect salty, bitter, sweet, and sour information.

Ears: detect sound waves with mechanical receptors. Fluctuations in air pressure move a membrane attached to hair cells in the Organ of Corti. These motions open ion channels in neurons, sending the signal to the CNS.

Eyes: detect photons or light. The retina is the neural portion of the eye. Photons (light) activate receptors on the retina and the signal is transported to the CNS via the optic nerve.

Motor nervous system
Spinal Nerve Anatomy: There are 31 nerves exiting the spinal cord, dorsal connections bring sensory information to the CNS, ventral motor connections send commands to the periphery.

Reflexes: For painful stimuli, involuntary withdrawal (like a hand from a flame) occurs without input from the brain. This very simple nervous pathway is called a reflex arc.

Autonomic nervous system: directly controls automatic body functions (involuntary movements). The autonomic system has two opposing parts: the sympathetic and parasympathetic nervous systems.

14: The Sensory Nervous System

Chapter Summary:

This tutorial discusses the organization and integration of the sensory nervous system. The sensory nervous system receives information from the environment such as touch or heat, and relays this information back to the central nervous system for processing.

Tutorial Features:

Specific Tutorial Features:

- A detailed description of the five, major senses and how they function within the sensory nervous system is presented.
- The connection between the sensory nervous system and its interactions with the central nervous system is illustrated.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

The Sensory Nervous System: Internal Senses
Anatomy
Pathways
Functions

Proprioceptors
Mechanoreceptors
Vestibular system

The Sensory Nervous System: External Senses
Sight
Smell
Touch
Hearing
Taste

Chapter Review:

The Sensory Nervous System: Internal Senses
The Internal Senses include Proprioception and inputs responsible for regulating homeostasis. Homeostasis is a state or tendency towards equilibrium.

Proprioceptors: Proprioception: Sensors that keep track of where the body is in space. The sensory nervous system includes internal monitoring systems that allow us to coordinate movement.

Mechanoreceptors: Proprioception is carried out by Mechanoreceptors: In the joints, Pacinian Corpuscles detect deformation of the joints In the muscles, Muscle Spindles detect stretching of the muscle fibers In the muscles where tendons connect, Golgi Organs detect stretching of the tendons.

Vestibular system: An aspect of knowing where you are in space is knowing your orientation One component of your ears, the vestibular system informs your brain of how your body is oriented in space.

The Sensory Nervous System: External Senses
Sight: The retina is the neural portion of the eye Photons (light) activates receptors on the retina and the signal is transported to the CNS via the optic nerve.

Smell: Aromatic compounds are passed over the olfactory epithelium when you breathe. The olfactory epithelium contains nerve endings that signal to the olfactory bulb and other centers in the brain.

Touch: Skin: Three separate kinds of nerves detect sensations on the skin 1. Mechanoreceptors: Detect pressure and tension on the skin 2. Thermoreceptors: Detect the temperature of the stimulus 3. Nociceptors: Detect painful stimuli.

Hearing: Detect sounds and air pressure. Organ of Corti Sound in the form of pressure waves enter the ear, pass through the middle ear and vibrate a membrane in an elegant organ called the Organ of Corti.

Taste: Receptors on our tongue act in concert with the olfactory system to distinguish taste. There are five basic taste receptors: Salty, Sour, Bitter, Sweet and Umami.

15: The Endocrine System

Chapter Summary:

This tutorial discusses the endocrine system and the glands that produce the major hormones.

Tutorial Features:

Specific Tutorial Features:

- Graphical illustrations of the anatomical location of the hypothalamus and pituitary glands are presented.
- The production, release and the regulation of the major hormones is discussed with illustrations.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Endocrine glands

Endocrine vs. exocrine organs
Human endocrine system
The hypothalamus
The pituitary gland
The thyroid gland
The adrenal gland
The pancreas
The testes
The ovaries

The Menstrual Cycle and Pregnancy

Mechanisms of hormone action

Chapter Review:

Endocrine glands: Endocrine organs, called glands, secrete hormones into the bloodstream. Hormones affect the activity of target sites that are often located far from the site of release. Exocrine organs direct the function of their target sites by releasing their active.

Human endocrine system: The major endocrine organs include the hypothalamus and the hypophysis, or pituitary gland. Other endocrine glands within the body include: thyroid, parathyroids, adrenals, pancreas, ovaries, and testes.

The hypothalamus: The hypothalamus is located in the forebrain, directly above the pituitary gland. The hypothalamus receives input from other parts of the brain and from peripheral nerves. This input affects neurosecretory cells within the hypothalamus.

The pituitary gland: The anterior pituitary synthesizes its own hormones. Capillaries within the anterior pituitary receive signals from the hypothalamus that tell the anterior pituitary whether or not to release certain hormones.

The thyroid gland: The thyroid gland is a bilobed structure found at the trachea. It synthesizes and secretes three hormones: thyroxine (T4), triiodothyronine (T3), and calcitonin. The parathyroids are four small glands embedded in the thyroid. They produce and secrete parathyroid hormone (PTH).

The adrenal gland: The adrenal glands are located on top of the kidneys. Each gland is subdivided into an outer adrenal cortex and an inner adrenal medulla.

The pancreas: The pancreas is both an endocrine organ and an exocrine organ. The exocrine portion of the pancreas secretes digestive enzymes into the pancreatic duct. The endocrine portion of the pancreas secretes hormones, including insulin and glucagon.

The testes: The testes are responsible for the synthesis and secretion of androgens, such as testosterone. Interstitial cells, located between the seminiferous tubules of the testes, produce androgens.

The ovaries: The ovaries produce and secrete steroid hormones known as estrogens and progesterone.

The Menstrual Cycle and Pregnancy

From puberty to menopause, hormonal interplay between the hypothalamus, pituitary, and ovaries results in the monthly menstrual cycle, which has four distinct phases: follicular phase and the luteal phase.
Fertilization on or around day 14 of the menstrual cycle is followed by implantation of the zygote and development of the placenta.

Mechanisms of hormone action

Hormones may be grouped into three major categories, depending on their chemical structures: (A) Peptide hormones include simple peptides like ADH, (B) Steroid hormones include fat derived compounds like estrogen and (C) Amino acid-derived hormones include epinephrine and T4.

16: Cardiovascular System

Chapter Summary:

This tutorial presents the cardiovascular system including the heart, blood vessels and components of the blood. One of the major roles of the cardiovascular system is to deliver oxygen taken in at the lungs and deliver it to the tissues.

The interaction between the heart and the blood returning from the body is presented along with the connection between the heart and lungs.

Tutorial Features:

Specific Tutorial Features:

- Detailed anatomical pictures of the heart and blood vessels are presented.
- A description of the electrical conduction system of the heart and the action potentials that result in cardiac muscle contraction are presented.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Cardiovascular System:
The Circulatory System
Blood circulation
The Heart: Anatomy and Conduction
SA node
Electrocardiography
Oxygen Delivery to the Tissues
Blood & Blood Vessels

Chapter Review:

Cardiovascular System
The Circulatory System: The circulatory system delivers oxygen and nutrients to tissues and removes carbon dioxide and waste from tissues.

Blood circulation: Pulmonary Circuit - circulation between lung and heart releases carbon dioxide. Systemic Circuit - circulation between the heart and body delivers oxygen and nutrients and also picks up waste.

The Heart: Anatomy and Conduction: The main pump in the cardiovascular system which generates the pressure required to move blood through the system.

SA node: The heart has a unique, automatic electrical conducting system. The central nervous system (CNS) modulates the rate of contraction of the heart, but the heart can generate and maintain its own rhythm independent of the CNS. Sinoatrial node contains pacemaker cells, which create action potentials at a frequency that results in a normal heart rate of 70-80 beats/minute.

Electrocardiography: The electrocardiogram detects the electrical activity of each heartbeat as it develops over time. The P wave represents the depolarization as it spreads over the atria. The QRS complex corresponds to the current that spreads over the ventricles. The T wave represents the repolarization of the ventricles, during which time they become ready for the next contraction.

Oxygen Delivery to the Tissues

Blood pressure is generated by the heart and facilitates delivery of nutrients to the body.

Capillaries are the smallest blood vessels, where exchange takes place. Passive diffusion lets oxygen/ nutrients out of the blood into the tissue, and lets carbon dioxide/ waste out of the tissue into the blood. Hydrostatic pressure is caused by the blood pressure generated by the heart beating. Na+ and other electrolytes cause osmotic pressure.

Blood & Blood Vessels

Smooth muscle around arterioles modulates blood pressure by changing peripheral resistance. If systemic blood pressure is decreased, neuromodulation of the arterioles causes vasoconstriction, which, in turn, causes an increase in blood pressure.

Blood is made up of the following components: plasma contains water and proteins, red blood cells, white blood cells and platelets. Coagulation is an important process in which soluble proteins form an insoluble clot.

Oxygen is delivered to the tissues bound to hemoglobin. Hemoglobin is a metalloprotein, made up of 4 globin polypeptide chains with 4 imbedded oxygen-binding heme molecules.

17: The Lymphatic and Immune Systems

Chapter Summary:

The lymphatic system and the immune system work together tom protect the body from invading pathogens. Immune cells and antibodies circulate in the bloodstream and lymphatic vessels seeking out the pathogens to destroy them.

Tutorial Features:

Specific Tutorial Features:

- Step by step description of how the body mounts a specific immune response is presented.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Pathogens
The Lymphatic System
Lymph nodes
Lymph fluid
The Immune System:
Humoral immunity
Cellular Immunity
B-cells
T-cells
Antibodies

Chapter Review:

Pathogens
Pathogens are infectious agents that cause illness or disease to its host. Pathogens are categorized into 4 main groups:
(A) Viruses: Genetic material (RNA or DNA) inside a protective protein capsid. (B) Bacteria: release toxins or break down surrounding tissue, (C) Parasites: Can survive inside or outside of human cells and (D) Prions: Proteinaceous infection particles, which are abnormallystructured host proteins.

The Lymphatic System
Lymphoid organs: (A) spleen - is made up of masses of lymphoid tissue which are located around terminal branches of the circulation, (B) thymus - is made up of 2 lateral lobes, which are enclosed in a capsule. Each lateral lobe is made up of many

smaller lobules and (C) lymph nodes - Lymph nodes are located throughout the body and serve as filters for tissue fluid.

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 (originally tissue fluid) is collected in the lymphatic vessels and ultimately transported back into the systemic circulation by the pressure in the tissue, skeletal muscle activity and a series of one-way valves.

The Immune System:

Humoral immunity: Primary response: The very first time the lymphocytes meet a particular antigen, plasma cells produce antibodies to kill the pathogen. Memory B cells remember how to kill the antigen. Secondary response: Exposure to the same antigen later triggers a stronger immune response, because the system is already prepared.

Cellular Immunity: T cells kill infected cells in the cell-mediated response. Once inside cells, pathogens are harder to detect. Cell-mediated immunity recognizes and kills the body's own infected cells.

B-cells: Develop in the bone marrow and become antibody-producing plasma cells. Bind antigens to surface-bound antibodies.

T-cells: Develop in the thymus; differentiate into T-helper cells or T-cytotoxic cells.

Antibodies: Antibodies are soluble proteins that are bound to the surface of cells, as well as unbound in the circulation. There are 5 types (isotypes) of antibodies: IgA: protects mucosal surfaces, IgD: B-Cell antigen receptor, IgE: involved in allergy, IgG: majority of antibody-based immunity and IgM: key to B-Cell immunity.

18: The Respiratory System

Chapter Summary:

The respiratory system is responsible for delivering oxygen to the tissues and removing carbon dioxide from the tissues. The lungs are also involved in protecting the body from infection and are involved in thermoregulation.

The alveoli are the functional unit of the lung where gas exchange takes place.

Tutorial Features:

Specific Tutorial Features:

- Detailed diagrams of the breathing cycle are presented.
- Illustrations showing the mechanisms of gas exchange and lung elasticity are included.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Respiratory Organs
Lungs
Alveoli

Function of the Respiratory System
Protection
Thermoregulation

Respiratory Mechanics
Differential pressure during inspiration
Differential pressure during expiration
Lung elasticity and surface tension effects
Pulmonary surfactant

Chapter Review:

Respiratory Organs
Lungs: The lungs' primary function is gas exchange. Oxygen is delivered to the tissue and carbon dioxide is removed from the tissues. Breathing is an automatic, rhythmic mechanical process, which delivers O2 to the tissues and removes CO2 from the tissues.

Alveoli: The exchange of gases between the external environment and cells of the body takes place in the individual alveolus. Oxygen and carbon dioxide exchange passively between the pulmonary capillaries and the alveoli; These gases move along their partial pressure gradients, i.e- from high to low.

Function of the Respiratory System

Protection: Cilia, both in the upper airways and trachea, beat and move mucous continually towards the mouth. Macrophage Alveolar macrophages phagocytose inhaled particulate matter and pathogens.

Thermoregulation: Heat loss from the respiratory system helps the body regulate internal body temperature.

Respiratory Mechanics

Differential pressure during inspiration: At the end of expiration, just before the beginning of inspiration, the pressure inside the lung is the same as the atmospheric pressure outside the body. 15/29 When the diaphragm actively contracts, the internal lung volume increases and the pressure inside the lung decreases. The change in internal pressure causes air to rush into the lungs and down its pressure gradient.

Differential pressure during expiration: At the end of inspiration, the diaphragm relaxes passively. The lung volume decreases and this causes the internal pressure inside the lungs to increase to a level higher than atmospheric pressure outside the body.

Lung elasticity and surface tension effects: the ability of the lungs' elastic tissue to recoil during expiration. Elastins are elastic fibers present in the walls of the alveoli, which allow the lungs to return to their resting volume after expiration.

Pulmonary surfactant: Pulmonary surfactant is a phospholipid, similar to those found in a lipid bilayer surrounding human cells. It is made by pneumocytes in the lungs.

19: The Digestive System

Chapter Summary:

Food must be ingested and digested so the resultant nutrient molecules can be absorbed in the intestines. As food passes through the mouth and into the stomach, stomach acid and enzymes in the stomach break it down. This process continues in the small intestine where the nutrient molecules themselves are absorbed.

Tutorial Features:

Specific Tutorial Features:

- A detailed discussion of each step from ingestion, digestion and absorption into the body, is presented.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Ingestion and Swallowing
    Oral phase
    Pharyngeal phase
    Esophageal phase
Stomach
    Gastric juices
    Liver and Gallbladder
    Bile production and storage
Pancreas
    Structure
    Digestive enzymes
Intestines
Small Intestine
Large Intestine

Chapter Review:

Ingestion and Swallowing: 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.

> Oral phase: initially, the food bolus is moved to the back of the tongue. This triggers swallowing, by stimulating touch receptors in the pharynx. Then, the anterior of the tongue lifts to the hard palate and forces the bolus to the pharynx.

Pharyngeal phase: during the pharyngeal phase, the larynx is pulled forward and upward under the tongue by muscular contraction. As the larynx rises, the epiglottis moves backwards and downwards to seal off the glottis (the entrance to the respiratory system).

Esophageal phase: during the esophageal phase, the food bolus is pushed through the esophagus by involuntary muscle contractions called peristalsis.

Stomach: The stomach is a J-shaped organ, directly under the diaphragm. The uperior portion is a continuation of the esophagus. The inferior portion (pylorus) empties the stomach contents into the first segment of the small intestine.

Gastric juices: 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.

Liver and Gallbladder
Bile production and storage: The liver is involved in many aspects of nutrient metabolism, and the regulation of the products of digestion in the blood: (A) Carbohydrate metabolism, (B) Protein and lipid metabolism and (C) Vitamin storage.

Bile is an alkaline fluid produced by hepatocytes in the liver, and it helps to emulsify fats during digestion and absorption in the small intestine. Bile contains taurocholic and deoxycholic salts; these salts combine with fat globules and break them down into small droplets for absorption in the small intestine.

Pancreas
Structure: The pancreas is an elongated organ, adjacent to the stomach and in close association with the first segment of the small intestine, the duodenum.

Digestive enzymes: The pancreas produces a number of enzymes used in the process of digestion: (a) trypsinogen and chymotrypsinogen, (b) pancreatic lipase and (c) amylase.

Small Intestine: The small intestine is 8-22 ft. in length in an adult; it is divided into three main segments: duodenum, jejunum and the ileum. The small intestine is the site were most of the nutrients from digested food takes place.

Large Intestine: The large intestine is shorter in length (4-5 ft) than the small intestine, but it is so named because of its increased diameter. The large intestine is divided into four major areas: the ascending, transverse, descending and sigmoid colon.

20: Metabolism and Nutrition

Chapter Summary:

After the nutrient molecules are digested in the stomach and the small intestine they must be absorbed into the bloodstream. The nutrient molecules are then catabolized into key precursor molecules necessary for the cell to make ATP for the cellular energy.

Tutorial Features:

Specific Tutorial Features:

- The steps of nutrient molecule absorption into the bloodstream and then the conversion of these into cellular ATP are presented.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Absorption of Macronutrients
- Absorption of water
- Absorption of nutrient molecules

Metabolism
- Carbohydrate metabolism
- Protein metabolism
- Lipid metabolism

Energy Production
- Glycolysis

Citric Acid Cycle
- Oxidative phosphorylation
- ATP production

Regulation of Metabolism
- Absorptive state
- Postabsorptive state
- Hormonal regulation of metabolism

Chapter Review:

Absorption of Macronutrients

Absorption of water: Water and electrolyte ions (Na+, Ca2+, Cl-) move across the intestinal epithelial cells by passive diffusion and are absorbed into the bloodstream.

Absorption of nutrient molecules: Glucose and the other simple sugars are transported across the intestinal epithelial cells by a GLUT transporter. This is a sodium dependent transporter that binds sodium then glucose and transports them inside the cell. Amino acids are transported across the intestinal epithelial cells by four sodium dependent amino acid transporters.

Metabolism

Carbohydrate metabolism: As glucose and fructose are absorbed in the small intestine, they are first brought to the liver via the portal vein. Depending on the needs of the body, the liver will either store excess glucose as glycogen (glycogenesis) or breakdown glycogen to release glucose into the bloodstream (glycogenolysis).

Protein metabolism: Proteins are digested and absorbed as amino acids. Amino acids can be used inside cells to build proteins, or can be catabolized and used for producing energy.

Lipid metabolism: Lipids are stored in the body as triglycerides, and when they are mobilized for energy they are released as free fatty acids (FFA).

Energy Production

Glycolysis: Glycolysis is a pathway in which a molecule of glucose is oxidized into two molecules of pyruvic acid. Glycolysis takes place in the cytosol of the cell.

Citric Acid Cycle: The Citric Acid Cycle, also known as the Krebs Cycle, converts Acetyl CoA into NADH and FADH2, which are coenzymes that transfer electrons during the last step in energy production.

Oxidative phosphorylation: Nutrient molecules contain stored energy; enzymes perform oxidation-reduction reactions to facilitate the formation of adenosine triphosphate (ATP).

ATP production: During the process of electron transport, electrons from NADH and FADH2 are passed through the chain, which leads to protons (H+) being pumped into the intermembrane space in the mitochondria. The energy of the proton gradient is used to drive the energy consuming reaction ADP converted into ATP.

Regulation of Metabolism

Absorptive state: Absorptive state: during this state the majority of glucose absorbed from the gastrointestinal tract is converted to glycogen and triglycerides.

Postabsorptive state: the main goal of the body during this state is to maintain a normal blood sugar level. In order to do this, glucose is released from glycogen, and triglycerides are converted into free fatty acids. Glycerol is oxidized into energy, in the form of ATP.

Hormonal regulation of metabolism: The main hormones that regulate metabolism in the body are: (A) insulin (B) glucagon and (C) epinephrine.

21: The Urinary System

Chapter Summary:

The urinary system is involved osmoregulation and acid-base equilibrium, as well as the excretion of waste. The kidney filter blood and the filtrate is delivered to the bladder for excretion out of the body. As part of the filtering process, kidneys also reabsorb fluids depending on the needs of the body.

Tutorial Features:

Specific Tutorial Features:

- Detailed anatomical drawings of the kidneys, the nephron, and the filtration system are presented.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Homeostasis
Urinary System Structure
    Kidney
    Ureter
    Bladder
    Nephron
    Glomerulus
Urine Formation

Chapter Review:

Homeostasis

Homeostasis I: A balancing act The basic principle of homeostasis is that if there is too much of something in the body, it will be eliminated, while if there's too little of something, it will be retained.

Kidney: The kidneys are bean-shaped organs located behind the stomach that screen the body's blood and remove wastes for subsequent excretion in the form of urine. The kidney has three regions: the outer cortex, the central medulla, and the inner pelvis.

Ureter: The ureters transport the urine from the kidneys to the bladder for storage.

Bladder: The bladder stores urine until the moment of elimination.

Nephron: The basic unit of the kidney is the nephron. Each kidney is composed of roughly 1 million nephrons. Kidney nephrons filter the blood, reabsorbing what the body needs and excreting the rest as urine.

Urine Formation

Blood is continually filtered within Bowman's capsule. Wastes and other solutes are passed into the tubule for inclusion in the urine, while large items like cells or large proteins are retained in the blood.

High pressure within the glomerulus allows small solutes and water to escape from the glomerular blood flow into the space of the Bowman's capsule.

The renal tubule is the second portion of the nephron, and it is specialized for absorption. It descends from the Bowman's capsule.

22: Fluid, Electrolyte and Acid-Base Balance

Chapter Summary:

The mass of the human body is approximately 60% water. Water is used in all parts of normal body functions: blood supply, intracellular reactions. Total body water and the 3 compartments it is divided into, are regulated and their volume is strictly controlled.

Tutorial Features:

Specific Tutorial Features:

- The body fluid compartments and their interactions are presented.
- The Kidneys role in regulating total body water is discussed.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Body Fluid Compartments
- Total body fluid
- Extracellular fluid
- Intracellular fluid

Fluid Movement Between Compartments

Kidney's Role in Fluid Regulation

Acid-Base Balance
- Henderson-Hasselbalch equation
- Acid Formation in the Body
- Davenport Diagram
- Acidosis and Alkalosis

Compensation for a Disruption in the Acid-Base Balance

Chapter Review:

Body Fluid Compartments: Water moves freely throughout the various body fluid compartments, this movement is in response to two forces: hydrostatic pressure and osmotic pressure. While both forces contribute to fluid movement across a capillary membrane, osmotic pressure is the major force that drives fluid across the plasma membrane of cells.

Total body fluid: Total Body Water (TBW) = 60% x Body Weight.

Extracellular fluid: is made up of Cations (positively charged molecules): Ca2+, Mg2+, Na+; and anions (negatively charged molecules): Cl-, HCO-3 and proteins are in equal concentrations.

Intracellular fluid: Inside cells, cations (positively charged molecules): Ca2+, Mg2+, Na+;and anions (negatively charged molecules): Cl-, HCO-3 and proteins are in equal concentrations.

Fluid Movement Between Compartments

As water and salt are ingested there is a change in the osmolality of the ECF, and subsequently water moves between the ECF and ICF, towards the higher solute concentration. Water moves into the compartment with a higher solute concentration or osmolality, until equilibrium is reached between the two compartments.

Kidney's Role in Fluid Regulation

The nephron is the functional unit of the kidneys; nephrons are contained within the renal medulla. Nephrons are connected via the collecting duct system; fluid flows collectively from the nephrons into the collecting duct system and ultimately is excreted as urine.

Acid-Base Balance: The acidity and alkalinity of blood is tightly regulated, and is slightly basic within a range of pH= 7.35-7.45.

Henderson-Hasselbalch equation: The Henderson-Hasselbalch equation derives the pH as a measure of the acidity in biological systems.

Acid Formation in the Body: Carbonic Anhydrase is a metalloenzyme that rapidly and reversibly converts carbon dioxide and water into carbonic acid. The main function of this enzyme is to interconvert carbon dioxide and bicarbonate to maintain the acid-base balance in the blood and tissues.

Davenport Diagram: The Davenport diagram is a graphical representation of the relationship between the plasma bicarbonate concentration and the pH of the blood. Disturbance in the normal values of bicarbonate and pH lead to acidosis and alkalosis.

Acidosis and Alkalosis: Acidosis is a state of increased acidity in the body, characterized by a pH < 7.35. Acidosis can be caused by two mechanisms: (A) Respiratory Acidosis results from a build-up of carbon dioxide, due to hypoventilation. Alkalosis is a state of decreased acidity (increased pH) in the body, characterized by a pH > 7.45. Alkalosis can be caused by two mechanisms: (A) Respiratory Alkalosis and (B) Metabolic Alkalosis.

Compensation for a Disruption in the Acid-Base Balance

The human body has 3 main mechanisms to control a change in the acid-base balance of body fluids: (A) Extracellular and intracellular buffering, (B) changing the respiration rate of the lungs and (C) adjustments to renal acid secretion.

23: The Reproductive System

Chapter Summary:

Sexual reproduction involves the reproductive system and the support of the endocrine system. The reproduction system is necessary for the species to continue and produce children.

Tutorial Features:

Specific Tutorial Features:

- Detailed anatomical drawings are included, as well as the steps of implantation in the uterus.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Reproductive Anatomy
The male genitals
The female genitals
Gametogenesis
Spermatogenesis
Oogenesis
Sexual Reproduction

Chapter Review:

Reproductive Anatomy

The male genitals: The genitals include those organs or parts of the body that are involved in the process of reproduction. There are external and internal genitalia. The male external genitals include the penis and the scrotum. The male internal genitalia include the testes, epididymis, the ductus (or vas) deferens, the prostate, the seminal vesicles, and the urethra.

The female genitals: The female external genitalia include the vulva, which is comprised by the labia and clitoris. The female internal genitalia include the vagina, cervix, uterus, fallopian tubes, and ovaries.

The male and female gonads are the sex organs that produce the gametes, or the reproductive germ cells. The female gonad is the ovary, while the male gonad is the testis. The ovaries produce the female gametes, the ova, while the testes produce the male gametes, the spermatozoa.

Gametogenesis

Spermatogenesis: Spermatogenesis takes place in the seminiferous tubules of the testes. The seminiferous tubules contain undifferentiated diploid cells called spermatogonia. The spermatogonia divide and enlarge and undergo genomic replication to produce primary spermatocytes. The spermatids mature within the epididymis to produce a flagellum and the acrosome, which houses derivative enzymes important for fertilization.

Oogenesis: In oogenesis, a haploid ovum is produced from a single diploid oogonium in the ovaries. A diploid oogonium begins meiosis to produce a primary oocyte. The

primary oocyte undergoes meiosis I with unequal division of the cytoplasm to produce a large secondary oocyte and a small polar body.

Sexual Reproduction

Ovulation involves the release of a mature ovum from one of the two ovaries in response to hormonal signals. In the ovaries, each mature ovum is enveloped in a layer of supporting cells. This structure is known as a follicle. When sperm encounter the ovum, enzymes within the acrosome allow it to degrade and penetrate the corona radiata and zona pellucida. A placenta forms from embryonic and maternal tissues to allow the transfer of nutrients to and waste products from the fetus.

24: Development and Inheritance

Chapter Summary:

This tutorial discusses the development and inheritance of humans. Starting with DNA and working towards embryogenesis, this tutorial presents this in a detailed manner.

Tutorial Features:

Specific Tutorial Features:

- The expression of genes into phenotypes is discussed, along with the further development into human traits.

Series Features:

- Concept map showing inter-connections of new concepts in this tutorial and those previously introduced.
- Definition slides introduce terms as they are needed.
- Visual representation of concepts
- Examples given throughout to illustrate how the concepts apply.
- A concise summary is given at the conclusion of the tutorial.

Key Concepts:

Genes and Inheritance
- Fertilization
- Chromosome ploidy
- Meiosis
- Dominant versus recessive

Laws of Segregation
- Independent assortment
- Punnett Square
- Linkage and recombination

Development
- Early development
- Blastocyst formation
- Implantation
- Fetal development
- Labor induction
- Stages of labor

Chapter Review:

Genes and Inheritance

Fertilization: New life begins at fertilization, when the sperm and egg combine their genetic material. Genetic material is located in the nucleus.

Chromosome ploidy: Haploid (1N) = one complete set of all the different chromosomes in one cell. Diploid (2N) = two copies of each chromosome. Mitosis = Duplication and division of 2N diploid cells to produce more diploid cells.

Meiosis: Human somatic cells (body cells):
23 pairs (46 total) of homologous chromosomes (2N,
22 pairs are autosomes
1 pair is sex chromosomes - X & Y
Females are XX
Males are XY
Human germ line cells (eggs and sperm):
23 chromosomes (1N, haploid)

Dominant versus recessive: Dominant allele - An allele that expresses its trait regardless of the other allele, usually designated with an upper-case letter. Recessive allele - An allele that cannot express its phenotype when a dominant allele is present, usually designated with a lower-case letter.

Laws of Segregation: During the gamete formation, the two alleles of one gene segregate independently without mixing with each other.

Independent assortment: During the gamete formation, genes from different chromosomes assort independently and combine randomly.

Punnett Square: Punnett Squares simplify genetic problem-solving to predict genotypes of progeny.

Linkage and recombination: Some traits (genes) can be linked, linked = genes on the same chromosome that are likely to be inherited together. Linked genes can cross-over and recombine at a certain frequency called the linkage ratio.

Development

Early development: Day 0 = Ovulation of an egg from the ovary into the oviduct, Day 1 = Fertilization of the egg by a sperm, Days 2-5 = Cleavage and blastocyst formation and Day 6 or 7 = Implantation into uterus endometrium.

Blastocyst formation: Blastocyst = ball of cells with a center cavity, first evidence of cell differentiation is formation of trophoblast and inner cell mass. Blastocoel = fluid-filled cavity in the center of the blastocyst. Trophoblast = outer layer of cells, contributes to placenta. Inner cell mass = inner group of cells, contributes to embryo.

Implantation: Around Day 6-7: Blastocyst fuses to uterine endometrium and embeds itself into the tissue.

Fetal development: Trimesters = the 9-10 month pregnancy is divided into 3 trimesters. First Trimester: early embryogenesis, organogenesis begins, limb formation, heartbeat detected. Second Trimester: organ systems become more complex, fetal movement felt by mother (quickening), lung surfactant first produced. Third Trimester: largest increase in size and weight, most organ systems functional, fetus able to survive outside mother if born prematurely.

Labor induction: Labor = delivery of fetus from uterus to external environment Marked by regular time intervals between contractions. Dilation stage (lasts 6-12 hours), from labor onset, to complete cervical dilation, there are contractions of the uterus and rupture of amniotic sac ("my waters broke"). Expulsion stage (lasts minutes to hours) - From cervical dilation to delivery, the baby travels out through birth canal. Placental stage (lasts 5-30 minutes) - From delivery to placenta

elimination Placenta must be removed from mother, called the “afterbirth”.